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 II

by

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A dissertation submitted as the partial fulfilment for the degree of Doctor of Philosophy (PhD), Department of Education, University of Newcastle upon Tyne, October 2001.

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Volume II

Chapter 5

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

The aims of this chapter are to:

- provide a review of literature and empirical investigations into teacher learning and development through reflection (Section 5-1-1),
- explore the links between teacher reflection, pedagogy and learning outcome (Section 5-1-2),
- investigate the underlying structure of factors affecting the use of computers for teaching and learning from the perspective of the resulting challenges perceived by teachers (Section 5-2-1 & Section 5-2-2),
- explore the links between teachers' perceived challenges concerning the use of ICT for teaching and learning purposes, pedagogy, reflection and learning outcome (Section 5-2-3, Section 5-2-4 and Section 5-2-5).

- A list of the section in Chapter 5 -

(5-1-2-5) The potential links between the teachers' pedagogical preferences and reflection measures (based on the two learning theories): a correlational study

(5-1-3) The potential influences of teachers' learning orientations, their reflective thinking and practice, their personal judgement about the perceived complexity of challenges concerning the use of ICT, and their pedagogical preferences on the effectiveness of teaching and learning

(5-1-3-1) Teachers' learning orientation and their potential impact on pupil learning outcomes: a correlational study

(5-1-3-2) Teachers' reflective thinking and practice, and their potential impacts on pupil learning outcomes: a correlational study

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(5-2) Tackling challenges concerning the pedagogy of using ICT: The links between challenges concerning the use of ICT, pedagogy, reflective learning and practice, the extent of computer use, and effective teaching and learning

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(5-2-3-2) The potential links between measures of perceived challenge concerning the use of ICT for teaching and learning purposes and the measure of pedagogical preference concerning the use of ICT: a correlational study

(5-2-3-3) The potential links between measures of perceived challenge concerning the use of ICT for teaching and learning purposes and teacher reflection: a correlational study

- End of the list –

(5-1) Teacher reflection, the formulation and development of pedagogy supported by ICT and their potential impacts on teaching and learning effectiveness

Two major aspects of teacher characteristics will be addressed in this section. The first one is teacher reflection, which will be presented in terms of two theories concerning transformative learning. The second one is pedagogy, which will be represented by two sets of measures of pedagogy. The first set of measures is teachers' judgement about the complexity of challenges concerning their own use of ICT to support subject teaching and the second set of measures is comprised of various pedagogical preferences. The findings of this section will be linked with findings of the other sections in this chapter.

In relation to the "model of effective curricular teaching and learning supported by computers and other types of ICT" in chapter 2, teachers need to be aware of their own practice and their practice environment, which includes their pupils and other people in their own work situation. They also need to have insights or initiatives to plan and act for their duties and to react to their own practice environment. During their own perception and (re)action processes, teachers can learn from their own experience through reflection. Their reflection of experience is linked to the formulation and the development of their pedagogical preferences, which has an impact on the teachers' daily practice.

(5-1-1) The concept of teacher reflection in experiential learning theory and in transformative learning theory, assessment of reflection and the potential links between the two theories

Terminology such as reflection, reflective thinking, reflective practice, reflective judgement and reflective learning appears a lot in journals and literature about education, training and development. Research literature consistently stresses the importance of reflection in the training of teachers and professionals (e.g. Kolb, 1984; Mezirow, 1991; Colton & Sparks-Langer, 1993; Morine-Dershimer, 1989; Copeland et. al., 1993; Kirby, 1988). The following text will present a literature review of two major strands of reflective thinking and learning. Basically, the work is mainly from the models suggested by Kolb and Mezirow. The review of other prominent models will address the similarities as well as the differences between the two models. It is hoped that the descriptions and the addressed issues will justify the use of the two measures of reflection in this thesis.

In relation to the use of ICT, teachers need to reflect and learn from the experience of applied pedagogy. As discussed in chapter 4, this includes pedagogical practice with and without the use of information and communications technology in the primary classroom. In order to prepare an effective pedagogical arrangement with the use of ICT, there is a need to include issues about pedagogy, instruction, pupil learning, teaching practice and the personal development of teachers. From a methodological point of view, there is a need to provide empirical justification for the measures of "reflective thinking" used in this study. On the basis of this rationale, this chapter will report some statistical work on clarifying the factor structure of an instrument that is used to measure teachers' reflective thinking and practice on the basis of Mezirow's transformative learning theory, as well as its potential links with some measures in Kolb's Learning Style Inventory (LSI-1985). The LSI-1985 was an established and well-tested instrument measuring learning styles, and one of the dimensions of the measures in the instrument was an assessment of the use of the "reflective observation" learning orientation. The outcomes of analysis (e.g. confirmatory factor analysis) provide a sound empirical basis for further investigations of the possible relationships between teachers' reflective thinking and pupil learning attainments/gains, or alternatively, the challenge of using ICT in primary classroom settings.

(5-1-1-1) Clarification of the conception of reflection

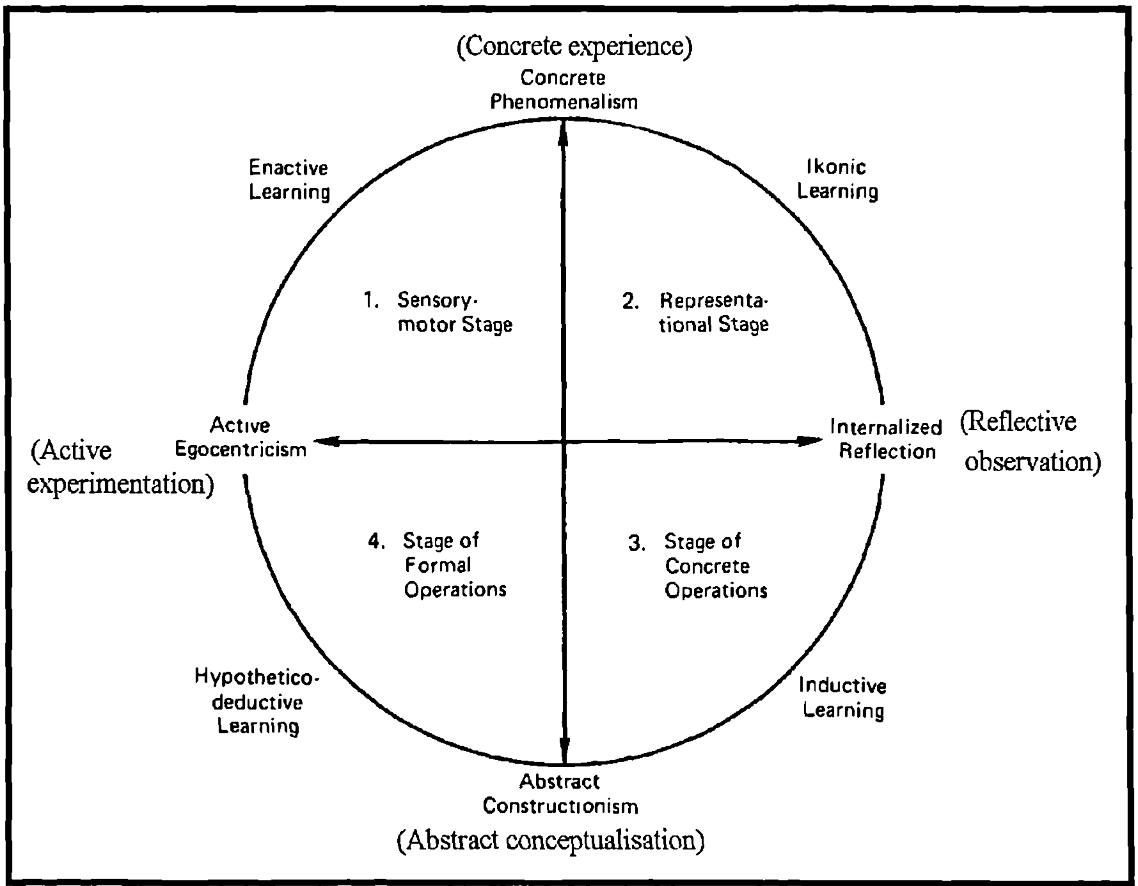
The paragraphs below will provide the theoretical background about two prominent theories that have addressed the issue of reflection. This will include information about the formulation of the two measuring instruments.

(5-1-1-1-1) Kolb's experiential learning theory

Background

Kolb's Experiential Learning Theory is one of the prominent models about learning by experience based on research in psychology, philosophy and physiology. The theory was formulated by linking John Dewey's model of learning, Kurt Lewin and his followers' model of action research and laboratory training, Jean Piaget's model of learning and cognitive development and other writers' work on experience-based learning. The theory widely considers and incorporates issues about human inquiry, creativity, decision making, problem solving and human learning as basic adaptation processes to the environment. Kolb has made an attempt to synthesise the similarities among conceptions of adaptive processes. Illustration I5-1A presents Piaget's model of learning and development together with the four learning orientations addressed in Kolb's experiential learning theory.

Illustration I5-1A: Piaget's model of learning and development and Kolb's learning orientations (Source: Kolb, 1984, page 25)



Remark: The words in brackets are used in Kolb's learning theory adapted from Piaget.

Experiential Learning Theory

Kolb's experiential learning theory has adopted Piaget's ideas about learning and development from the perspective of human inquiry. Although Kolb has used a different set of terminology in his theory, the four learning orientations that he suggested originate from the four learning orientations suggested by Piaget.

Instead of going through each of them in detail, the author of this thesis would like to draw attention to some of the key ideas that link them together. It starts with the framework of the illustration, the two structural dimensions underlying the process of experiential learning, the "prehension" dimension and the "transformation" dimension. The former is represented by the vertical axis of the Illustration I5-1A, and the latter is represented by the horizontal axis of it. A highlighted version of the two axes is presented in Illustration I5-1B, together with the type of knowledge addressed by the mechanism.

As a major process of the adaptation to the environment, Kolb thinks that knowledge results from the combination of grasping experience and transforming it. To grasp the reality, there are two dialectically opposed forms of "prehension", namely:

1. direct apprehension, and
2. comprehension.

The knowledge obtained through the former process is represented in the form of concrete experience, while the knowledge obtained through the latter process is represented in the form of abstract concepts. In order to make them meaningful to an individual, being a learner, the figurative representation of knowledge needs to be transformed into experience. There are two dialectically opposed ways of "transformation", namely:

1. intention (i.e. internal reflection), and
2. extension (i.e. active external manipulation of the world).

The two dialectically opposed orientations of adaptation in the prehension dimension are called "concrete experience" orientation and "abstract conceptualisation" orientation. The two dialectically opposed orientations of adaptation in transformation dimension are called "active experimentation" orientation and "reflective observation" orientation. The definitions of the four orientations of adaptation can be found in Table T5-1-1 below:

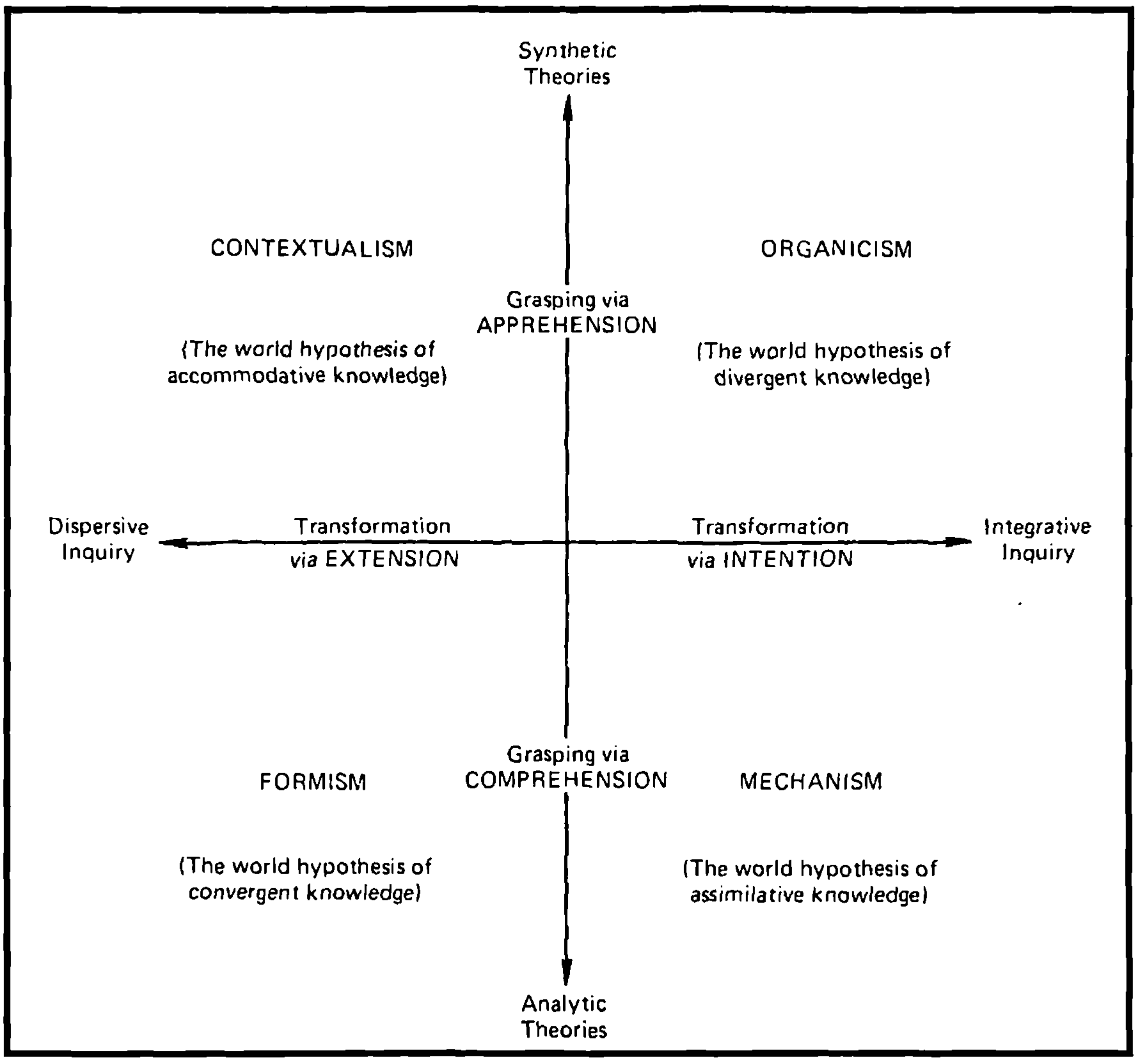
Table T5-1-1: Kolb's dimensions of adaptation and definitions of the four orientations of learning

Dimension of adaptation	Orientation of learning	Definition of the orientation of learning
Prehension	Concrete experience	It focuses on being involved in experiences and dealing with immediate human situations in a personal way. It emphasizes feeling as opposed to thinking; a concern with the uniqueness and complexity of present reality as opposed to theories and generalizations; an intuitive, "artistic" approach as opposed to the systematic, scientific approach to problems. People with concrete-experience orientation enjoy and are good at relating to others. They are often good intuitive decision makers and function well in unstructured situations. The person with this orientation values relating to people and being involved in real situations, and has an open-minded approach to life.
	Abstract conceptualisation	It focuses on using logic, ideas, and concepts. It emphasizes thinking as opposed to feeling; a concern with building general theories as opposed to intuitively understanding unique, specific areas; a scientific as opposed to an artistic approach to problems. A person with an abstract-conceptual orientation enjoys and is good at systematic planning, manipulation of abstract symbols, and quantitative analysis. People with this orientation value precision, the rigor and discipline of analyzing ideas, and the aesthetic quality of a neat conceptual system.

Transformation	Active experimentation	It focuses on actively influencing people and changing situations. It emphasizes practical applications as opposed to reflective understanding; a pragmatic concern with what works as opposed to what is absolute truth; an emphasis on doing as opposed to observing. People with an active-experimentation orientation enjoy and are good at getting things accomplished. They are willing to take some risk in order to achieve their objectives. They also value having an influence on the environment around them and like to see results.
	Reflective observation	It focuses on understanding the meaning of ideas and situations by carefully observing and impartially describing them. It emphasizes understanding as opposed to practical application; a concern with what is true or how things happen as opposed to what will work; an emphasis on reflection as opposed to action. People with a reflective orientation enjoy intuiting the meaning of situations and ideas and are good at seeing their implications. They are good at looking at things from different perspectives and at appreciating different points of view. They like to rely on their own thoughts and feelings to form opinions. People with this orientation value patience, impartiality, and considered, thoughtful judgement.

(Source: From Kolb, 1984, p.68-69)

Illustration I5-1B: Pepper's system of world hypotheses and the structure of learning (Source: Kolb, 1984, page 112)



The two dimensions of experiential learning proposed by Kolb have close links with Pepper's system of world hypotheses and the structure of learning. A graphical presentation of that is presented in Illustration I5-1B. According to the structure of knowledge, knowledge of the world can be classified using two broad categories: synthetic theories and analytic theories. Knowledge of the former is perceived through the act of seizing or grasping called "apprehension", while knowledge of the latter is perceived through the act of interpretation called "comprehension". According to the approach of inquiry, human mental processing of knowledge can be classified using two broad categories: dispersive inquiry and integrative inquiry. The former inquiry approach transforms knowledge through an "extension" of existing knowledge with the ground of ideas and experience in the external world, while latter inquiry approach transforms knowledge through the use of deliberate "intention" in the mental processing of existing knowledge.

Pepper's system of knowledge about the world has focused on the nature of knowledge to be learnt. Kolb's experiential learning theory has focused on learning styles. For him, information of the world is perceived through prehension, but learning is a creation of experience through the process of transformation. In each of the two dimensions of adaptation to the world, learners need to tackle conflicts between the two dialectically opposed orientations of dimension. Although Kolb has adopted Pepper's classification system, he has used a new terminology to represent ideas in the experiential learning theory. Kolb keeps the distinction between the "perception" of information and the "transformation" of perceived ideas and experience proposed by Pepper. He thinks learning occurs through enriching existing knowledge with ideas and experiences in the external world (i.e. extention) or through the internal reflection about the attributes of these experiences and ideas (i.e. intention). So, in experiential learning theory, reflection (as opposed to action) has a crucial role to play in knowledge transformation.

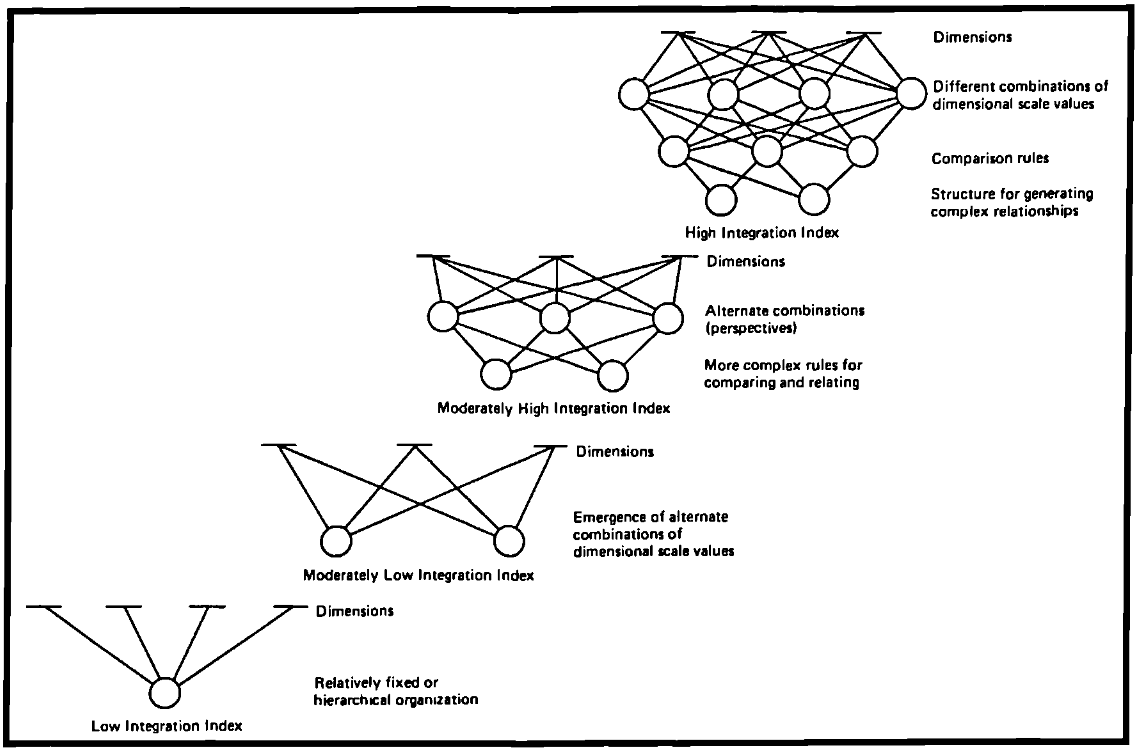
The conceptions of reflection and transformation

One should note that Kolb's theory regards reflection as one of the two contrasting orientations of learning along the transformative dimension of adaptation. With reference to Lewin's action research techniques and the laboratory method, Kolb thinks reflection involves the analysis of data collected from observations to serve as a form of feedback to the pre-set goal and for the development of future action goals. By incorporating Piaget's constructivist perspective on intelligent adaptation, Kolb also considers reflection as the basis for knowledge internalisation mechanism during which accommodation and assimilation processes operate. Reflection is an important process for the construction and reconstruction of cognitive structure within an individual. This orientation of learning is the determinant of the integration of conceptions about the world, while the active experimentation orientation of learning is the major determinant of the differentiation of conceptions about the world.

Learning and development in the experiential learning theory

Kolb also draws a distinction between learning and development. Learning is focused on the creation of personal knowledge through transformation of perceived ideas and experience, but human development is a transaction between personal characteristics and social knowledge about the living environment. The mechanism of human development is characterised by differentiation and integration processes. It is the maturation towards a higher-level integration and non-dominant modes of learning.

Illustration I5-1C: Levels of hierarchic integration (Source: Kolb, 1984, p.137)



Kolb also made an attempt to illustrate different levels of integration of knowledge in a hierarchical structure, as the product of the reflective observation orientation of learning. The idea is presented in Illustration I5-1C. Such a classification is in line with the work of Biggs and Collins' Solo Taxonomy of learning outcome (Biggs & Collins, 1982). It is proposed that learning outcomes can be classified as prestructural, unistructural, multistructural, relational and extended abstract. The taxonomy also describes a progression of knowledge structure, starting from the one without a structure to the one with the most complex in structure. In fact, the analogy is supported by recent research in cognitive psychology and neuroscience, as mentioned in chapter 3. Knowledge "activated" by an expert is much better than the knowledge activated by a novice, in terms of its breadth and depth (Anderson, 1990). The difference is not only between the number of concepts, but also the complexity between links between the concepts. The differences could be fairly similar to the difference between the low integration index and high integration index in Illustration I5-1C. So, with reference to experiential learning theory, reflection can be viewed as an inquiry approach that can establish links between concepts.

Learning Styles

Kolb also has particular interest in the characteristics of individuals. On the basis of the four quadrants of the two dimensions of learning, he tried to classify learners who consistently employ different orientations of learning as using the four learning styles. He used the term "converger" to describe a learner who highly depends on the "abstract conceptualisation" and "active experimentation" learning orientations. He used the term "diverger" to describe a learner who highly depends on the "concrete experience" and "reflective observation" learning orientations. He used the term "assimilator" to describe a learner who highly depends on the "abstract conceptualisation" and "reflective observation" learning orientations, and the term "accommodator" to describe a learner who highly depends on the "concrete experience" and "active experimentation" learning orientations. Further details about each of the learning styles can be found in Table T5-1-2 below.

Table T5-1-2: Descriptions of learning styles

Learning Style	Descriptions
Converger	The convergent learning style relies primarily on the dominant learning abilities of abstract conceptualization and active experimentation. The greatest strength of this approach lies in problem solving, decision making, and the practical application of ideas. We have called this learning style the converger because a person with this style seems to do best in situations like conventional intelligence tests, where there is a single correct answer or solution to a question or problem (Torrealba, 1972; Kolb, 1976). In this learning style, knowledge is organized in such a way that through hypothetical-deductive reasoning, it can be focused on specific problems. Liam Hudson's (1966) research on those with this style of learning (using other measures than the LSI) shows that convergent people are controlled in their expression of emotion. They prefer dealing with technical tasks and problems rather than social and interpersonal issues.
Diverger	The divergent learning style has the opposite learning strengths from convergence, emphasizing concrete experience and reflective observation. The greatest strength of this orientation lies in imaginative ability and awareness of meaning and values. The primary adaptive ability of divergence is to view concrete situations from many perspectives and to organize many relationships into a meaningful "gestalt." The emphasis in this orientation is on adaptation by observation rather than action. This style is called diverger because a person of this type performs better in situations that call for generation of alternative ideas and implications, such as a "brainstorming" idea session. Those oriented toward divergence are interested in people and tend to be imaginative and feeling-oriented.
Assimilator	In assimilation, the dominant learning abilities are abstract conceptualization and reflective observation. The greatest strength of this orientation lies in inductive reasoning and the ability to create theoretical models, in assimilating disparate observations into an integrated explanation (Grochow, 1973). As in convergence, this orientation is less focused on people and more concerned with ideas and abstract concepts. Ideas, however, are judged less in this orientation by their practical value. Here, it is more important that the theory be logically sound and precise.

Accommodator	The accommodative learning style has the opposite strengths from assimilation, emphasizing concrete experience and active experimentation. The greatest strength of this orientation lies in doing things, in carrying out plans and tasks and getting involved in new experiences. The adaptive emphasis of this orientation is on opportunity seeking, risk taking, and action. This style is called accommodation because it is best suited for those situations where one must adapt oneself to changing immediate circumstances. In situations where the theory or plans do not fit the facts, those with an accommodative style will most likely discard the plan or theory. (With the opposite learning style, assimilation, one would be more likely to disregard or re-examine the facts.) People with an accommodative orientation tend to solve problems in an intuitive trial-and-error manner (Grochow, 1973), relying heavily on other people for information rather than on their own analytic ability (Stabell, 1973). Those with accommodative learning styles are at ease with people but are sometimes seen as impatient and "pushy."

(Source: From Kolb, 1984, p.77-78)

Adaptive competence

In response to different tasks or problems, individuals may have to make use of different skills. Kolb thinks that the effective match of task requirement and personal skills is the key for effective performance. He used the term "adaptive competence" to describe the ability to form an effective match of such. Generic adaptive competence works as the linkage between learning styles. It can facilitate the development of "specific" skills for effective performance in the task or problem. As a brief conclusion, adaptive competence is the skill of adjusting between the learning styles of an individual, according to the tasks or problems encountered. We shall have further discussion about this issue and the technical measurement issues in section 5-1-1-2-1.

(5-1-1-1-2) Mezirow's transformative learning theory & related theories concerning reflective thinking and learning

Schon (1987) suggests that problems or challenges faced by professionals can be classified as "technical" or "complex or ill-defined" in nature. Problems of the former type have clear answers or solutions, while there is no ideal solution for the latter type of problem. Problems of the latter type are difficult to solve by rationality because problems of the real world are often multi-faceted in nature. Schon thinks practitioners sometimes have a gap between theory and practice. He used the term "espoused theory" to describe knowledge of the ideal practice that the practitioner has learnt from books, professional guidebooks or academic situations. This kind of knowledge can be quite different from the practitioner's "theory-in-use", which is the valid mechanism of operational practice. To foster an effective practitioner, Schon suggests that the education and training of professionals needs to equip the practitioners with the ability to learn and adjust their theory-in-use through reflection.

The thinking process is actually a learning process through which one's experience is gained, extended or/and transformed. The thinking processes can take place during or after the action taken by the practitioner. In Schon's terms, if the thinking process takes place simultaneously when a practitioner performs the action, it is called "reflection-in-action". If the thinking process takes place some time after the action, it is called "reflection-on-action". For premise reflection, the reflective practitioner may need a "time out" process during which the practitioner removes himself or herself from the action for premise reflection. The actual duration of the time out process may or may not be long, and it varies between individuals. For example, a lawyer's reflection might take less than a second without withdrawing from the action being taken. On the contrary, a trainee teacher or an inexperienced professional might find reflection-in-action too difficult, but keep reviewing his or her classroom action after the teaching practice took place.

Since technical rationality is unable to solve all the problems that professionals encounter, Schon suggests that the education and training of professionals should not focus only on problem-solving skills, but also on the skills of redefining the problem setting. The idea is that the knowledge about a problem is sometimes limited by the practitioner's interpretation of the puzzling phenomena and its consequences. The view about the problem setting is constrained within the practitioner's mental frame. To deal with complex, ill-defined problems that cannot be solved by technical rationality, practitioners need to redefine their view of the problem setting. Schon uses "problem posing" to describe the process of reframing. It will bring the formulation of new routes for resolving the problem or viewing the puzzling phenomena differently or as something else. In other words, reframing is the process leading to the change or adjustment of the practitioner's theory-in-use.

Mezirow is a prominent figure working on the transformative dimension of learning. He has proposed that learning "may be understood as the process of using a prior interpretation to construe a new or revised interpretation of the meaning of one's experience in order to guide future action" (Mezirow, 1998). His theory makes practical contributions in the education and training of professionals by explaining the roles of critical thinking, learning and development, reflection, problem-posing and problem-solving. He has tried to distinguish "reflective actions" from "non-reflective actions" in his theory (i.e. can be described as "critical reflection" and "without critical reflection", according to his later work). Here is a summary of the sub-categories of actions and reflection from the book published in 1991:

A) Non-reflective actions (i.e. in referring to Mezirow's work in 1998, it could be re-named "actions without critical reflection"), including:

- habitual action,
- introspection, and
- thoughtful action.

B) Reflection (i.e. re-named as "critical reflection" in Mezirow, 1998), including:

- content reflection,
- process reflection,
- content and process reflection, and
- premise reflection (or "critical reflection of an assumption", as in Mezirow, 1998).

Mezirow's work has incorporated John Dewey's work on reflection (i.e. which is compatible to "critical reflection" in Mezirow, 1998) and the idea originated from critical theory and emancipatory education (see Mezirow, 1981). According to Dewey (1933), reflection is an:

> "active, persistent and careful consideration of any belief or supposed form of knowledge in the light of the grounds that support it and the further conclusion to which it tends".

In his book published in 1991, Mezirow interprets Dewey's definition of reflection (i.e. refers to "critical reflection" introduced in Mezirow, 1998) as "validity testing" and he stresses the importance of being critical in his own definition of reflection. The major criterion used to differentiate Mezirow's "reflective action" and "non-reflective action" (i.e. in relation to Mezirow, 1998, they could be referred to "critical reflection " and "without critical reflection") is whether the process of appraisal or review of knowledge has taken place. Only actions that have gone through the meta-cognitive evaluation process can be classified as reflective (i.e. critically reflective, as in Mezirow, 1998). He regards reflection (i.e. critically reflection, as in Mezirow, 1998) as:

> "the critique of assumptions about the content or process of problem solving....The critique of premises or presuppositions pertains to problem posing as distinct from problem solving. Problem posing involves making a taken-for-granted situation problematic, raising questions regarding its validity."

The transformative learning theory has the special feature of defining reflection from a critical perspective. Mezirow (1998) proposes that the critique of a premise or presupposition on which the practitioner has defined a problem is a special mode of critical reflection, through which personal meaning perspective is transformed or the problem is re-defined. The term "premise self-reflection" or "critical self-reflection of an assumption" is used to describe this special type of critical reflection. We shall return to this when we address each of the four categories or levels of reflection in the section A1-2.

(5-1-1-2) Assessment of reflection

(5-1-1-2-1) Assessing learning styles and reflection based on experiential learning theory: the use of learning style inventory (LSI-1985)

The review of literature about learning through experience and experiential learning theory of development above has suggested that the practitioner's learning styles have an essential role to play in professional development. So, the Kolb's Learning Style Inventory (LSI, 1985) was administered together with a teacher survey administered in 1998/99. It was expected that the data would provide some information about:

- the extent of a specific orientation of learning that a teacher or a pupil employs in general situations,
- the classification of individuals into categorical groups, according to their learning orientations, and
- the extent of adaptive competence.

After items of the same theoretical orientation were combined together, eight measurement scales were formulated in relation to the three aspects above. The details of the variable names, their composition and the alpha statistics are presented in Table T5-1-3 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.

Table T5-1-3: The composition of measurement scales derived from experiential learning theory

Variable	Description of the measure / learning orientation (Abbrev.)	Composition of the scale / items to be referred	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
ls_kf	Abstract-concrete (AC - CE)	Mean of 12 AC – CE scores	74	.83
ls_oh	Active-reflective (AE - RO)	Mean of 12 AE – RO scores	74	.89
ls_kft	Abstract and concrete (AC + CE)	Mean of 12 AC + CE scores	74	.83
ls_oht	Active and reflective (AE + RO)	Mean of 12 AE + RO scores	74	.84

Kolb's investigation of adaptive competence is based on the construction of two measurement scales. AC - CE in Table T5-1-3 is used to show the extent to which the individual has a preference on the abstract to concrete orientation and AE - RO is used to show the extent to which the individual has preference on the action to reflection orientation. Note that these two measures are focusing on the relative difference between the preference for the two dialectic learning orientations in a specific dimension of learning. They are not good enough to show the whole picture about the capability to tackle a whole range of problems or a problem (or problems) that require(s) an adjustment(s) between the two dialectic learning orientations. For example, it is possible that a learner with high scores in both AE and RO may have the same relative difference (i.e. AE-RO) as another learner whose scores in both AE and RO are low. In referring to cases like these, the AE-RO measure is not useful to differentiate between the two learners. Similarly, the problem applies to the AC-CE measure. So, there is a need to seek for other measures.

Note that different orientations of learning are used to acquire different types of knowledge. According to the context, individuals need to make use of different types of knowledge and different learning orientations to tackle problems in the real world. And the better the mastery of the right orientation to be used, the more likely it is that the individual will succeed in the acquisition of the target knowledge for a specific need. On this basis, the group of teachers who are high in the sum of the two orientations could be named as those with high adaptive competence, while the group of teachers who are low in the sum of the two orientations could be named as those with low adaptive competence. Generally speaking, as different types of knowledge are required to solve a problem (or problems) in the real world, the group with high adaptive competence is more capable in tackling various types of classroom problem than the group with low adaptive competence. It is possible that teachers with low adaptive competence are very good at tackling some specific type(s) of classroom problems, however, they are relatively weak in tackling classroom problems that require the learning orientation at the other end of that dimension of adaptation. So, the better the teacher's mastery of the use of both orientations, the better the teacher will adapt to the classroom environment. And the ideas of synthesising the two dialectically opposed orientations seem to be consistent with Kolb's description of the relationship between orientations of learning (1984, p.74). He states that:

> "these dimensions are not unitary theoretically, such that a higher score on one orientation would automatically imply a low score on its opposite, but rather that they are dialectically opposed, implying that a higher-order synthesis of opposing orientations makes highly developed strengths in opposing orientation possible".

With the support of the background discussed above, two additional measurement scales of adaptive competence were constructed for the purpose of the present study. They are introduced as the last two variables in T5-1-3. The computational basis of these two measures treats adaptive competence as aggregate measures of the two learning orientations in a specific dimension of adaptation. Instead of focusing on the relative difference between the two orientations in a specific dimension, the AC+CE and AE+RO focus on the sum of the two learning orientations in a specific dimension of adaptation. As the perceptual dimension and the processing dimension of adaptation have different roles to play, no further attempt is made to combine the two measures of adaptive competence.

When analysing the pattern of learning orientations of people in different professions, Kolb found that the education profession requires people who depend on the abstract conceptualisation learning orientation and the reflective observation learning orientation, as dialectically opposed to the concrete experience learning orientation and the active experimentation learning orientation (Kolb, 1984, page 174). In referring to the results of descriptive statistics reported in Table T5-1-4, the respondents in the present study tend to depend on the abstract conceptualization and the active experimentation learning orientation, as dialectically opposed to the concrete experience and reflective observation learning orientation. The results indicate a slight difference between the learning orientations used by practising primary teachers and the requirements of the teaching profession proposed by Kolb. Nevertheless, further investigation of these learning orientations will be reported in section A3-1.

Table T5-1-4: The results of descriptive statistics concerning measures derived from experiential learning theory

Learning orientation/ measure	N	Minimum	Maximum	Mean	S.D.
Concrete experience (CE)	74	1.00	4.00	2.23	.57
Reflective observation (RO)	74	1.33	3.75	2.48	.65
Abstract conceptualization (AC)	74	1.42	4.00	2.45	.69
Active experimentation (AE)	74	1.08	4.00	2.84	.71
Abstract-concrete (AC-CE)	74	-1.67	3.00	.22	1.04
Active-reflective (AE-RO)	74	-2.33	2.50	.36	1.15
Abstract and concrete (AC+CE)	74	3.17	6.50	4.68	.72
Active and reflective (AE+RO)	74	3.50	6.83	5.32	.73

Remark: *N* refers to the number of respondents and *S.D.* refers to the standard deviation of the mean.

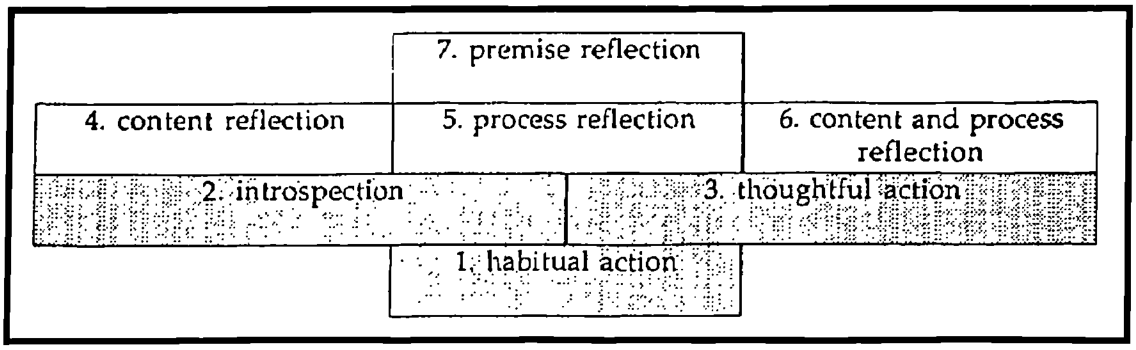
(5-1-1-2-2) Assessing reflection on the transformative learning theory: a confirmatory factor analysis (CFA)

Assessing reflective thinking and practice

Although the importance of reflection in the education and training of professionals is widely accepted, the amount of research about assessing reflection on a quantitative basis is surprisingly little. There are standardised tests of critical thinking, such as the Cornell Critical Thinking Test (CCTT) and the Watson-Glaser Critical Thinking Appraisal (WGCTA). An instrument assessing reflective judgement was constructed and tested by King and Kitchener (1994). It is an instrument for assessing the development of critical reasoning that relates to assumptions. However, although "critique of assumptions" is a major topic covered by the instrument, its scope is not wide enough to cover the whole spectrum of reflection and critical reflection in a structural order, such as thoughtful application and various types of critical reflection. The closest examples were two studies in assessing the level of reflective thinking in journal writing. The first one was done by Wong et. al. (1995), based on the model suggested by Boud, Keogh & Walker (1985). It describes reflection as the link between prior knowledge and new knowledge. The assessment of reflection was guided by the sequence suggested in their model of reflection, starting from "return to experience", "attending to feelings", "re-evaluation", "association", "integration", "validation" and ending with "appropriation" (see Boud and Walker, 1993).

The second one was done by Kember, et. al. (1999), which has a close relationship with this study. It assessed the level of reflective thinking from students' written journals. Qualitative written data was assessed with the use of a coding scheme based on the work of Mezirow. Although the inter-rater reliability appeared to be only marginally acceptable, it gave a sound qualitative research background for constructing a questionnaire to assess the level of reflective thinking in professional education, as an extension of the categories used in the coding scheme. The final coding scheme consisted of four categories or modes of reflective thinking. These categories provide the basis for the construction of the measuring instrument in this thesis, which was specially designed to assess reflective thinking and learning in teaching practice. Their coding scheme is illustrated in Illustration I5-1D. Their first category starts with the zero level of reflection, which was named as "habitual action". Reflective thinking is not necessary because the action can be performed when the practitioner spends attention on other things or events. This is followed by the second category - "thoughtful action", and "introspection" was omitted because it was regarded as an activity within the affective domain (e.g. see Kember, 1999 & Mezirow, 1991). Their third category is "reflection", the content of which was re-defined as "critical reflection" by Mezirow in 1998. Their final category is originally given as "premise reflection", which refers to the concept of "critical reflection of assumption(s)" to be described in the text below.

Illustration I5-1D: Coding scheme used to classify reflective thinking and practice (Source: Kember et. al., 1999)

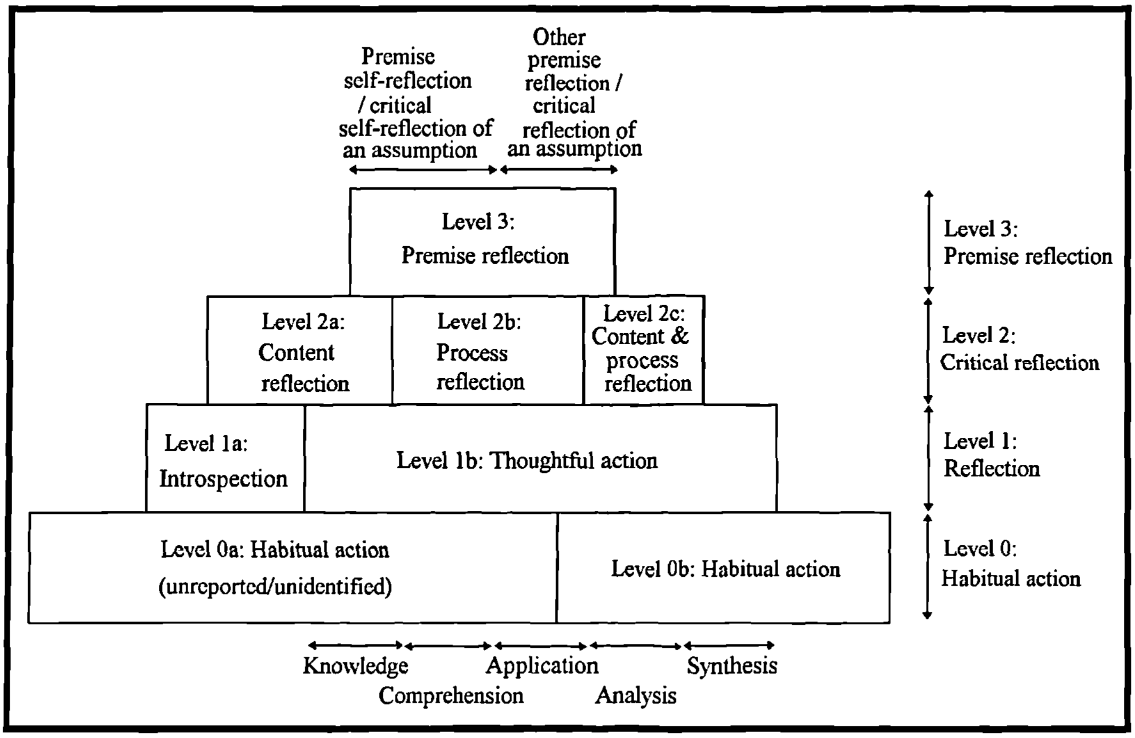


The instrument assessing teachers' reflective thinking and practice in this study

For the specific purpose of this thesis, an instrument was constructed to measure the level of reflective thinking and practice of teachers involved in this study. The instrument was constructed on the basis of the coding scheme suggested by Kember (1999). Since the idea of the expected factorial structure was inspired and supported by previous research evidences, it would be appropriate to carry out a confirmatory factor analysis (CFA) to validate the factorial structure of the measuring instrument. A questionnaire about reflective thinking in the context of teaching was formulated and was carried out during the Easter term in the academic year 1998/99. The details of the items and the results of initial statistics can be found in Chapter 4 section 4-2-D2 and section 4-4-D2.

Roughly at about the same time, an extended work was carried out by Kember et. al. (2000) in another part of the world. To a certain extent, it can be regarded as a parallel study to this study because the two confirmatory factor analyses were done independently in different contexts. Their instrument measures the category of reflection in the context of professional education, while the instrument for this study measures the level of reflection in the context of in-service teacher education. Their results support the analysis and interpretation of the present study, as they were released shortly after the data collection of this study was completed. Their results seem to be fairly consistent with those of their previous study, and they have successfully demonstrated that reflective thinking and practice has a four-factor structure. Having said that, there are discrepancies between the content of some measurement sub-scales of their instrument and the instrument designed for this thesis. The major difference is the choices for response. In their instrument, trainee and practising professionals were asked to indicate their agreement with the statement, using the scale "definitely agree", "agree with reservation", "only to be used if a definite answer is not possible", "disagree with reservation", and "definitely disagree". In the instrument for this thesis, teacher respondents were asked to indicate the extent of validity of statements about their reflective thinking in relation to their teaching, using the scale "never true of me", "occasionally true of me", sometimes true of me", "often true of me" or "always true of me". When not possible or unsure about the answer, respondents were allowed to choose the option "N.A." on the scale. The paragraphs below will provide further description of each of the measurement sub-scales addressed by the instrument used in this thesis. Further comments or clarifications will be made when the content of a sub-scale is found to be different from the respective sub-scale used by Kember et. al. (2000). The measurement scales and the terminology used in the measurement instrument for this thesis is summarised in Illustration I5-1E.

Illustration I5-1E: Levels of reflective thinking and practice and the terminology used in the measuring instrument of this thesis



Level 0: Habitual action

In their daily practice, professionals might be so familiar with certain tasks or problems that they can perform the action spontaneously as a routine. For example, maintaining balance when riding a bicycle certainly requires some knowledge. The knowledge that the practitioner has is "tacit" in nature because the action takes place outside of focal awareness. It seems to be embedded in the action. In this thesis, habitual action is regarded as making a contribution to learning. Through repetitive habitual practice, professionals may equip themselves with automatic responses to familiar tasks or problems. Practitioners are able to perform the action, but they have difficulty in explaining how to do it. The major reason is that the knowledge is implicit in nature, which is embedded in the action. Schon (1983, 1987) calls knowledge of this type "knowledge-in-action". One of the ways of making the implicit knowledge explicit is to reflect at the time when the action takes place, such as saying aloud the action that he is performing. Having said that, the mental processes at this level are unconscious and automatic. The implication is that assessment of habitual action through questionnaire survey has methodological weaknesses because the self-ratings might not be accurate.

Level 1: Thoughtful application

When performing their tasks or encountering problems, professionals may make reference to their learnt knowledge and experience without reviewing the validity of the information. For example, a trainee teacher or an inexperienced professional may link the task or problem that he/she is addressing with knowledge learnt from books or learnt from other social context. The internal activities may take the form of introspection or thoughtful action. Learnt knowledge or experience is used as the "reference" or "theory-in-use" for the action without re-evaluation of its authenticity or validity. They are classified as "reflective" because previous knowledge or experience is revisited. In relation to the knowledge structure (or cognitive structure) of the practitioner, activities presented by items in this level would only enable learning that remains within pre-existing meaning schemes and perspectives. So, learning that takes place beyond pre-existing meaning schemes would be classified as a higher level activity, such as critical reflection or premise self-reflection. Unlike habitual action, the activities in this level are conscious and intentional.

The work by Kember et. al. has regarded thoughtful action as a composition of the "knowledge (rote learning)", "comprehension", "application", "analysis" and "synthesis" in Bloom's taxonomy of educational objectives (Bloom et. al. 1956). To avoid addressing a wide range of responses in education in their measurement sub-scale, they have focused only on "comprehension" knowledge (Kember et. al., 2000). On this basis, they have described items in this level as measures of "understanding". For the specific purpose of this study, the present worker also narrowed the scope of this measurement sub-scale by focusing on the "application" objective. It is hoped that the arrangement will increase the uniqueness of the measurement sub-scale and this will facilitate the formulation of a reliable scale.

Nevertheless, Mezirow classified thoughtful action as "non-reflective" in his work in 1991 because he defined reflection as "validity testing". The idea was adopted by Kember et. al. (1999, 2000). In his later work, Mezirow (1998) refined the definition of reflection as "a turning back on experience", and it can be described as "simple awareness of an object, event or state, including awareness of a perception, thought, feeling, disposition, intention, action, or of one's habit of doing these things" and "letting one's thoughts wander over something, taking something into consideration, or imagining alternatives". It would imply that, according to his new definition of reflection, thoughtful action should have been classified as "reflective". In line with this, items in this level are regarded as measurement of reflection through thoughtful actions that are used to learn "application" knowledge, as in Bloom's taxonomy.

Level 2: Critical reflection

In a synthesis of researches addressing reflection, Atkins and Murphy (1993) suggested two other definitions that were consistent and supplementary to the definition of reflection proposed by Boud, Keogh & Walker (1985) and the work by Schon (1983) and Mezirow (1991). Here is the first definition:

> "reflective learning is the process of internally examining and exploring an issue of concern, triggered by an experience, which creates and clarifies meaning in terms of self, and which results in a changed conceptual perspective" (by Boyd & Fales, 1983).

The definition above is enriched by the second one, which states that:

> "reflection in the context of learning is a generic term for those intellectual and affective activities in which individuals engage to explore their experience in order to lead to new understandings and appreciations" (by Boud, Keogh & Walker, 1985).

The two definitions above indicate that reflection can be presented as a spectrum of activities, which includes mental exploration of experience, creation and clarification of personal meaning, internal examination of an issue of concern, the change in understandings, appreciations and even personal perspective. Although each of these activities incorporates a revisiting of experience, some of them also incorporate the meta-cognitive process of making an examination of what is being reflected upon. For Mezirow (1991, 1998), some reflection incorporates an assessment of the validity of the content, process of problem-solving or the validity of the premise of the problem, but some reflection does not. To make a distinction, he has used the term "critical reflection" to describe the former sub-type of reflection and the term "reflection" to describe the latter (Mezirow, 1998). He regards critical reflection as "principled thinking"; and ideally, "it is impartial, consistent, and non-arbitrary".

The terms "reflection" and "critical reflection" suggested by Mezirow in 1991 and adopted by Kember et. al. (1999, 2000) were inappropriate. Later, Mezirow (1998) clarified that these constructs were referring to "critical reflection" and "premise reflection". So, although items in this level are comparable to items in the "reflection" category in Kember et. al. (1999, 2000), the term "critical reflection" is used as the sub-heading here because it is an appropriate description of the measurement items at this level. Similarly, the two definitions of reflection (by Dewey, 1933 and Mezirow, 1991) are conceptually referring to the concept of "critical reflection" here. The refinement of terminology concerning reflection and the re-definition of "critical reflection" seems to be an advance for transformative learning theory, as they make Mezirow's conception of reflection compatible with definitions suggested in literature addressing reflective thinking and learning (e.g. Boud, Keogh & Walker, 1985; Atkins & Murphy, 1991; Kirby, 1988, Schon, 1983; Spark-Langer et. al., 1991). Mezirow's work in 1998 clearly clarified that some reflection can be classified as "critical reflection" if there is an "assessment of what is being reflected upon". In other words, critical reflection can be described as "reflection with assessment of what is being reflected upon", in which meta-cognition is involved. There are various types of critical reflection, but "critical reflection of an assumption" is a special type of critical reflection. This type of critical reflection will be classified as the next level, as discussed in the text below.

In relation to an updated version of Mezirow's idea (presented in 1998 and 1991), critical reflection can be sub-divided into "content reflection", "process reflection" and "premise reflection". The first one is reflection on what is perceived, thought, felt or acted upon (Mezirow, 1991, p.107) and the second one involves the examination of how one performs the functions of perceiving, thinking, feeling, or acting and an assessment of efficacy in performing them. The objects of various sub-types of critical reflection are different, too. The former focuses on the content of the problem and the latter focuses on the process of problem-solving. Items in this level refer to these two sub-types of critical reflection, and the mixture of both, which can be called "content and process reflection". Kember et. al. (1999) has made an attempt to construct questionnaire survey items to measure sub-scales of critical reflection. Their experience suggests that it was technically difficult or inappropriate because there were inter-relationships between the content of the problem and the process of problem solving. So, the content presented by items in this level is a mixture of both content and process reflection. Premise reflection is not included in this level because it is a special form of critical reflection, and it will be addressed later.

In relation to the knowledge structure (or cognitive structure) of the practitioner, learning through simple critical reflection (except critical reflection of an assumption or critical self-reflection of an assumption) results in the creation of a new meaning scheme or a change in pre-existing meaning schemes. The result is quite different from adding information onto pre-existing meaning schemes, as presented by items in the second level. Unlike simple critical reflection, learning through critical reflection of assumptions (i.e. premise reflection) or critical self-reflection of assumptions (i.e. premise self-reflection) results in the change in meaning perspective. So, items concerning premise self-reflection belong to level 3.

Level 3: Premise self-reflection

Mezirow thinks that many of our actions are performed according to a set of beliefs and values which one has taken for granted. For instance, Brookfield (1995) has identified three types of assumption as below:

1. causal assumptions - about how the world works and how it may be changed,
2. prescriptive assumptions - about what we think ought to be happening in a specific situation, and
3. paradigmatic assumptions - that structure the world into fundamental categories.

Assumptions or pre-suppositions often act as the "frame of reference" or "theory-in-use" for the thinking and actions carried out by an individual. In problem solving, assumptions or pre-suppositions are often regarded as "premises" because they act as the ground on which a problem is based. Mezirow thinks that a critical re-examination of assumptions or presuppositions is an essential process for the transformation of perspective. He named this special type of critical reflection "critical reflection of assumptions" (CRA) or "premise reflection", and he thinks that adults can perform critical reflection of an assumption of their own as well as those of others (Mezirow, 1998).

When the object of critical reflection is an assumption or pre-supposition on which one's own interpretation or definition of a problem is made, it functions as a special form of critical self-reflection that leads to a re-interpretation or re-definition of the problem. That is called "critical self-reflection of an assumption" (CSRA) by Mezirow (1998) and it is referred to "premise self-reflection" throughout this thesis. The ultimate outcome of premise self-reflection is the emancipation from any inappropriate premise on which the practitioner has defined or interpreted the problem. For education purposes, this thesis has greater interest in premise self-reflection than premise reflection because it involves the transformation or reconstruction of personal knowledge, rather than getting the problem solved by critical examination of an assumption of others.

Perspective transformation or redefinition of a problem is a difficult process and the occurrence is rare. It must involve a "hiatus" or "pause" in task-oriented problem solving to critically find faults embedded in the premise of the problem. By doing so, the practitioners of premise reflection (including premise self-reflection, as described below) become aware of why they perceive, think, feel or act as they do and their course of action is re-directed (Mezirow, 1991). In addition to the features of premise reflection described here, premise self-reflection also has a special impact on the problems encountered by practitioners. It leads to a re-definition or re-interpretation of the problem, which is the starting point for the formulation of a potential clue to solve the problem. Compared with items in other levels above, they are at the highest order of abstraction. As the research interest of this chapter is in the potential links between teacher reflection, pedagogy, perceived challenges, practice, learning and development concerning the use of ICT to support subject teaching and learning, transformation or reconstruction of personal knowledge is one of the topics of interest. This is why premise self-reflection is the focus of assessment made by items in this level.

To sum up, items in the four levels above are presented in a hierarchical model of reflection. If each of the measurement items is comprised of thinking and action, the descriptions in the four levels above indicate a well-ordered change in their composition. At one end, a very high proportion of action and a very low proportion of thinking represents the lowest level of reflection. At the other end, a very high proportion of thinking and a very low proportion of action represents the highest level of reflection. The identified relationship seems to be similar to the "opposing" relationship between the active experimentation learning orientation and the reflective observation learning orientation in experiential learning theory.

Research hypothesis

It was expected that the results of confirmatory factor analysis would demonstrate the goodness of fit of the four-factor model of reflection.

Sampling and data treatment

As mentioned in Chapter 4, the questions concerning teacher reflection were asked in a questionnaire sent to 197 practising primary teachers in 1998/99. The return rate was 59%. A total of 117 teachers made responses to this section, but 4 cases were dropped due to consistent omission in answering part of the questionnaire. For the formulation of structural equation models, the number of teachers who participated in this study seems to be small. Schumacker (1996) mentions that 100 to 150 subjects seems to be the minimum satisfactory sample size and Hoyle (1995) suggests that 250 seems to be the minimum sample size for stable results. And the requirement of having 10 to 20 subjects per variable seems to be the rule of thumb in many statistical analyses (Schumacker, 1996, p.20). As the sample size is small, special attention has been paid to the estimation of missing data so as to make the best of the available sample. For this reason the AMOS statistical package was used. The collected data was coded according to the numerical scale from 0 to 4. And responses for not possible or unsure about the answer were dropped from the analysis.

Data analysis

The data collected was first analysed by the EQS statistical computer software and finally by the AMOS software. The main reason for using EQS is that this application is particularly good at the estimation of parameter changes during the model re-specification stage as well as providing descriptive information about the model. And AMOS can make a unique contribution to the study by its feature of "full information estimation" of missing data. Arbuckle (1996a) demonstrated that the maximum likelihood estimation methods, as used in AMOS, could produce more accurate estimations than some other traditional missing data estimation methods, such as "listwise", "pairwise" and "imputation". This estimation method is also recommended by Schumacker (1996). The percentage of missing data of each level of the measurement scale is reported in Table T5-1-5. On average, the percentage of missing data was 2.7%. Although the percentage of missing data seems to be acceptably low, the relatively small sample size in this study requires a maximum use of the information from the collected data through careful estimation of missing values.

Table T5-1-5: Some basic statistics about each of the reflective thinking measures

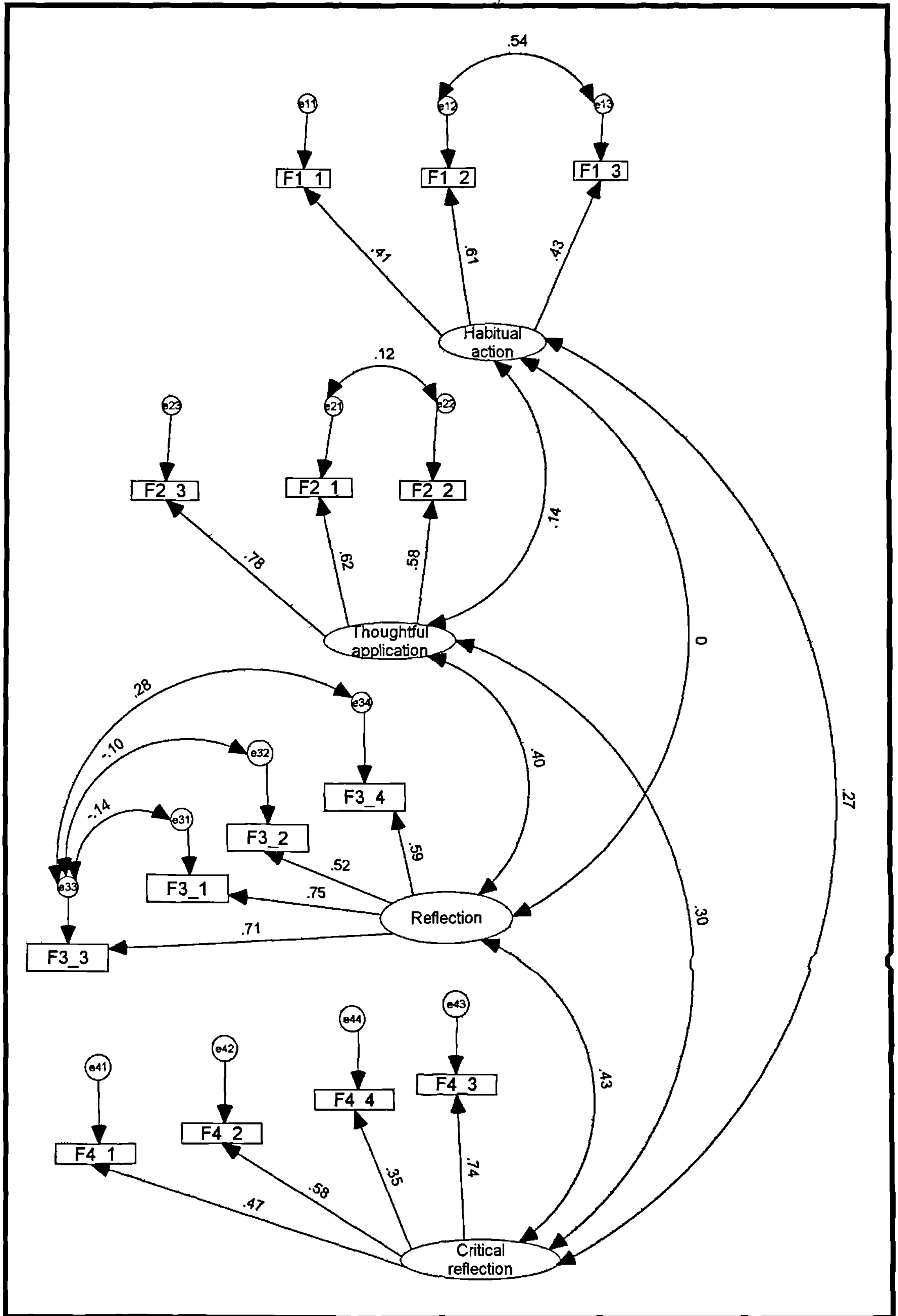
	Habitual action	**Knowledge application**	**Critical reflection**	**Premise self-reflection**
Missing data	1.8%	1.8%	1.55%	5.3%
Alpha	.63	.74	.73	.66
Mean (S.D.)	2.02 (.99)	3.10 (.71)	3.05 (.60)	1.75 (.92)

Keys: *S.D.* refers to the standard deviation of the mean.

Results and discussions

The results of the confirmatory factor analysis shows that it is appropriate to group the items into four levels, as suggested in Chapter 4 section 4-4-D2. Each factor is composed of three to four items, as literature suggests that at least three observed variables are needed for each latent variable (e.g. Schumacker, 1996). As there were missing data, the overall fit of the model was assessed by the difference between the function of log likelihood of the proposed model and that of the saturated model, as suggested by Arbuckle (1996b). The difference between the two represents a chi-equivalent index, which represents the statistical significant of the model. In this model, the chi-square statistic was found to be 73.78 with 67 degree of freedom. It means there is no indication that the model is inaccurate and the model should be confidently accepted at the 5% level of statistical significance (i.e. $p < .05$). And the four-factor structure model seems to be statistically accurate. In addition to this, the four-factor structure has been checked against the results of a scree plot, which suggests that it would not be appropriate to describe the model with less than four factors. The results give support to the proposed four-factor structure. When working together, the four factors can explain 61% of the total item variance.

Illustration I5-1F: A graphical presentation of the main results of confirmatory factor analysis



Remark: The content of the items and the statistics concerning its internal consistency are reported in Chapter 4 Table T4-B4-2 and Table T4-D4-2c.

A graphical presentation of the computations is reported in Illustration I5-1F above. One-way arrows on the figures are used to link the latent factor or predictor to its dependent item, while two-way arrows are used to show the covariance between two items or two factors. The composition and the standardised regression weighting of each of the items that contribute to the factor are presented. The covariance estimations are also presented. All the coefficient estimations are statistically significant at p < .05 level (two-tailed). That means each item of the scale is found to be a statistically significant indicator of the expected latent factor and all the coefficient estimations are statistically significant. The covariance matrix is presented in Table T5-1-6 below.

Table T5-1-6: The covariance between each of the items

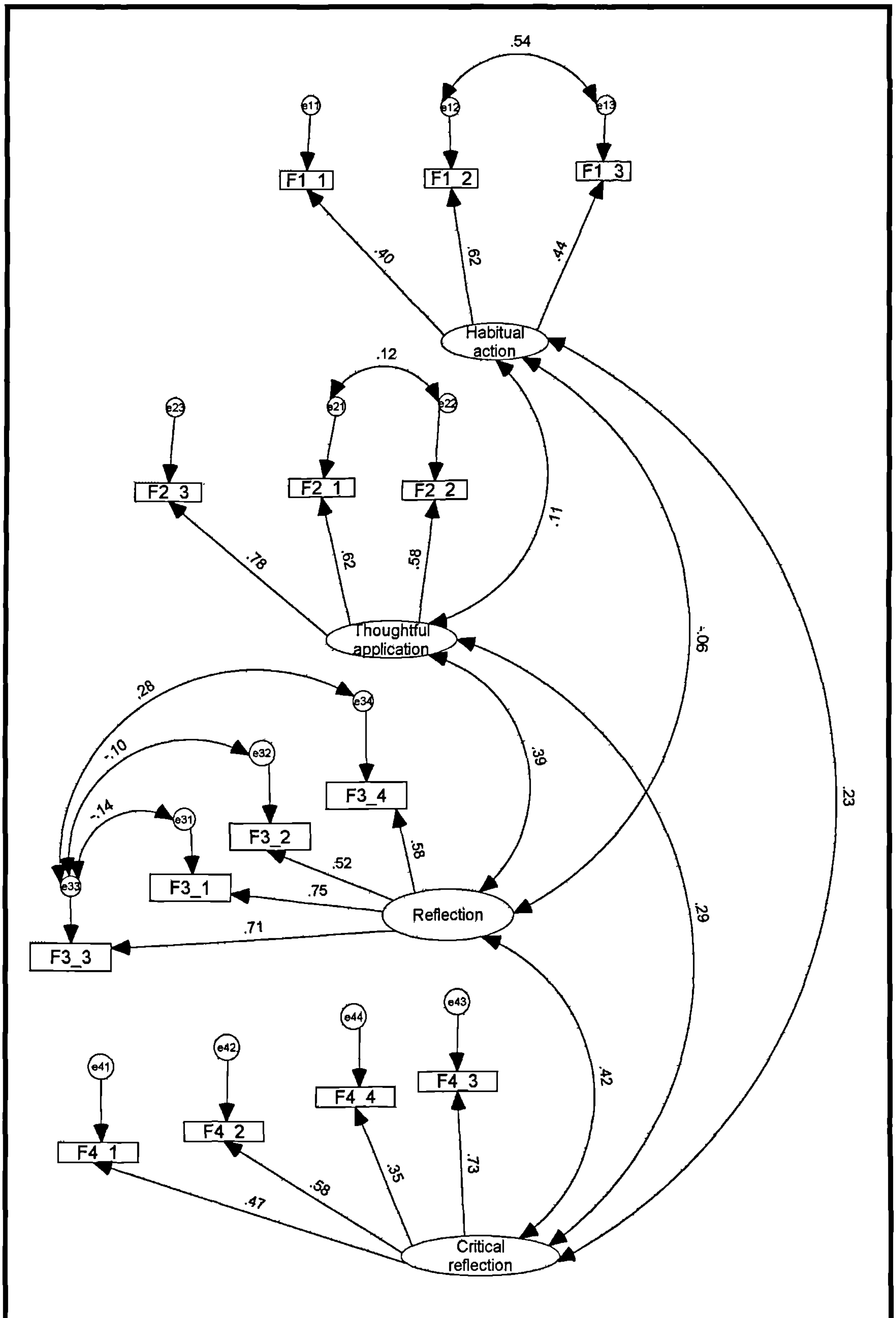
	F1_1	F1_2	F1_3	F2_1	F2_2	F2_3	F3_1	F3_2	F3_3	F3_4	F4_1	F4_2	F4_3	F4_4
F1_1	1.33													
F1_2	0.35	1.46												
F1_3	0.24	0.93	1.44											
F2_1	0.08	0.12	0.09	0.82										
F2_2	0.07	0.11	0.08	0.41	0.76									
F2_3	0.09	0.14	0.10	0.36	0.32	0.66								
F3_1	0.00	0.00	0.00	0.33	0.30	0.37	0.86							
F3_2	0.00	0.00	0.00	0.17	0.15	0.19	0.24	0.44						
F3_3	0.00	0.00	0.00	0.35	0.32	0.40	0.38	0.16	1.08					
F3_4	0.00	0.00	0.00	0.29	0.26	0.32	0.42	0.21	0.72	1.04				
F4_1	0.10	0.15	0.10	0.15	0.13	0.16	0.23	0.11	0.24	0.20	0.80			
F4_2	0.13	0.20	0.14	0.20	0.18	0.22	0.30	0.15	0.32	0.26	0.24	0.94		
F4_3	0.17	0.27	0.19	0.27	0.24	0.30	0.41	0.20	0.43	0.36	0.32	0.43	1.08	
F4_4	0.08	0.13	0.09	0.13	0.12	0.15	0.20	0.10	0.21	0.17	0.16	0.21	0.29	1.14

Remark: The content of the items and the statistics concerning its internal consistency are reported in Chapter 4 Table T4-B4-2 and Table T4-D4-2c.

Note that the correlation between habitual action and critical reflection has been fixed at zero. This follows from the assumption that habitual action is a form of low level thinking and it does not have direct relation with metacognitive level of problem solving, such as reviewing the content of the problem or process of problem-solving. The link between habitual action and premise self-reflection is an exception because the subject for critical self-reflection - an assumption, is the basic reference of habitual action. The significant correlation between habitual action and thoughtful application, and between habitual action and premise self-reflection is consistent with Schon's view about the nature of problems that professionals encounter, as in the literature review section - section 5-1-1-1-2. Simple problems or straightforward jobs can be addressed by the use of technical knowledge, usual procedures or technique. An experienced professional may act routinely or habitually and with very minimal attention, when repeatedly dealing with familiar problems of this level. Novice or student trainees, however, may need to make reference to learnt knowledge and experience for solutions. Some problems are complex or messy in nature, as mentioned by Schon (1983). They can't be solved simply by the application of technical knowledge, usual procedures or technique. Professionals may be able to see possible solutions or a new perspective when they have found the fault in taken for granted assumptions or suppositions. Premise self-reflection or critical self-reflection of an assumption has great potential for a change in perspective or direction for action as it affects the practitioner's established "frame of reference" or "theory-in-use".

The significant correlations between e31, e32, e33, e34 mean that there is an interweaving relationship between content reflection and process reflection, and they give support to the mixture of content and process reflection mentioned in Kember et. al. (1999). As the nature of the relationship appears to be complicated, it is sensible not to ignore the possibility that content or process reflection may make independent contributions to the latent factor. The present results also illustrate the technical difficulty of establishing further differentiation between content and process reflection.

Illustration I5-1G: A graphical presentation of the main results of confirmatory factor analysis of the alternative model (without restriction)



Remark: The content of the items and the statistics concerning its internal consistency are reported in Chapter 4 Table T4-B4-2 and Table T4-D4-2c.

The estimation appears to be consistent with the research results published by Kember et. al. (2000). In the covariance matrix of their model, covariance of the items of the two sub-scales are between -.12 and .11. To carry out further investigations of the appropriateness of the assumption that there was no relation between habitual action and critical reflection, an alternative model was formulated without imposing the restriction on the covariance between the two factors. The results are graphically summarised in Illustration I5-1G. All the coefficient estimations are statistically significant at $p < .05$ level, except the covariance estimation between habitual action and critical reflection and the covariance estimation between habitual action and thoughtful application. The chi-square statistic is 73.33 with 66 degree of freedom. And the four-factor structure model seems to be statistically accurate. The covariance matrix can be found in Table T5-D4-2e below. The covariance is found to be -.06 with a statistical significance value close to zero. The covariance estimates between items of the two sub-scales are also found to be close to zero, ranging between -0.02 and -0.06, as to be presented on the covariance matrix in Table T5-1-7 (covariance of each single item, without factors). As the size of all the covariance are close to zero, the assumption that there is no significant relationship between habitual action and critical reflection is supported by the data.

Table T5-1-7: The covariance between each of the items in the alternative model

	F1_1	F1_2	F1_3	F2_1	F2_2	F2_3	F3_1	F3_2	F3_3	F3_4	F4_1	F4_2	F4_3	F4_4
F1_1	1.33													
F1_2	0.35	1.46												
F1_3	0.24	0.93	1.44											
F2_1	0.06	0.10	0.07	0.82										
F2_2	0.05	0.09	0.06	0.40	0.75									
F2_3	0.07	0.11	0.07	0.35	0.32	0.65								
F3_1	-0.04	-0.06	-0.04	0.33	0.29	0.37	0.86							
F3_2	-0.02	-0.03	-0.02	0.16	0.15	0.18	0.24	0.44						
F3_3	-0.04	-0.06	-0.04	0.35	0.31	0.39	0.38	0.16	1.08					
F3_4	-0.03	-0.05	-0.03	0.28	0.25	0.31	0.42	0.21	0.72	1.04				
F4_1	0.08	0.13	0.09	0.14	0.13	0.16	0.22	0.11	0.23	0.19	0.79			
F4_2	0.11	0.17	0.12	0.19	0.17	0.21	0.29	0.15	0.31	0.25	0.23	0.93		
F4_3	0.15	0.23	0.16	0.26	0.23	0.29	0.40	0.20	0.42	0.34	0.31	0.42	1.06	
F4_4	0.07	0.12	0.08	0.13	0.11	0.14	0.20	0.10	0.21	0.17	0.15	0.21	0.28	1.14

Remark: The content of the items and the statistics concerning its internal consistency are reported in Chapter 4 Table T4-B4-2 and Table T4-D4-2c.

Lastly, it would be worthwhile to note that there are limitations in the proposed measurement scale and sub-scales. In particular, there are technical difficulties in measuring habitual action. The author of this thesis believed that the four levels of reflection are hierarchically structured. The occurrence of habitual action is the most frequent. However, the results of descriptive statistics reported in Chapter 4 Table T4-D4-2d indicated that the reported usage of habitual action was lower than expected. A possible explanation for this is the problem of consciousness, which can be a major reason for the discrepancy between actual usage and reported usage of habitual action. As habitual actions often occur sub-consciously, it is believed that the actual usage of habitual action is higher than the reported usage in this study. This makes it difficult to interpret the measurement construct. A high usage of habitual action reported in this thesis might mean a high awareness of usage of habitual action, which could be interpreted as a good performance at the baseline level of reflection. Having said that, the presence measurement scales cannot show or estimate the extent of difference between the actual usage and the reported usage of habitual action.

Reflective professional practice and reflective teaching practice

Reflection not only affects the teacher's practice, but also has a crucial role in the education and training of professionals. There is research evidence showing that the importance also applies to teacher training and teacher education. For example, reflection leads to teacher development (Colton & Sparks-Langer, 1993; Grimmett & Erickson, 1988; Atkins & Murphy, 1993) and it has links with effective teaching (Cooper & McIntyre, 1996; Kirby, 1988). Pollard (1997) has further elaborated reflective teaching in terms of daily classroom practices. The author of this thesis has prepared a summary of his key ideas of reflective teaching, as presented in Illustration I5-1H. To demonstrate the hierarchical structure of these ideas, they are later transferred into a concept map, as presented in Illustration I5-1I.

Illustration I5-1H: Ideas concerning reflective teaching practice defined by Pollard, 1997

Reflective teaching in the primary classroom

I. Knowing who we are as teachers and pupils.
  A. Knowing ourselves as teachers
    1. Examining our perceptions of 'pupils'
    2. Analysing ourselves
    3. Articulating values, aims and commitments
    4. Analysing ourselves as 'teachers'
  B. Knowing the children as pupils
    1. Children's views of themselves in school
    2. Children's view of teachers
    3. Understanding individual children
    4. The physical development of children
    5. Children's culture and their views of each other
II. Knowing how to support children's learning
  A. Learning processes
    1. Social constructivist models
    2. Behaviourist models
    3. Constructivist models
  B. Children and learning
    1. Motivation
    2. Personality and learning style
    3. Culture
    4. Intelligence
    5. Meta-cognition
III. Knowing how we are getting on tegether
  A. Classroom climate and interpersonal relationship
  B. Classroom rules and relationship
    1. Children's perspectives
    2. The working consensus
    3. Teacher's perspectives
  C. Enhancing classroom climate
    1. Developing children's confidence and self-esteem
    2. Developing an incorporative classroom
IV. Knowing the aims, structure and content of the curriculum
  A. Primary practice
    1. The basic and the 'other' curriculum
    2. An integrated curriculum?
    3. A subject-based curriculum?
  B. The structure and content of the curriculum
    1. Teacher's subject knowledge
    2. Learning and national curricula
    3. Structure of the educatisystem
    4. Development of national curricula
    5. Knowledge, curriculum and values
V. Knowing how to plan and implement the curriculum
  A. Lessons, activities and tasks
    1. School curriculum policies and schemes of work
    2. Developments in whole-school planning
  B. Selecting a classroom curriculum
    1. Cross-curricula issues
    2. Relevance
    3. Coherence
    4. Progression
    5. Selection and negotiation
    6. Breadth and balance
    7. Activity and experience
    8. Resources
    9. Values adn the hidden curriculum
  C. Whole school curricular planning
    1. Differentiation
    2. Planning and reviewing teaching sessions
    3. Analysing curriculum tasks
VI. Knowing how to organise the classroom
  A. Integrating the school day
    1. Organizational coherence
    2. Integration and organizational judgements
  B. Organizing the class and the classroom
    1. Records

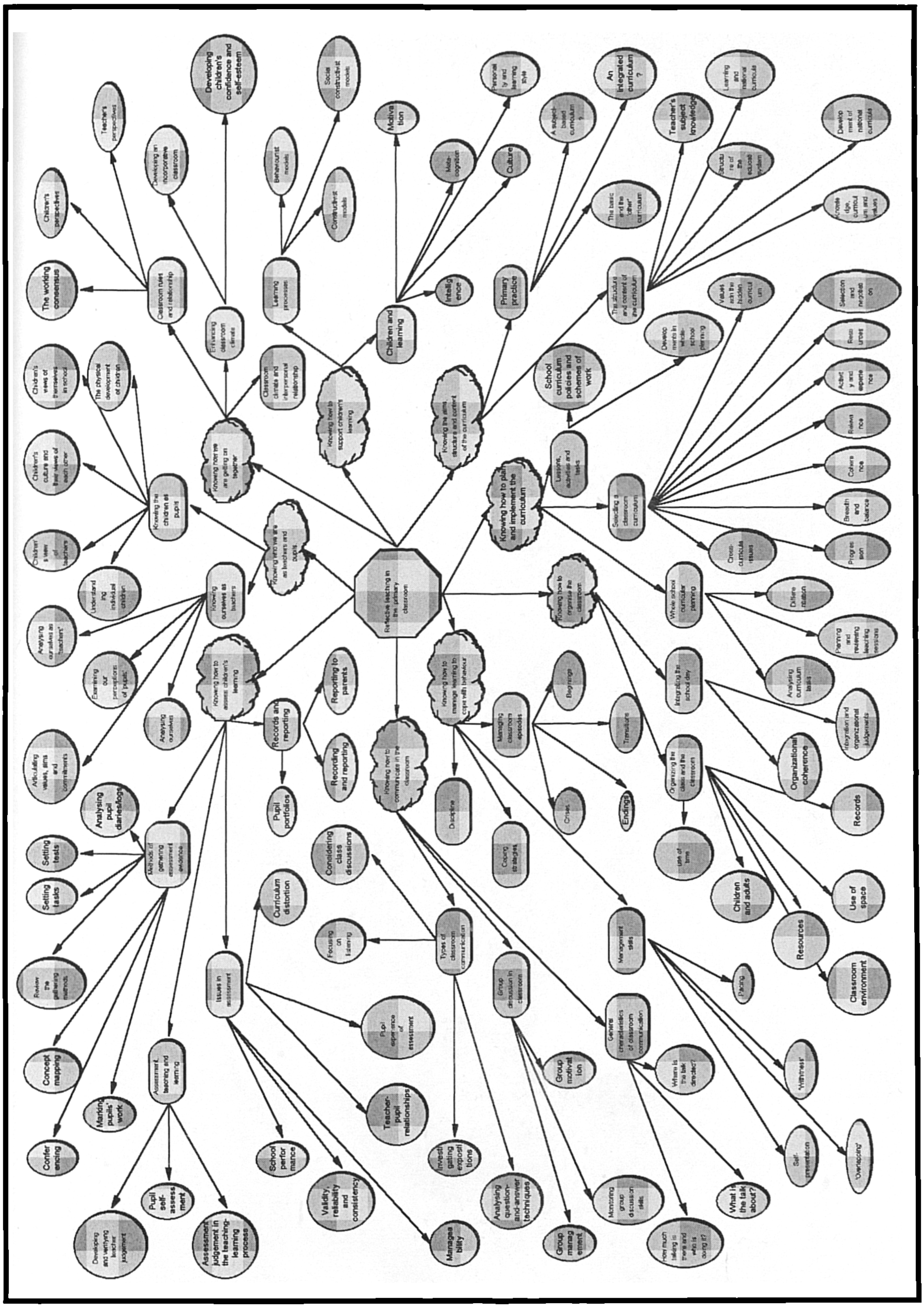
2. Resources
3. Use of space
4. Classroom environment
5. use of time
6. Children and adults

VII. Knowing how to manage learning to cope with behaviour
   A. Managing classroom episodes
      1. Beginings
      2. Transitions
      3. Crises
      4. Endings
   B. Discipline
   C. Coping strategies
   D. Management skills
      1. Pacing
      2. 'Withitness'
      3. 'Overlapping'
      4. Self-presentation

VIII. Knowing how to communicate in the classroom
   A. Group discussion in classroom
      1. Group management
      2. Monitoring group discussion skills
      3. Group motivation
   B. Types of classroom communication
      1. Focusing on listening
      2. Analysing question-and-answer techniques
      3. Investigating expostitions
      4. Considering class discussions
   C. General characteristics of classroom communication
      1. How much talking is there and who is doing it?
      2. What is the talk about?
      3. Where is the talk directed?

IX. Knowing how to assess children's learning
   A. Records and reporting
      1. Pupil portfolios
      2. Recording and reporting
      3. Reporting to parents
   B. Issues in assessment
      1. Pupil experience of assessment
      2. Curriculum distortion
      3. School performance
      4. Manageability
      5. Validity, reliability and consistency
      6. Teacher-pupil relationships
   C. Assessment, teaching and learning
      1. Pupil self-assessment
      2. Developing and verifying teacher judgement
      3. Assessment judgement in the teaching-learning process
   D. Methods of gathering assessment evidence
      1. Setting tests
      2. Setting tasks
      3. Conferencing
      4. Analysing pupil diaries/logs
      5. Marking pupils' work
      6. Concept mapping
      7. Review the gathering methods

Illustration I5-1I: A concept map presentation of reflective teaching practice defined by Pollard, 1997



Remark: Readers are advised to refer to Illustration I5-1H for the names and the structure of these concepts.

Pollard seems to have a pragmatic view of reflection. The work helps to define the scope of reflection in the primary classroom setting, which is particularly relevant to this thesis. But Pollard did not incorporate Kolb's and Mezirow's work on reflective thinking and learning as one of the recommended readings for teachers in the book that he edited (Pollard, 1996). If effective teaching can be achieved through the reflection in and on the pedagogical variables that Pollard has considered, then research is needed to draw attention to the reflective use of computers in the context of these variables. This gives support for linking the measures of reflection with some other pedagogical variables (e.g. refer to section 5-1-2-4, 5-2-3-3 and 5-2-4-3), as they have close alignment with the variables that Pollard (1997) has considered.

Further discussion about the scope of transformative learning theory

It is worthwhile to note that Mezirow regards his theory as applying to adult learning, rather than to the acquisition of basic or foundational knowledge. So far researchers are not sure about the extent of its validity when applying to education at primary education and secondary levels. Having said that, this thesis proposes that it is highly possible and necessary for children to learn from identifying misconceptions as well as through the process of redefining constructs. So, the transformative dimension of learning should not only apply to adults, but also to human being of all ages.

(5-1-1-3) The potential links between measures based on experiential learning theory (learning styles) and measures based on transformative learning theory (reflective thinking and practice): a correlational study

Kolb and Mezirow are similar in some ways because both of them emphasize the importance of "transformation" in learning. On the other hand, their definitions of reflection are reasonably different from each other. Therefore, it was decided to carry out a quantitative investigation into the relationships between the two major strands of reflection with data obtained from the administration of the two measuring instruments.

Research hypotheses

It is obvious that both experiential learning theory and transformative learning theory are concerned with knowledge transformation. This is the common theoretical ground for bridging the two theories. It was expected that:

- the measure of reflective observation learning orientation would be positively related to the critical reflection or premise self-reflection measures, and
- the measure of active and reflective learning orientation would be positively related to the critical reflection or premise self-reflection measure, and
- the measure of active experimentation would be positively related to the habitual action measure.

Table T5-1-8: The results of correlation statistics (two-tailed) concerning measures of learning style and measures of reflective thinking and practice

	Habitual action	Thoughtful application	Critical reflection	Premise self-reflection
Concrete experience (CE)	-.22 .06 74	-.07 .54 74	-.03 .77 74	-.02 .86 74
Reflective observation (RO)	.05 .70 74	.01 .94 74	-.11 .36 74	-.16 .18 74
Abstract conceptualisation (AC)	.19 .10 74	.11 .36 74	.15 .21 74	.10 .40 74
Active experimentation (AE)	-.05 .68 74	-.06 .62 74	-.01 .91 74	.06 .59 74
Abstract-concrete (AC - CE)	.25* .03 74	.11 .34 74	.12 .33 74	.08 .52 74
Active-reflective (AE - RO)	-.06 .63 74	-.04 .73 74	.05 .65 74	.13 .28 74
Abstract and concrete (AC + CE)	.01 .95 74	.05 .70 74	.11 .34 74	.08 .51 74
Active and reflective (AE + RO)	-.01 .95 74	-.05 .68 74	-.11 .35 74	-.08 .50 74

Remark: In each cell, the first statistic refers to correlation, the second one refers to statistical significance and the third one refers to the number of respondents. Refer to Table T5-1-3 and Chapter 4 Table T4-D4-2c for the internal consistency of each scale.

The results of correlation statistics concerning measures of learning style and reflection are reported in Table T5-1-8 above. Each of the measures of learning style is related to the four measures of reflective thinking and practice. None of the correlation statistics were found to be statistically significant. The only exception was the association between habitual action and the abstract-concrete learning orientation, with a Pearson correlation statistic (r) of 0.25, significant at $p < .05$ level and with $N = 74$. In relation to the research hypotheses above, none of the expected patterns of relationships was found to be statistically significant. So the present attempt to link the two theories does not seem to be successful. If the failure is not due to measurement error, the results seem to suggest that the scope and definitions of reflection and transformation were interpreted differently. In the experiential learning theory, reflective observation is a form of learning orientation. Being dialectically opposed to the active experimentation, it is a way of transforming perceived information in order to create personal knowledge. It is an approach that a person consistently employs to process the information that he or she has perceived. In transformative learning theory, reflection is a revisit of experience and critical reflection is an internal examination of the content of the problem, the process of problem solving or the premise of the problem. Transformation in perspective only happens when faults, invalidity or misinterpretation of assumption(s) are found (Mezirow, 1991). So, the two theories have different definitions toward the two concepts; although both of them think that internal mental processing, as dialectically opposed to observable actions, make contributions to the transformative dimension of learning.

(5-1-2) Teachers' personal judgement about the complexity of challenges concerning the use of ICT to support subject teaching, pedagogical preferences and their potential links with the measures of reflection

In Chapter 4 section 4-2-D2, we have discussed the theoretical background leading to the formulation of an instrument measuring teachers' pedagogical preferences.

Pedagogical preferences are determined by the teachers' beliefs, conceptions, personality (as personal constructs), practical judgements, instructional choice and polarities in teachers' thinking. In relation to the specific type of practical need, challenge or problem encountered, many teachers will have established a preference that affects their pedagogical decision. For example, in relation to the use of ICT, some teachers will have established a pedagogical preference that affects their decisions about using or not using ICT.

Apart from the specific pedagogical preference concerning the use (and "not use") of ICT mentioned above, there are other ways to illustrate that a pedagogy concerning the use of ICT has been formulated in some practising teachers. Teachers' personal judgement about the complexity of challenges concerning the use of ICT to support subject teaching, to be introduced in the section 5-1-2-1, is one of them. It could give us some idea about how problems concerning the use of ICT were defined by individual teachers. The sections below will also investigate the potential links between the two measures of pedagogy supported by ICT and the measures of reflection mentioned in section 5-1-1.

(5-1-2-1) Teachers' personal judgement about the complexity of challenges concerning the use of ICT to support subject teaching (i.e. all curriculum subjects except ICT)

In a teacher survey administered in Feburary 1999, teachers were asked about the perceived complexity of challenges concerning their own use of ICT to support subject teaching. The content of the two items was the same, except that they were referring to the teachers' perception in different academic years. The second item addressed their perception about the complexity of challenges concerning the use of ICT to support subject teaching when the survey was carried out in the fourth week of February, 1999, while the first item was based on retrospection of their perception about the complexity of challenges concerning the use of ICT to support subject teaching in the autumn term, 1997. The working of the two items is reported below:

Generally speaking, how did you perceive the challenge of using ICT to support subject teaching (i.e. all curriculum subjects except ICT): [Please tick the appropriate box]

IN AUTUMN 1997			
*It was **not** a problem to me at all*	*It was a problem, but it could be solved by **rational** application of educational knowledge and technique*	*It was a **complex** problem. Rational application of educational knowledge and technique was **not sufficient** to solve the problem*	*Not sure or impossible to give an answer e.g. not using ICT at all*

NOW			
*It is **not** a **problem** to me at all*	*It is a problem, but it can be solved by **rational** application of educational knowledge and technique*	*It is a **complex** problem. Rational application of educational knowledge and technique is **not sufficient** to solve the problem*	*Not sure or impossible to give an answer e.g. not using ICT at all*

Research hypotheses

A majority of the data sample in the second teacher survey was a repeat of the previous survey. Teachers had gained more experience in using ICT for subject teaching, from autumn term 1997 to Feburary 1999. It was expected that more teachers in the 1997/98 survey would think challenges concerning the use of ICT for subject teaching is a problem than in the 1998/99 survey.

Data analysis and discussion

Table T5-1-9: The percentage of valid responses to the survey items addressing teachers' personal judgement about the complexity of challenges concerning the use of ICT for subject teaching in 1997/98 and 1998/99

	It is not a problem to me at all	*It is a problem, but it can be solved by rational application of educational knowledge and technique*	*It is a complex problem. Rational application of educational knowledge and technique is not sufficient to solve the problem*
In autumn 1997	23.1%	52.3%	24.6%
In February 1999	33.8%	53.5%	12.7%

There were 73 teachers who responded to each of the two items. Among them, there were 8 teachers who made the response "not sure or impossible to give an answer" for the first item and there were 2 teachers who made the same response for the second. This might mean that teachers were more certain about their judgement about the complexity of challenges concerning their own use of ICT for subject teaching in academic year 1998/99 than in 1997/98. The results indicated that in both academic years, more than half of the teacher respondents thought that the use of ICT for subject teaching was a problem, but it could be solved by rational application of educational knowledge and techniques. The percentage of valid responses to the two survey items is reported in Table T5-1-9. It showed that a higher percentage of teacher respondents reported that it was not a problem in 1998/99 than in 1997/98 and a lower percentage of teacher respondents reported that it was a complex problem in 1998/98 than in 1997/98. If this is true, the results might imply that the teacher respondents were generally more confident or more experienced in tackling challenges concerning the use of ICT for subject teaching in 1998/99 than in 1997/98. A paired t-test was carried out to examine the validity of the identified pattern of relationship. It began by coding the response "it is not a problem to me at all" as "1", the response "it is a problem, but it can be solved by rational application of educational knowledge and technique" as "2" and the response "it is a complex problem...rational application of educational knowledge and technique is not sufficient to solve the problem" as "3". A significant difference was found between the mean of the first item and the mean of the second item, at $p < .01$ level with valid $N = 65$. The mean of the first item was 2.02 and the mean of the second item was 1.79. So, the identified pattern of relationship and the research hypothesis above were supported by the results of data analysis. Teachers' responses showed that there was a significant reduction in the complexity of challenges concerning their own use of ICT from 1997/98 to 1998/99.

To facilitate further investigation into the change in the perceived complexity of challenges concerning the use of ICT, teachers who made valid responses to both items were classified into four groups according to their personal changes. The classification procedure began by coding the responses of the two measures with the scheme above, and then working out the difference between the two responses made by the teacher. On the basis of the magnitude and the extent of changes from 1997/98 to 1998/98, teachers who made valid responses to both items were classified into four groups. Only 1 teacher indicated that the extent of reduction was 2, 16 teachers indicated that the extent of reduction was 1, 46 teachers indicated that the extent of change was 0, and 2 teachers indicated that the extent of increment was 1. The classification seems to be useful for further analysis, although the limitation is that the number of valid cases in some of the groups is small and that would affect the quality of measurement and the generalisation of findings.

(5-1-2-2) Five selected aspects of pedagogical preference: a factor analysis and inter-item correlation statistics concerning pro-ICT preference

As there are different types of practical need, challenge or problem encountered in their own practice situations, there are many aspects of pedagogical preference formulated by every individual teacher. A pedagogical preference found in one teacher may differ from that of another teacher. And due to the lack of thinking and experience, some aspects of pedagogical preference may not exist among some teachers. In the course of professional development and as a process of adaptation, the pedagogical preferences of a teacher are subject to change.

The present investigation into pedagogical preferences began in Chapter 4 section 4-2-D2 and section 4-4-D2 that described the formulation of a measuring instrument and it reported that five aspects of pedagogical preference were identified by internal consistency (alpha statistic) analysis. In this chapter, an exploratory factor analysis was carried out to confirm the existence of the five aspects of pedagogical preference among the 20 items selected for this thesis. This is followed by exploration of the potential links between pedagogical preferences and other issues concerning teacher learning and development and pupil learning outcomes.

Research hypothesis

It was expected that the results of factor analysis would show the existence of five aspects of pedagogical preference embedded in the data.

Data analysis and discussion

An exploratory factor analysis was carried out to confirm the five-factor structure of the 20 items. The major results are summarised in the rotated component matrix in Table T5-1-10. The "principal component analysis" extraction method and the "equamax" rotation method were used. The identity of the items and the content of the item are also reported in the table. All the factor scores above 0.4 are presented. The results clearly support the hypothesis that there are five aspects of pedagogical preference among these items. They explain 68.17% of the variance of the data.

Table T5-1-10: The major results of factor analysis concerning the five selected scales measuring teachers' pedagogical preferences

Item ID	Description of the item on the scale: Preferred A (to B)	1	2	3	4	5
C_11R	tasks with a computer (without a computer)			.716		
C_27R	ICT activities (activities without ICT)			.793		
C_33R	pupils using machines (without machines)		.491	.672		
C_61R	pupil using a calculator (without a calculator)			.623		
C_12R	pupil investigating (teacher instructing)		.673			
C_22R	children choosing (teacher directing)		.667			
C_28R	pupil making decisions (teacher...decisions)		.656			
C_32R	finding out (being taught)		.731			
C_02R	open activities (closed activities)					.760
C_20R	pupil problem solving (getting correct answers)					.425
C_42	tasks with several answers (with one answer)					.757
C_70	task which have multiple solutions (tasks which are right or wrong)					.709
C_03R	collaborative activities (individual activities)				.747	
C_16R	pupils interacting (pupils working on their own)		.494		.621	
C_29R	group activities (individual activities)				.680	
C_64R	social activities (individual activities)				.777	
C_04R	language tasks (maths tasks)	.815				
C_15	literacy (numeracy)	.830				
C_31R	English tasks (Maths tasks)	.909				
C_50	language tasks (number tasks)	.794				
C_50	language tasks (number tasks)	.794				

Remark: Further details about the measuring instrument and the internal consistency of the measurement scales can be found in Chapter 4 section 4-2-D2 and section 4-4-D2. All the items that ended with an "R" had a reverse in the direction of the scale before the factor analysis was carried out.

To sum up, the results of the component matrix indicate that there are five aspects of pedagogical preference among the items on the list. The results confirm the 5-factor structure of the items, as expected. As a clear factor structure has emerged, no further consideration of alternative factor structure (e.g. 4-factor or 6-factor structure) is made. These pedagogical preferences can be named as:

- pro-ICT preference (as opposed to anti-ICT preference),
- pupil control preference (as opposed to teacher control preference),
- open activities preference (as opposed to closed activities preference),
- collaborative work preference (as opposed to individual preference), and
- language teaching preference (as opposed to Maths teaching preference).

Further investigation of the potential links between pro-ICT preference and the other four aspects of pedagogical preference was carried out. It included four two-tailed correlation tests. It was also expected that pro-ICT preference would have a positive relationship with the other four pedagogical preferences, respectively. The results indicated that pro-ICT preference was:

- positively related to the pupil control preference at $p < .01$ level,
- positively related to the open activities preference at $p < .01$ level, and
- positively related to the collaborative work preference at $p < .01$ level.

The Pearson correlation statistics were 0.55, 0.56 and 0.52 with all N=75, respectively. By linking these results together, it might be sensible to suppose that teachers who preferred using computers were likely to be open-minded or emancipatory in their cognitive style. They were teachers who preferred pupils to take responsibility and control their own learning and they preferred open activities. With genuine enthusiasm in their teaching, they might be willing to prepare instructions for collaborative group work, rather than serving pupils at the "individual" level. In Sternberg's terms, teachers or educators of this kind are people with "legislative and judicial" thinking styles (i.e. people who like to create their own rules, to analyse and evaluate things and ideas) in the classroom, and they are most compatible with methods of instructions that enhance their pupils' analysis capability and creativity (Sternberg, 1997, chapter 2 and 7).

(5-1-2-3) Teachers' personal judgement about the complexity of challenges concerning the use of ICT to support subject teaching and the potential links with their pedagogical preferences: a correlational study

The sections above have introduced two measures of pedagogy supported by the use of ICT. It would be interesting to investigate the relationships between them. It would be quite straightforward to begin with the potential link between teachers' personal judgement about the complexity of challenges concerning the use of ICT and the pro-ICT preference. Teachers who regard challenges concerning the use of ICT as a sophisticated problem might have an anti-ICT preference. They could have encountered a lot of difficulties when using ICT to support subject teaching and they might lack confidence in using it. On the other hand, teachers who regard challenges concerning the use of ICT as a simple matter might have a pro-ICT preference. They could possess some techniques, strategies, skills or methods of using ICT to support subject teaching and they might have strong confidence in using it.

Furthermore, as the pedagogy concerning the use of ICT should not be regarded as an independent aspect of the teachers' pedagogy, we should not rule out the possibility of the presence of links between teachers' personal judgement about the complexity of challenges concerning the use of ICT and each of the other four pedagogical preferences. Teachers who regard challenges concerning the use of ICT as a sophisticated problem might try to avoid various types of problem associated with the use of ICT. In relation to the results of section 5-1-2-2, teachers who have negative attitudes towards the use of ICT might also have a preference for a teacher-controlled style of practice, a preference for closed activities, or a preference for individual work, or vice versa. Compared with teachers who prefer teaching maths, generally speaking, teachers who prefer teaching language might not be good at technical knowledge or computer skills. It might be difficult for a teacher who is not good at or keen on computers to teach pupils the IT skills required for the use of computers.

Research hypotheses

It was expected that teachers' personal judgement about the complexity of challenges concerning the use of ICT to support subject teaching would be:

- negatively related to pro-ICT preference,
- negatively related to pupil control preference,
- negatively related to open activities preference,
- negatively related to collaborative work preference, and
- positively related to language teaching preference.

Data analysis

The hypotheses above were investigated through the use of one-tailed correlation tests. Among the five research hypotheses above, the results only supported that the teachers' personal judgement about the complexity of challenges concerning the use of ICT to support subject teaching in 1997/98 was:

- negatively related to pro-ICT preference, at $p < .01$ level with N=37,
- negatively related to open activities preference, at $p < .05$ level with N=37, and
- positively related to language preference, at $p < .05$ level with N=37.

The Pearson correlation statistics (r) were -0.37, -0.36 and 0.29, respectively. Furthermore, teachers' personal judgement about the complexity of challenges concerning the use of ICT to support subject teaching in 1998/99 was positively related to language preference, at $p < .01$ level with N=41. The Pearson correlation statistic (r) was 0.37. The results support the fifth research hypothesis above.

In line with this finding, a significant negative correlation was found between the measure of language teaching preference and the use of ICT to support the development of pupils' IT skills at $p < .05$ level (one-tailed). The Pearson correlation statistics (r) was -0.21. The results suggest that teachers who prefer teaching language, as a contrast to teachers who prefer teaching Maths, are not good at developing the IT skills of their pupils. It could be a possible explanation for viewing the use of ICT to support subject teaching and learning as a sophisticated task for a language teacher.

No other significant correlation was found at $p < .05$ level. So, the results provide some support for the first and the third hypotheses mentioned above. The findings also raise the query about why most of the significant correlational relationships found are between teachers' pedagogical preferences and the retrospective measure of their judgement about the complexity of challenges concerning their own use of ICT in 1997/98, rather with the current measure of their judgement in 1998/99. If it is not a result of measurement error, one possible explanation is that pedagogical preference was affected by their prior judgement about the complexity of challenges concerning the use of ICT to support subject teaching. To respond to the change in adjustment, adjustments in one or more than one aspect of pedagogical preference are needed. This might be the cause for a time lag between the change in judgement and the change in pedagogical preferences.

(5-1-2-4) The potential links between the teachers' personal judgement about the complexity of challenges concerning the use of ICT to support subject teaching and reflection measures (based on the two learning theories): a correlational study

Teachers' personal judgement about the complexity of challenges concerning the use of ICT could be affected by the way they perceive those challenges. When dealing with the same problem associated with the use of ICT, a teacher who is highly dependent on the abstract conceptualisation learning orientation could have a different judgement about the complexity of the problem than another teacher who is not highly dependent on that orientation. Furthermore, the two learning theories above infer that reflection plays a role in the transformation of teachers' knowledge, attitudes, belief and perspectives. It is possible that there are links between the two reflection measures (based on the two learning theories) and the teachers' personal judgement about the nature of problems associated with the use of ICT to support subject teaching. The paragraphs below will report a statistical investigation of these potential links in a correlational study.

This is followed by an investigation of the role of critical reflection and premise reflection on the change in judgement about the complexity of challenges concerning the use of ICT to support subject teaching and learning. A change in personal judgement about the complexity of challenges concerning the use of ICT could result from an examination of the content of the challenges or of the process of making judgement. Furthermore, a change in judgement could also result from the redefinition of the ground for making judgements, which might take place when an error embedded in the teacher's assumption or premise is found.

Research hypotheses

Teachers who depend highly on the reflective observation learning orientation are expected to be patient, objective, and careful in making judgements. These personal characteristics may help them in interpreting the nature of challenges concerning the use of ICT and reducing the perceived complexity. And teachers who depend highly on critical reflection or premise self-reflection will tend to develop different interpretations or redefine the problems they meet in the classroom. In relation to the complexity of challenges concerning the use of ICT to support subject teaching, it was expected that:

- the abstract conceptualisation learning orientation would be negatively related to the measures of the complexity of challenges concerning the use of ICT to support subject teaching in section 5-1-2-1 above,
- the reflective observation learning orientation would be negatively related to the measures of the complexity of challenges concerning the use of ICT to support subject teaching in section 5-1-2-1 above,
- the critical reflection measure would be negatively related to the measures of the complexity of challenges concerning the use of ICT, and
- the premise self-reflection measure would be negatively related to the measures of the complexity of challenges concerning the use of ICT.

It was also expected that the four groups of teachers with different changes in personal judgement about the complexity of challenges concerning the use of ICT between 1998/99 and 1997/98 (as mentioned in section 5-1-2-1 above) would have different:

- extent of usage of critical reflection, and
- extent of usage of premise self-reflection.

Data analysis and discussion

The results indicated that no significant associations between the abstract conceptualisation measure and the measures of the complexity of challenges concerning the use of ICT to support subject teaching in 1997/98 and 1998/99 at $p < .05$ level with $N=65$ and 71 (two-tailed), respectively. The Pearson correlation statistics (r) were 0.00 and -0.01, respectively. And the results indicated that no significant associations were found between the reflective observation measure and the measures of the complexity of challenges concerning the use of ICT to support subject teaching in 1997/98 and 1998/99 at $p < .05$ level with N=65 and 71 (two-tailed), respectively. The Pearson correlation statistics (r) were -0.07 and -0.01, respectively. So, the first and the second hypotheses above are not supported by the results of data analysis.

No significant associations were found between the critical reflection measure and the measures of the complexity of challenges concerning the use of ICT to support subject teaching in 1997/98 and 1998/99 at $p < .05$ level with N=65 and 71 (two-tailed), respectively. The Pearson correlation statistics (r) were -0.11 and -0.08, respectively. So, the third hypothesis above is not supported by the results of data analysis. Similarly, no significant associations were found between the premise self-reflection measure and the measures of the complexity of challenges concerning the use of ICT to support subject teaching in 1997/98 and 1998/99 at $p < .05$ level with N=65 and 71 (two-tailed), respectively. The Pearson correlation statistics (r) were -0.04 and 0.09, respectively. So, the fourth hypothesis above is not supported by the results of data analysis.

The fifth and the sixth research hypotheses were investigated through two one-way ANOVAs. In each of the tests, the independent variable was formulated by the four groups of teachers with different changes in personal judgement about the complexity of challenges concerning the use of ICT between 1998/99 and 1997/98, as suggested in section 5-1-2-1. The dependent variable was the critical reflection measure or the premise reflection measure. The results showed that there was a significant difference in the use of critical reflection between the four groups of teachers at $p < .05$ level with N=65 (two-tailed). The mean statistics were 4.00, 2.52, 2.91 and 2.13 (see section 5-1-1-2-2 for the coding scheme). No significant differences in the use of premise self-reflection were found between the four groups of teachers at $p < .05$ level with N=65 (two-tailed). So, the results of data analysis support the fifth research hypothesis above, but the results do not support the sixth research hypothesis above.

The significant findings suggest that the extent of usage of critical reflection seems to be different between the four groups of teachers, but the result do not identify which mean differs from another. To investigate this, post-hoc pairwise multiple comparisons were carried out. The comparisons were done with three groups of teachers because there is only one teacher in the last group and the small number of individuals in the group is a threat to the reliability of the finding. No significant findings were found at $p < .05$ level. The results failed to give a clear indication of the presence of a linear relationship between the use of critical reflection and the change in personal judgement about the complexity of challenges concerning the use of ICT between 1998/99 and 1997/98. So, the significant findings cannot tell us whether a reduction in complexity would be associated with a greater usage of critical reflection or a smaller usage of critical reflection, although the finding suggests that the extent of usage of critical reflection seems to be different between teachers with different extent of changes in personal judgement about the complexity of challenges concerning the use of ICT. As the results are not convincingly clear, further investigation will be needed to confirm the finding.

(5-1-2-5) The potential links between the teachers' pedagogical preferences and reflection measures (based on the two learning theories): a correlational study

In section 5-1-2-2 above, we have talked about the speculation that teachers who preferred using computers would probably be teachers who were open-minded or emancipatory in their cognitive style. They were teachers who preferred pupils to take responsibility and control their own learning and they preferred open activities. The open-minded or emancipatory approach may link with the characteristics of reflective teachers described in section 5-1-2-4 above. They are patient, objective, careful in making judgements, and they like to develop different interpretations or redefinition of the problems they meet in the classroom. Upon speculation, the sense of scientific and evidence-based judgement might appear as a personal preference for logic and maths and for teaching of maths and science.

Research hypotheses

In relation to the discussion above, the five aspects of pedagogical preference were used for this study. These include: the pro-ICT preference, the pupil control preference, the open activities preference, the collaborative work preference and the maths teaching preference. It was expected that each of the five aspects of pedagogical preference would be:

- related to the reflective observation measure (introduced in section 5-1-1-2-1),
- related to the critical reflection measure (introduced in section 5-1-1-2-2), and

- related to the premise self-reflection measure (introduced in section 5-1-1-2-2).

Data analysis and discussion

A correlation analysis was carried out to investigate the relationships between each of the pedagogical preference mentioned in section 5-1-2-2 above and each of the first four learning orientation measures in Table T5-1-3. The only significant correlation found was between the active experimentation learning orientation and the language teaching preference, at $p < .05$ level with N=72 (two-tailed). The Pearson correlation statistic was 0.38. The results indicate that the first research hypothesis above is not supported.

Another set of correlation tests was carried out to investigate the relationships between each of the pedagogical preferences mentioned in section 5-1-2-2 above and each of the first four reflective thinking and practice measures. The results indicated that there were significant correlations (at $p < .05$ level with N=69,69,68 and 68) between:

- habitual action and the preference for collaborative work (negative),
- critical reflection and the preference for open activities (positive),
- premise self-reflection and the preference for open activities (positive), and
- premise self-reflection and the preference for pupil control activities (positive).

The Pearson correlation statistics were -0.25, 0.26, 0.29 and 0.30, respectively. No significant relationships were found between other reflection sub-scales and other measures of pedagogical preference at $p < .05$ level. The results above indicate that teachers who perform their job as a routine or habit tend to prefer individual work in their teaching. It might mean that they are not aware of the need to or less willing to spend their time and effort to prepare and review their own teaching using collaborative work. On the other hand, reflective teachers and critically reflective teachers tend to prefer open activities and pupil-controlled activities. It might mean that they are more open-minded, as a result of self-evaluation and self-assessment. Generally speaking, the results seem to support the second and the third research hypotheses above.

(5-1-3) The potential influences of teachers' learning orientations, their reflective thinking and practice, their personal judgement about the perceived complexity of challenges concerning the use of ICT, and their pedagogical preferences concerning the effectiveness of teaching and learning

Section 5-1-2-4 was concerned with the role of reflection in the transformation of perceived information or personal perspectives, attitudes or belief systems. Readers need to bear in mind that the impact of reflection is not restricted to personal development, but it can affect practice and actions. So, section 5-1-3-1 and section 5-1-3-2 below will be concerned with the potential links between teachers' learning orientations and pupil learning outcomes as well as the potential links between reflective thinking and practice, and pupil learning outcomes. This will be followed by investigation of the potential links between pupil learning outcomes and two measures concerning teachers' pedagogy, including teachers' personal judgement about the complexity of challenges concerning the use of ICT to support subject teaching and their pedagogical preferences. The results of correlational studies below are not sufficient to demonstrate cause-and-effect relationships through statistical analyses. It was hoped that the results could give a better picture about the potential impact of pedagogy as well as the potential impact of teacher reflection on the effectiveness of teaching and learning. Various measures of pupil learning outcomes discussed in Chapter 2 were used as indicators of teaching and learning effectiveness.

(5-1-3-1) Teachers' learning orientation and their potential impact on pupil learning outcomes: a correlational study

Kolb had made an attempt to analyse the learning orientations of university students in different departments. He stated that the demands of the education profession requires trainees who depend on the abstract conceptualisation learning orientation and the reflective observation learning orientation, as dialectically opposed to the concrete experience learning orientation and the active experimentation learning orientation (Kolb, 1984, page 174). Trainees who met the demands of the profession were likely to be successful in their careers in the profession. On the other hand, the demands of the teaching profession are changing everyday. It is doubtful whether the preference in learning orientation reported in section 5-1-1-2-1 still remains in the teaching profession today. An updated investigation into these issues and learning outcomes is needed.

Research hypotheses

In relation to Kolb's ideas about the characteristics of the teaching profession, it was expected that:

- the measure of "concrete experience" (CE) learning orientation would be negatively related to the learning outcome measures above,
- the measure of "active experimentation" (AE) learning orientation would be negatively related to the learning outcome measures above,
- the measures of "reflective observation" (RO) learning orientation would be positively related to the learning outcome measures above, and
- the measures of "abstract conceptualisation" (AC) learning orientation would be positively related to the learning outcome measures above.

In relation to the conceptions and interpretations of adaptive competence in section 5-1-1-2-1 above, it was expected that:

- the difference between abstract conceptualisation and concrete experience (AC-CE) learning orientation would be related to the learning outcome measures above,
- the difference between abstract experimentation and reflective observation (AE-RO) learning orientation would be negatively related to the learning outcome measures above,
- the sum of abstract conceptualisation and concrete experience (AC+CE) learning orientation would be positively related to the learning outcome measures above, and

- the sum of abstract experimentation and reflective observation (AE+RO) learning orientation would be positively related to the learning outcome measures above.

Data analysis and discussion

Table T5-1-11: The results of correlation statistics (one-tailed) concerning measures of learning style and pupil learning outcomes

	CE	RO	AC	AE	AC-CE	AE-RO	AC+CE	AE+RO
T_O_ZMA	-.32* .03 36	.27 .06 36	-.03 .44 36	.07 .34 36	.16 .18 36	-.14 .21 36	-.32* .03 36	.33* .02 36
T_O_ZRE	-.40* .01 36	.35* .02 36	.04 .42 36	-.03 .43 36	.24 .08 36	-.24 .08 36	-.32* .03 36	.33* .02 36
T_O_ZAA	-.38* .01 36	.33* .03 36	.01 .49 36	.02 .46 36	.21 .11 36	-.20 .12 36	-.34* .02 36	.35* .02 36
T_R_VOMA	-.16 .18 36	.21 .11 36	-.12 .24 36	.08 .33 36	.01 .48 36	-.10 .30 36	-.27 .06 36	.28 .05 36
T_R_VORE	-.30* .04 36	.38* .01 36	-.04 .42 36	-.09 .31 36	.14 .21 36	-.29* .04 36	-.31* .03 36	.31* .03 36
T_R_VOAA	-.26 .07 36	.32* .03 36	-.09 .31 36	-.01 .49 36	.09 .31 36	-.22 .10 36	-.33* .03 36	.33* .03 36

Remark: In each cell, the first statistic refers to correlation, the second one refers to statistical significance and the third one refers to the number of respondents. Refer to Table T5-1-3 for internal consistency of each scale. Only six measures of learning outcomes were used here because the number of valid cases for other correlation statistics were small with N < 20.

Keys: ***CE*** refers to concrete experience, ***RO*** refers to reflective observation, ***AC*** refers to abstract conceptualisation, ***AE*** refers to active experimentation, ***AC-CE*** refers to the difference between abstract conceptualisation and concrete experience, ***AE-RO*** refers to the difference between active experimentation and reflective observation, ***AC+CE*** refers to the sum of abstract conceptualisation and concrete experience, ***AE+RO*** refers to the sum of active experimentation and reflective observation. ***T_O_ZMA*** refers to maths attainment in T-score in 97/98, ***T_O_ZRE*** refers toreading attainment in T-score in 97/98, ***T_O_ZAA*** refers to averaged maths and reading attainments in 97/98, ***T_R_VOMA*** refers to maths value-added in 97/98, ***T_R_VORE*** refers to reading value-added in 97/98, ***T_R_VOAA*** refers to averaged maths and reading value-added in 97/98.

The results of correlation statistics concerning measures of learning style and pupil learning outcomes are reported in Table T5-1-11 above. Due to the limited number of valid cases, only six measures of pupil learning outcome were used. Two sets of correlation statistics were found to be impressive, at $p < .05$ level. These include the negative correlation between concrete experience learning orientation and the measures of:

- maths attainment in 1997/98,
- reading attainment in 1997/98,
- averaged maths and reading attainments in 1997/98, and
- reading gains in 1997/98.

The Pearson correlation statistics were -0.32, -0.40, -0.38 and -0.30, respectively. This might mean that teachers who are used to learning intuitively from specific experiences and are sensitive to feelings and people, as opposed to systematic thinking, are not good at raising the academic attainment and progress of their pupils. With concerns and flexible responses to the present reality, they might be teachers who can establish a good relationship with their pupils and they might be good at dealing with immediate human situations in a personal way. However, with reference to the characteristics described in section 5-1-1-1-1, their "intuitive" or "artistic" perception style is also one of their major weaknesses in their own learning and development. The knowledge and experience that they acquire in the classroom may not be systematic. It may hinder the generalisation and development of a personal theory of education and the formulation of long-term educational goals. Although the pupils may be emotionally happy with their classroom experience, their potential in academic learning may not be fully exploited. When too many concessions are made to the difficulties or limitations of the reality or when too much freedom is given to pupils, it may have negative impacts on academic learning outcomes.

The results also indicated that the reflective observation learning orientation was positively related to the measures of:

- reading attainment in 1997/98,
- averaged maths and reading attainments in 97/98,
- reading gains in 1997/98, and
- averaged maths and reading gains in 1997/98.

The results above indicate that the reflective observation learning orientation is positively related to pupils' reading attainments and reading gains. Significant positive correlational relationships are also found between learning outcome measures and the active and reflective learning orientation (AE+RO), however, they are debatable and have to be treated with extra care. For example, the size of Pearson correlation statistic between reflective observation learning orientation and reading attainment is 0.35, and the size of Pearson correlation statistic between the active and reflective learning orientation and reading attainment is 0.33. The size of Pearson correlation statistic between reflective observation learning orientation and reading gain is 0.38, and the size of Pearson correlation statistic between the active and reflective learning orientation and reading gain is 0.31. As the size of association between the two sets of measures is more or less the same, it is possible that the latter set of findings (i.e. the relationships between active and reflective learning orientation and learning attainments/gains) is a resemblance of the relationships reported by the former set of findings (i.e. the relationships between reflective observation learning orientation and learning attainments/gains). It suggests that there are reservations about the unique contribution of the second set of findings. Similarly, the significant correlational relationships between learning outcome measures and the abstract and concrete learning orientation (AC+CE) seem to be a resemblance of the relationships between learning outcome measures and the concrete experience learning orientation (CE). There are reservations about the unique contribution of the set of findings.

To examine the resemblance of relationships, three sets of partial correlation tests were performed. They examine the correlation between each of the six outcome variables and:

- the difference between active experimentation and reflective observation learning orientation (AE-RO), with control for reflective observation learning orientation,
- the abstract and concrete learning orientation (AC+CE), with control for concrete experience learning orientation, and
- the abstract reflective learning orientation (AE+RO), with control for reflective observation orientation, respectively.

Table T5-1-12: The results of partial correlation statistics (two-tailed) concerning some measures of learning style and pupil learning outcomes

		AE-RO	AC+CE	AE+RO
	Control for:	**RO**	**CE**	**RO**
T_O_ZMA	correlation (r) sig. (p) sample size (N)	.16 .36 33	-.21 .23 33	.24 .16 33
T_O_ZRE	correlation (r) sig. (p) sample size (N)	.09 .60 33	-.17 .32 33	.20 .25 33
T_O_ZAA	correlation (r) sig. (p) sample size (N)	.13 .45 33	-.20 .25 33	.23 .18 33
T_R_VOMA	correlation (r) sig. (p) sample size (N)	.14 .41 33	-.22 .19 33	.21 .24 33
T_R_VORE	correlation (r) sig. (p) sample size (N)	.05 .80 33	-.21 .24 33	.16 .35 33
T_R_VOAA	correlation (r) sig. (p) sample size (N)	.11 .54 33	-.24 .16 33	.21 .23 33

The results are presented in Table T5-1-12. No significant results was found in the three sets of partial correlation tests, at $p < .05$ level with N=33 (two-tailed). This suggests that the significant findings in the last three column of Table T5-1-11 do not remain when the respective variables are under control. In other words, these significant findings were effects of resemblance, as discussed above. In relation to the experiential learning theory, the results demonstrate that there is no relation between the newly generated composite variables concerning adaptive competence and learning outcomes, when the respective variables are taken into account. The impact of adaptive competence on learning is not supported by the results of data analysis.

The results suggest that teachers who were good at understanding ideas and situations from different points of view tend to produce high reading attainment and reading gains. They were the group of teachers who rely on patience, objectivity, and careful judgement but might not necessarily take any action. They like to look for meanings of things and they rely on their own thoughts and feelings to form opinions. This is matched with the rationale of teaching literacy, which goes beyond the teaching of skills for the comprehension of scripts and incorporates the teaching of value judgements, culture and the understanding of the characteristics of the people living in a society.

Lastly, the results in Table T5-1-11 show that the number of significant correlations between learning outcomes and the measures of adaptive competence in terms of the relative differences between the two dialectically opposed orientations of a specific dimension of learning (i.e. AC-CE or AE-RO) are smaller than the number of significant correlations between learning outcomes and the measures of adaptive competence in terms of the aggregation of the two dialectically opposed orientations of a specific dimension of learning (i.e. AC+CE or AE+RO). This might be explained by the weaknesses of the first set of measures, as originally proposed in Kolb's LSI-1985 inventory. On the contrary, the results give indirect support to the need for constructing the two aggregated measures, as supplementary measures of adaptive competence, as mentioned in section 5-1-1-2-1.

(5-1-3-2) Teachers' reflective thinking and practice, and their potential impacts on pupil learning outcomes: a correlational study

There is literature suggesting a positive relationships between reflection and the effectiveness of teaching (e.g. Cooper & McIntyre, 1996; Kirby, 1988; Pollard, 1997). So, it would be interesting to examine if the pattern of relationship exists in the present data.

Research hypotheses

It was expected that:

- the extent of use of habitual action would be negatively related to various learning outcome measures, as mentioned in chapter 4 section 4-1,
- the extent of use of thoughtful application would be positively related to the learning outcome measures above,
- the extent of use of critical reflection would be positively related to the learning outcome measures above,
- the extent of use of premise self-reflection would be positively related to the learning outcome measures above, and
- the extent of use of reflection (i.e. including thoughtful application, critical reflection and premise self-reflection) would be positively related to the learning outcome measures above.

Table T5-1-13: The results of correlation statistics (one-tailed) concerning measures of learning outcome and reflective thinking and practice

	Habitual action	Thoughtful application	Critical reflection	Premise self-reflection
T_O_ZMA	-.20 .06 62	.13 .15 63	.06 .31 63	.01 .47 61
T_O_ZRE	.07 .31 62	.14 .13 63	.03 .40 63	.00 .50 61
T_O_ZAA	-.07 .30 62	.15 .13 63	.05 .35 63	.01 .48 61
T_R_VOMA	-.19 .07 62	.00 .50 63	.05 .36 63	.02 .44 61
T_R_VORE	.23* .04 62	.01 .48 63	.02 .45 63	.04 .38 61
T_R_VOAA	.01 .47 62	.00 .49 63	.04 .39 63	.03 .40 61
T_O_ZPP	.07 .35 32	.19 .15 33	.05 .39 33	.24 .09 31
T_O_ZPV	.10 .30 32	.30* .05 33	.23 .10 33	.32* .04 31
T_O_ZWE	.11 .28 32	.28 .06 33	.19 .15 33	.33* .04 31
T_AT_MA	-.02 .46 32	-.03 .44 33	-.03 .43 33	-.02 .45 31
T_AT_RE	.19 .15 32	.12 .26 33	.34* .03 33	.11 .27 31
T_AT_SH	-.13 .16 63	-.06 .31 64	-.01 .47 64	.08 .28 62

U_O_ZMA	-.14 .24 27	.30 .06 27	.19 .17 27	-.06 .39 27
U_O_ZRE	-.03 .44 27	.35* .04 27	.14 .24 27	-.28 .08 27
U_O_ZAA	-.09 .33 27	.34* .04 27	.17 .19 27	-.18 .19 27
U_R_VOMA	-.10 .31 27	.21 .14 27	.31 .06 27	.14 .24 27
U_R_VORE	.05 .41 27	.25 .11 27	.22 .14 27	-.16 .22 27
U_R_VOAA	-.02 .45 27	.25 .11 27	.28 .08 27	-.02 .47 27

Key: In each cell, the first statistic refers to correlation, the second one refers to statistical significance and the third one refers to the number of respondents. Refer to Table T5-1-3 for internal consistency of each scale. T_O_ZMA refers to maths attainment in T-score in 97/98, T_O_ZRE refers toreading attainment in T-score in 97/98, T_O_ZAA refers to averaged maths and reading attainments in 97/98, T_R_VOMA refers to maths value-added in 97/98, T_R_VORE refers to reading value-added in 97/98, T_R_VOAA refers to averaged maths and reading value-added in 97/98, T_O_ZPP refers to problem of positions measure in 97/98, T_O_ZPV refers to picture vocab in 97/98, T_O_ZWE refers to pupil context score in 97/98, T_AT_MA refers to attitude towards maths in 97/98, T_AT_RE refers to attitude towards reading in 97/98, T_AT_SH refers to attitude towards school in 97/98. U_O_ZMA refers to maths attainment in T-score in 98/99, U_O_ZRE refers toreading attainment in T-score in 98/99, U_O_ZAA refers to averaged maths and reading attainments in 98/99, U_R_VOMA refers to maths value-added in 98/99, U_R_VORE refers to reading value-added in 98/99, U_R_VOAA refers to averaged maths and reading value-added in 98/99.

The Table T5-1-13 above reports the correlation statistics (one-tailed) concerning measures of learning outcome and reflective thinking and practice. The results suggest that habitual action is positively related to reading gains, at $p < .05$ level with $N = 62$ (one-tailed). The Pearson correlation statistic (r) is 0.23. Compared with the first hypothesis above, the direction of the correlation is rather unexpected. Further investigation and checking were carried out on the correlation statistic between habitual action and maths gain. The respective Pearson correlation statistic (r) was -0.19, although it was not found to be sufficiently strong to be accepted as significant at $p < .05$ level, with N=62. As the polarities of the two correlation statistics are different, it leads to the new investigation into the relationship between habitual action and learning outcomes. Subject specificity is a possible explanation. As most of the pupils in the study are learning English language as their first and the major spoken language, many language skills (e.g. grammar and spelling rules) are acquired implicitly and developed as a habit. On the other hand, at primary school level, pupils are used to learning mathematical concepts through a problem-solving approach. The focus of maths learning is not only on the speed, but also the accuracy, understanding and application of mathematical concepts. The result is in no way rejecting the value of repetitive drill and mechanical practices in maths; instead, it suggests that over-dependence on repetitive and mechanical work may slow down the pupils' progress in maths, or eventually result in a fall in maths achievement.

An investigation was carried out into the correlation statistics between habitual action and other learning outcome measures. The Pearson correlation statistic (r) between habitual action and learning attainment towards maths was -0.20 and the Pearson correlation statistic (r) between habitual action and attitude towards reading was 0.07. Both of them were not statistically significant, although the first correlation statistic was close to the margin of the acceptable level of significance at $p < .05$. Further investigation was carried out on the correlation statistics between habitual action and other attitude measures. The Pearson correlation statistic (r) between habitual action and attitude towards maths was -0.02 and the Pearson correlation statistic (r) between habitual action and attitude towards reading was 0.19. The Pearson correlation statistic (r) between habitual action and maths gain in 1998/99 was -0.10 and the Pearson correlation statistic (r) between habitual action and reading gain in 1998/99 was 0.05. The Pearson correlation statistic (r) between habitual action and maths attainment in 1998/99 was -0.14 and the Pearson correlation statistic (r) between habitual action and reading gain in 1998/99 was -0.03. Except for the last correlation statistic, the results consistently support the subject specificity explanation above. As the associations were not statistically significant at $p < .05$ level, the extent of support is weak. Further investigation into this issue is needed in future research.

The results also indicate that thoughtful application is positively related to the picture vocabulary measure in 1997/98 and is positively related to reading attainment and averaged attainment in 1998/99, at $p < .05$ with N=33, 27 and 27, respectively. The Pearson correlation statistics (r) are 0.30, 0.35 and 0.34, respectively. It means that teachers' intentional mental effort in applying their learnt theoretical knowledge (e.g. grammar) into language teaching makes a positive contribution to their pupils' language learning. The measure of critical reflection is positively related to attitude towards reading in 1997/98, at $p < .05$ level with N=33 and the measure of premise self-reflection is positively related to the picture vocabulary measure and the context score measure in 1997/98. The Pearson correlation statistics (r) are 0.34, 0.32 and 0.33, respectively. The results illustrated that the teacher's self-evaluation, self-refinement and/or reconstruction of theoretical knowledge as a form of personal and professional development make positive contributions to their teaching practice.

The last hypothesis is investigated by integrating the results of the results of correlation between learning outcomes and thoughtful application, critical reflection and premise self-reflection above. A total of 6 significant findings out of 54 statistical tests have satisfied the requirement of the test of significance for a series of statistical tests at $p < .05$ level, as suggested by Sakoda et. al. (1953). So, the results support the last hypotheses. As a brief summing up, the reported results above consistently indicate the possible relationships between reflection sub-scales and measures of picture vocabulary, reading attainment or reading attitude. It implies that teachers' intentional mental efforts in applying their pedagogical content knowledge and in reviewing their own thinking and practice can facilitate children's development in reading and language skills and help their development in verbal ability. Alternatively, pupils' improvement in reading, language skills and verbal ability can also foster teacher reflection. The two alternatives may be complementary to each other. In applying Nunes' (1998) idea of developing children's minds through literacy, this group of teachers were using literacy as an activity for creating a new object of thought and a new tool for thinking, not just teaching literacy for language acquisition. If this is true, the group of teachers in the study succeeded in making children use scripts as the objects of thought and use text as the objects and the tools of thought.

(5-1-3-3) Teachers' personal judgement about the complexity of challenges concerning the use of ICT to support subject teaching and their potential impacts on pupil learning outcomes: a correlational study

The discussion in section 5-1-2-3 above leads us to conclude that teachers' personal judgement about the complexity of challenges concerning the use of ICT to support subject teaching could be interpreted as a part of the teacher's characteristics. It might be sensible to infer that a teacher who views using ICT to support subject teaching as a simple job will perform better, in a lesson supported by the use of ICT, than another teacher who views using ICT as a sophisticated job, and vice versa.

Research hypotheses

It was expected that teachers' personal judgement about the complexity of challenges concerning the use of ICT to support subject teaching would be negatively correlated with each of the measures of pupil learning outcomes.

Table T5-1-14: The results of correlation tests between teachers' personal judgement about the complexity of challenges concerning the use of ICT and pupil learning outcomes

Correlation between teachers' personal judgement about the complexity of challenges concerning the use of ICT to support subject teaching in 1997/98 and the variables below:	**Pearson statistic (r)**	**No. of samples (N)**
Maths attainment in 1997/98	-.34*	33
Reading attainment in 1997/98	-.42**	33
Average maths and reading attainment in 1997/98	-.40*	33
Maths gains in 1997/98	-.18	33
Reading gains in 1997/98	-.40*	33
Average maths and reading gains in 1997/98	-.32*	33
Attitude towards themselves and school learning in 1997/98	.11	33

Note: * refers to the result that was found to be statistically significant at $p < .05$ level in one-tailed test, ** refers to the result that was found to be statistically significant at $p < .01$ level in one-tailed test.

The results of correlation tests between teachers' personal judgement about the complexity of challenges concerning the use of ICT and pupil learning outcomes are reported in Table T5-1-14. Only seven statistical tests were performed because the number of other valid sample pairs was too small, with $N < 20$. This was also the reason why the correlation tests between measures of teachers' personal judgement about the complexity of challenges concerning the use of ICT to support subject teaching in 1998/99 and measures of pupil learning outcomes in 1998/99 could not be carried out.

Generally speaking, the results gave good support to the research hypotheses above. Almost all the correlation tests done were found to be statistically significant, except the correlation between teachers' personal judgement about the complexity of challenges concerning the use of ICT and pupils' maths gain in 1997/98, and pupils' attitude towards themselves and towards the school in 1997/98. It would also imply that pedagogical judgement, although it might be personal and subjective, had significant impact on pupil learning outcomes.

(5-1-3-4) Teachers' pedagogical preferences and their potential impact on pupil learning outcomes: a correlational study

With reference to the findings in chapter 3, it seemed that effective teaching and learning supported by the use of ICT requires a lot of effort and careful consideration. Without careful consideration about the challenges concerning its use, teachers' incentive or ambition towards using ICT may result in negative pupil learning attainments or negative pupil learning gains.

Effective teaching and learning research states that the extent of variation in educational achievement is positively linked with the complexity of the pedagogy being used (Reynolds and Farrell, 1996). The complexity may involve complex room arrangements, teacher changes between lessons, changes in pupil grouping strategies, the variations in the quality and consistency of instructional material and the multiplicity of educational goals.

Reynolds and Farrell (1996) suggested that the education system in England needed to learn from the experience of countries with high levels of educational achievement, such as the Pacific Rim societies. Compared with that of the schools in Pacific Rim societies, the variation in educational achievement in English schools is much wider. And it might be linked with the absence of effectiveness factors in English education, although they apply elsewhere in the world. They reported that children in an English classroom only had 20% of the lesson time being constantly attended by the teacher, while children in Pacific Rim societies had 80% of the lesson time being attended. They stated that children in an English classroom were working on their own or within a group with similar ability for a high proportion of their lesson time. Compared with the classroom practice in England, teaching and learning processes of the Pacific Rim society emphasise the "basics". Their classrooms were characterised by whole-class interactive instruction and the use of the same textbook by all children. Due to cultural differences, careful evaluation and pilot tests in local classrooms are needed before such changes are adopted as part of the English education system.

Research hypotheses

In applying the effectiveness factors identified from the Pacific Rim society, it was expected that:

- pro-ICT preference would be negatively related to measures of pupil learning outcome,
- pupil control preference would be negatively related to measures of pupil learning outcome,
- open activities preference would be negatively related to measures of pupil learning outcome,
- collaborative work preference would be negatively related to measures of pupil learning outcome, and
- language teaching preference would be negatively related to measures of pupil learning outcome.

Table T5-1-15: The results of correlation tests (one-tailed) between teachers' pedagogical preferences and pupil learning outcomes

	Pro-ICT preference	Pupil control preference	Open activities preference	Collaborative work preference	Language teaching preference
U_O_ZMA	-.45* .02 22	-.50** .01 22	.08 .37 22	-.39* .04 22	-.19 .20 22
U_O_ZRE	-.48** .01 22	-.36* .05 22	-.21 .28 22	-.38* .04 22	-.17 .22 22
U_O_ZAA	-.50** .01 22	-.45* .02 22	-.08 .36 22	-.40* .03 22	-.19 .20 22
U_R_VOMA	-.59** .00 22	-.28 .10 22	.28 .10 22	-.20 .19 22	.17 .23 22
U_R_VORE	-.65** .00 22	-.14 .27 22	-.08 .36 22	-.22 .17 22	.15 .25 22
U_R_VOAA	-.68** .00 22	-.22 .16 22	.09 .35 22	-.23 .16 22	.17 .23 22

Key: In each cell, the first statistic refers to correlation, the second one refers to statistical significance and the third one refers to the number of respondents. Refer to Table T5-1-3 for internal consistency of each scale. U_O_ZMA refers to maths attainment in T-score in 98/99, U_O_ZRE refers toreading attainment in T-score in 98/99, U_O_ZAA refers to averaged maths and reading attainments in 98/99, U_R_VOMA refers to maths value-added in 98/99, U_R_VORE refers to reading value-added in 98/99, U_R_VOAA refers to averaged maths and reading value-added in 98/99. * refers to the result that was found to be statistically significant at $p < .05$ level in one-tailed test, ** refers to the result that was found to be statistically significant at $p < .01$ level in one-tailed test.

The results of correlation tests between teachers' pedagogical preferences and pupil learning outcomes are reported in Table T5-1-15. Measures of pupil learning outcomes in 1998/99 were used because most of the data concerning pedagogical preferences were collected in 1998/99. Due to the lack of valid sample pairs, with $N < 20$, measures concerning ability and attitudes in 1998/99 were not used in the analysis. The results clearly showed that pro-ICT preference was negatively related to pupil learning attainment and learning gains in maths and in reading, at $p < .05$ and $p < .01$ levels. They give support to the first research hypothesis above. As the Pearson correlation statistics (r) were negative and ranged from -0.45 to -0.68, the results seemed to be a warning sign for those teachers who might be over-enthusiastic in using ICT. In relation to the results of Chapter 4 section 4-5, it supports the hypothesis that a positive attitude towards ICT alone, without careful consideration and without sufficient teacher effort, might have negative impact on pupil learning outcomes. The major reason for the negative impact on learning outcomes is that the use of ICT is an additional burden to the pedagogical practice of most teachers, as suggested by the results of section 5-1-2-1. Although the impact of a complex pedagogy could be positive, extra complexity on top of an already complex pedagogy would likely be a burden.

Pupil control preference was negatively related to pupil learning attainments in maths and in reading, at $p < .05$ level. Although the correlation between pupil control preference and pupil learning gains in maths and in reading were not sufficiently strong to be accepted as significant at $p < .05$ level, all the reported Pearson correlation statistics (r) in the respective column were negative. So, the second research hypothesis above was supported by the data. Collaborative work preference was also negatively related to pupil learning attainments in maths and in reading, at $p < .05$ level. Although the correlation between collaborative work preference and pupil learning gains in maths and in reading were not sufficiently strong to be accepted as significant at $p < .05$ level, all the reported Pearson correlation statistics (r) in the respective column were negative. So, the fourth research hypothesis above was supported by the data. The third and the fifth hypotheses above were not supported by the data because the Pearson correlation statistics (r) were not statistically significant and the direction of the associations was not clear.

It may not be appropriate to interpret the above results as a negative impact in learning; instead, it might be interpreted as a failure to keep up to the expected standard of achievement. In a pupil-controlled learning environment, the variations between pupils could be great. These might include differences in the level and difficulties of their work, the learning objectives, progress and methods of assessment. And the teacher would be likely to work on an individual or a small group basis. Compared with a teacher-led teaching and learning environment, as identified in the Pacific Rim societies, it might take longer to go through a curriculum topic. A low rate of teacher-pupil interaction could also be a possible cause for the inefficiency. Although pupils may benefit from a methodologically sophisticated collaborative learning experience that is planned and executed by the teacher, the results suggest that, generally speaking, it might be less cost-effective than spending the same amount of time and effort for teaching and learning activities at individual level, with the same set of learning material and/or instructions. And it is possible that a simple and straightforward pedagogy, as identified in the Pacific Rim societies, could be more cost-effective than a complex pedagogy.

(5-2) Tackling challenges concerning the pedagogy of using ICT: The links between challenges concerning the use of ICT, pedagogy, reflective learning and practice, the extent of computer use, and effective teaching and learning

The following sections will introduce a series of measures of "perceived challenges concerning the use of ICT". It is a composite measure that summarizes various factors concerning the use of computers for teaching and learning from a teacher's perspective, including favourable and unfavourable factors. This will be followed by an investigation of the compositional structure of the perceived challenge measures and their inter-relationships with pedagogy, teacher reflection, the extent of computer use, and the effectiveness of teaching and learning.

(5-2-1) Linking favourable and unfavourable factors concerning the use of computers for teaching and learning: challenges perceived by teachers concerning the use of ICT

Some literature suggests that computers, if used properly, have great potential in bringing positive educational outcomes. In daily classroom practice, the impact of computers can be positive or negative. The following paragraphs will discuss various factors that affect the use of ICT. These factors can form a composite measure in terms of perceived challenges concerning the use.

Factors affecting the use of ICT

The ImpacT project report named three principal factors that affected the use of IT in the classes which participated in the project (Watson, 1993). These included:

- access to computers,
- the organisation of IT in the class, and
- the teachers' skills and enthusiasm for using IT in the curriculum.

Marcinkiewicz (1994) also mentioned some potential factors affecting computer use in elementary classrooms. These included:

- innovativeness,
- teacher locus of control,
- perceived relevance of computers,
- self-competence in using computers, and
- teachers' personal variables: age, gender, and years of computer experience.

In this thesis, all the factors affecting the use of ICT can be described as "challenges" concerning the use of ICT in primary education. They can be classified as two major types: favourable and unfavourable factors. The presence of unfavourable factors is a major source of the challenges and the lack of favourable factors is also a major source of the challenges. Factors of the former type might be described as "barriers", "obstacles", or "difficulties", while factors of the latter type might include various types of "support", "resource" or "motivation". Factors of both sides are linked together as "challenges" because they have to be considered before a pedagogical decision about teaching and learning is made. To outline the process, such as planning to integrate ICT in the curriculum, some writers see tensions between these two major groups of factor. Among them, BECTa (1998a) tried to link favourable and unfavourable factors together for pedagogical consideration. It proposed a cost-benefit "equation" of the value of using ICT to support classroom teaching and learning as below:

Value = (Learning + attitude + staff development + enhanced learning environment + IT image) / (hardware, software and maintenance costs + staff training costs + disruption)

Unfavourable factors: barriers, obstacles and difficulties

Roblyer et. al. (1997) thought teachers' feeling of lack of access to the reliable provision of equipment was a reason for not using technology in their teaching. She expressed this as "one of the primary obstacles" in the classroom use of ICT. In a survey in Scotland, SOEID (1999) found that primary school teachers were in serious need for technical support and advice on the selection of ICT resources. The primary teachers in Scotland, especially those in rural areas, felt the lack of technical support operated against the use of ICT. In the evaluation of ILS in UK, Sizmur et. al. (1998) reported that "several of schools had experienced difficulty in making ILS work on a network or on individual machines. The difficulties experienced were various, including screen freezes caused by incompatibility with existing software installed on machines." To deal with this aspect of challenge for secondary schools in

Washington, Hancock (1990) suggested that a full-time lab co-ordinator was the key for promoting the computer use. In practice, most primary schools in UK cannot afford the "luxury" of having a full-time lab co-ordinator. The job is often the responsibility of the IT co-ordinator, who is also a teacher in the school. The IT co-ordinator makes decisions about resource allocation as well as helping colleagues with the organisation of the available resources.

Inexperience in organising classroom ICT resources can also be an obstacle leading to the effective use of ICT. Sizmur et. al. (1998) investigated the effects of three integrated learning systems on pupils at year 5, 6 and 8. They reported, "Though considered to be manageable overall, the use of integrated learning systems could introduce significant organisational disruptions. The impact on the timetable could be complex, and there was the danger that timtabling flexibility could be lost where specialised facilities were in use of ILS...Barriers to integration were lack of focused training and lack of familiarity with the content of the courses." In relation to challenges in this aspect, the TTA requires all initial teacher trainees to be able to (TTA, 1998):

- use a single screen with the whole class or a group,
- organise pairs or groups of children working on the computer,
- organise use of computers by individual pupils, either on a single classroom-based machine or at a computer workstation in a networked room,
- make ICT resources available for pupils for research or other purposes,
- position resources for ease of use, and to minimise distraction,
- position resources with due regard to health and safety, and

- allow ICT to support teaching rather than dominate activities.

Sizmur et. al. (1998) reported that there were two contrasting strategies in organising pupils with the ICT resources. They were:

- having individual children work on a single machine outside a classroom, with minimal supervision, and
- having the whole class work with their teacher in a dedicted ILS room.

They also identified two other common arrangements, which were combinations of the two contrasting strategies at different ratings. They were (Sizmur et. al., 1998):

- A whole class went to an ILS room, where half worked on the computers, usually independently, while the teacher worked with the remainder of the class, giving occasional attention to the ILS group as needs arose. Then the two groups swapped over half way through the session, allowing all to use the machines.
- It was used in particular for children with special educational needs withdrawn from their classroom to work in another area with the integrated learning systems, supervised and supported by a non-teaching assistant. Children were time-tabled to have a session each week.

In the literature review, the list of problems in using computers and reasons for not using computers was found to be the most comprehensive. A copy of the list is presented in Illustration I5-2A below. Furthermore, some barriers or obstacles are rooted on teachers' conceptual weakness, such as the lack of knowledge and guidance about classroom usage of ICT. Foliart and Lemlech (1989) identified five areas of confusion about computer use in the classroom were through a qualitative analysis of comments made by 29 pre-service and in service elementary school teachers. These issues included:

(1) process vs. product;

(2) entertainment vs. motivation;

(3) what constitutes ethical use of time;

(4) curriculum integration; and

(5) student accountability.

Illustration I5-2A: Challenges concerning the use of computers in education worldwide (Source: Pelgrum & Plomp, 1991, Page 134)

Hardware

1. insufficient number of computers available
2. insufficient number of peripherals (e.g. printer)
3. difficulty in keeping computers and peripherals in working order
4. limitations of computers (e.g. out-of-date, incompatible with current software, to slow, insufficient memory, etc.)

Software

5. not enough software for instructional purposes available
6. software too difficult or too complicated to use
7. software not adaptable enough for this school's courses
8. manuals and support materials poorly designed, incomplete or inappropriate
9. lack of information about software or its quality
10. most of the software is not available in the language of instruction

Instruction

11. not enough help for supervising computer using students/teachers
12. difficult to integrate computers in classroom instruction practices of teachers
13. integration of computer use in the existing prescribed (school/class) curriculum is difficult
14. computers are inappropriate for the age level of students
15. teachers lack knowledge / skills about using computers for instructionalpurposes
16. insufficient expertise / guidelines for helping teachers use computers instructionnally

Organization / administration

17. no room in the school time-table for students to learn about or to use computers
18. not enough space to locate computers appropriately
19. not enough technical assistance for operating and maintaining computers
20. computers are only available outside the school or the school building
21. problems in scheduling enough computer time for different classes / this class
22. computers not accessible enough for teachers' / my own use
23. insufficient training opportunities for teachers
24. lack of administrative support or initiatives from a higher level of school administration
25. inadequate financial support
26. computers do not fit in the educational policy of the school

Miscellaneous

27. not enough time to develop lessons in which computers are used
28. teachers had bad experiences with other innovations
29. lack of interest / willingness of teachers in using computers

Chiero (1997) carried out a survey of 36 elementary secondary teachers. It was found that 94% of them used computers to prepare instructional materials, but only 58% of them used computers for the subject area they taught. Brooks et. al. (1997) carried another survey of 3,476 trainees on initial teacher training courses. The results indicated that the trainees were very or fairly confident at using information technology for the following purposes:

- in preparing their work for school (88%),
- in delivering the curriculum in the classroom (68%), and
- in developing the information technology capability of pupils (61%).

Results of both surveys consistently indicated that computers were less frequently used as a means of supporting learning than were used as personal tools to facilitate the teaching and learning processes. There are many possible reasons for the phenomena. In addition to the factors above, teachers' lack of confidence or negative attitudes towards the classroom use are also possible factors. There is also a spectrum of pedagogical problems that might hinder this type of computer use. The ImpacT project report mentioned some of these problems teachers faced (Watson, 1993). Teachers:

- had difficulties in managing pupils' access to computing facilities consistent with the plan of the topic/lessons;
- often considered that computers were to be used to complement rather than change existing pedagogic practice, whether it is "traditional" or "progressive";

- were concerned about product or knowledge outcomes versus process, and how this might relate to the demands, or expectations of, for example, the National Curriculum;
- were concerned about the inappropriateness of conventional tests/ assessments for measuring some of the skills and understandings acquired in an IT related environment;
- had naïve views of the philosophy behind the software and the implications for its use;
- experienced difficulties in promoting collaborative work on tasks for groups of pupils; and
- found it difficult to incorporate the pupil's work into the usual selection of coursework collected for assessment.

To deal with these weaknesses, the ImpacT report suggested that teachers had to:

- widen the knowledge and awareness of software availability, and
- consider the means, organisation, management, and teaching style when ICT was used.

As a short conclusion, barriers or obstacles for using computers for classroom teaching and learning included technical unreliability or the inadequate provision of equipment, teachers' lack of personal or pedagogical knowledge, skills and experience concerning usage. Furthermore, teachers' lack of confidence or having negative attitudes toward classroom computer use are also potential obstacles.

Favourable factors: resources, supports, personal interest & motivation

Stanley, Lindauer and Petrie (1998) found both in-service teacher training and administrator support were important factors in encouraging teachers' use of technology at elementary secondary schools in America. In UK, McKinsey and Company (1997) suggested several dimensions of work in order to realise ICT's full educational promise. These include:

- more clarity over educational objectives for ICT,
- improved training and support for teachers,
- more substantial software packages,
- cheaper connections to the internet, and
- more up-to-date hardware.

Note that both authors stressed the importance of teacher training and development in supporting the use of ICT in subject teaching and learning. Teachers are the front-line people who provide the service of education. A lot of things can be done to develop their professional practice in teaching with the use of ICT. For example, Brown (1994) highlighted some teacher training issues in the process of supporting the use of information technology to enhance learning. These included:

- teacher involvement and the change process;
- teachers' professional development;
- instructional materials development;
- reflective practice; and

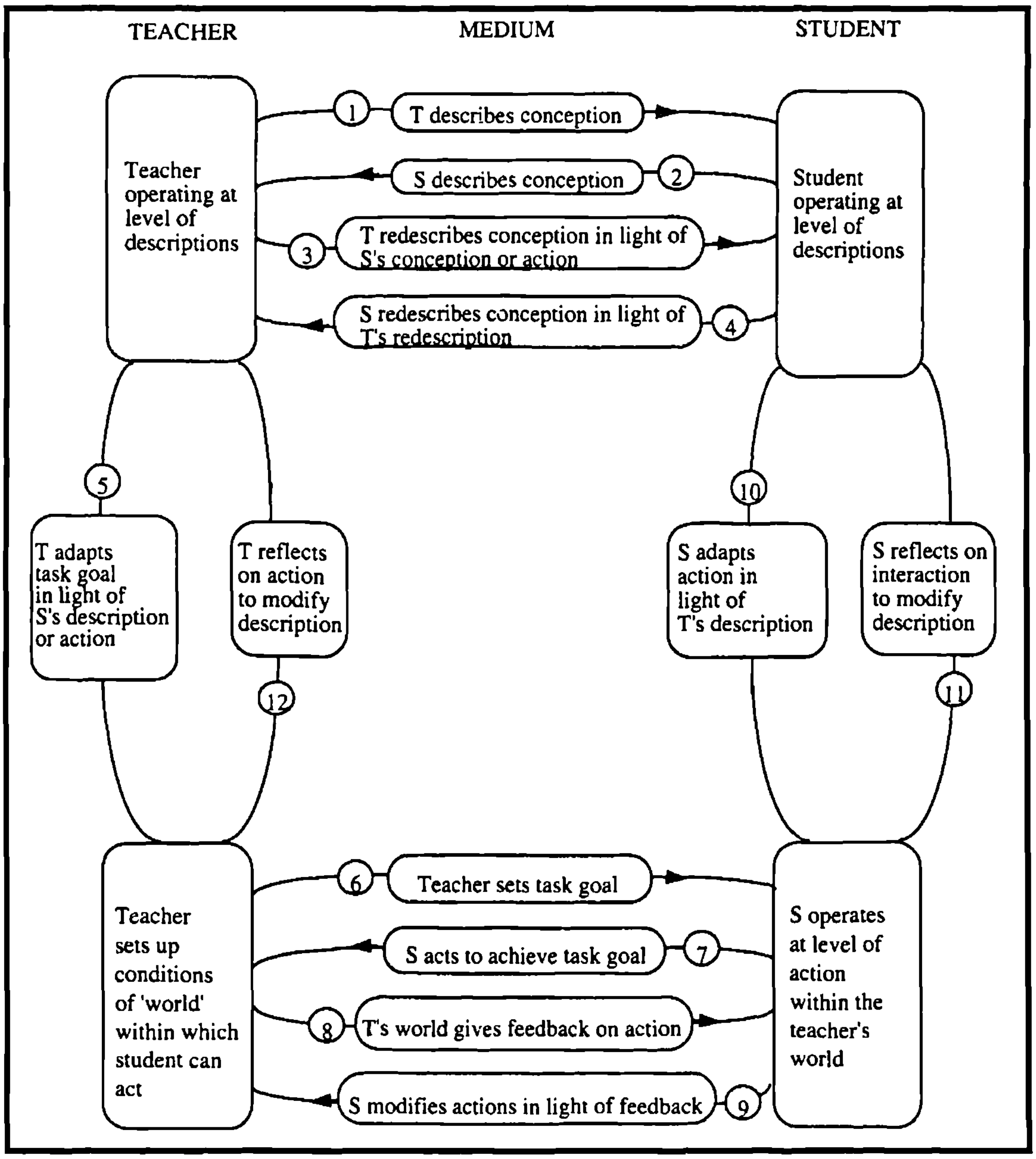
- support for institutional development.

Furthermore, David Gordon, the Vice Chair of the Campaign for State Education put forward suggestions on these aspects of training and development (from Xemplar Education, 1998):

- improve teachers' confidence in using ICT,
- develop a pedagogy for ICT capability in terms of lesson planning, pupil assessment and differentiation methodologies of teaching all aspects of the subject, whether in separate ICT lessons or within other subjects,
- offer support to non-specialist teachers in appropriate use of ICT applications in teaching and independent study, and
- develop more strongly the methodologies of teaching other subjects with the aid of ICT, and strengthen the networks and training facilities which disseminate good practice.

Illustration I5-2B: Teacher-pupil conversational interactions supporting the effective use of computers or other types of ICT

(Source: Laurillard, 1993 and Draper et. al., 1994)



In relation to the professional development of educational use of ICT, I would like to introduce Laurillard's "conversational" framework identifying activities necessary to complete the learning process in higher education. The framework gives a detailed analysis of interactions between teachers and students concerning effective use of ICT. Twelve types of activity are identified. Each of them requires collaborative "conversational" work between teachers and students. They are presented in Illustration I5-2B above. These frameworks make contributions to the professional development of teachers at conceptual and practice levels, however, its usefulness for the topic of this thesis is greatly limited by the age group of the pupils. Compared with students in higher education, pupils in primary education may be less competent in taking an active role in conversational interaction. Although some primary teachers might plan and conduct their use of ICT as a collaborative teaching and learning activity, many interactions in primary education are "one-way" or teacher-led in nature. Furthermore, to promote the use of ICT in primary education, we also need to consider the potential contributions made by an external body. However, this is an area that is not addressed by Laurillard's framework. Therefore, further examination on the applicability or validity of the framework in primary education is needed.

Decisions concerning the use of ICT in education go beyond the control of teachers and pupils. Pedagogical considerations or challenges that teachers have may be related to the target educational objectives that a society wants to achieve. In practice, decisions may be needed to prioritise these objectives, especially when the resources available in a society are insufficient to achieve all of them. As a reference, the author of this thesis would like to present a list of advice, information or supports required by teachers in Hong Kong. In relation to the target educational objectives, they are reported as the questions below (CITE, 1999):

1. How to use ICT to support the curriculum
2. How to use ICT with pupils with emotional or physical disabilities
3. How to use ICT with underachieving pupils
4. How to use ICT with highly gifted pupils
5. (National, regional, provincial, district) prescribed ICT capabilities
6. Information handling skills of students and teachers
7. How to use ICT for management support
8. How to use ICT for evaluating the function of the school
9. How to use ICT for administrative work
10. Others

It is clear that the target educational objectives give a high priority to the use of ICT to support curricular teaching and learning than to the use of ICT to facilitate staff efficiency, school administration and management. Therefore, the interest of using ICT to support subject curriculum is not the common interest of this thesis and of the UK government, but an education topic with growing interests from other societies around the world.

Measures of perceived challenge concerning the use of ICT

A series of measures of perceived challenge concerning the use of ICT for teaching and learning purposes was constructed specially for this thesis. Each of these measures is composed of various factors concerning the use of computers for teaching and learning from a teacher's perspective, including favourable and unfavourable factors. The details about the instrument can be found in Chapter 4 section 4-2-C2.

The section 5-2-2 below reports statistical investigation of the compositional structure and reliability of these measures.

(5-2-2) The classification of challenges concerning the use of ICT: a cluster analysis

When we look at ICT usage, teachers play a very important role in making the relevant pedagogical decisions. In this respect, a set of 18 questionnaire items was included in the third questionnaire to investigate challenges, barriers and support. Respondents in the present study were asked to rate how each aspect of instruction affected their use of ICT in the classroom using the codes 1 to 5 and "X". The codes were used to represent "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)", respectively. The names and the content of these items are presented in Table T5-2-1, with the graphical presentation of the results of hierarchical cluster analysis - a dendrogram. Note that these variables are presented in a meaningful order. They are linked together to form a cluster by the "between-groups linkage" method. The idea is to find the closest pair of variables according to a distance measure called "Squared Euclidean distance". The process of joining a pair of variables, a pair of clusters, or a variable with a cluster continues until all the variables are linked together to form a cluster.

Table T5-2-1: The results of cluster analysis on measures of perceived challenge concerning the use of ICT for teaching and learning purposes

Var.	Content of the questionnaire item	Dendrogram: Cluster anslysis results
chl_02	My knowledge and skills about hardware	`-+-----+----+`
chl_05	My knowledge and skills about software	`-+     +    +`
chl_09	My knowledge about how and when to use ICT	`-------+    +-----+`
chl_07	Access to information about hardware and software at school	`--------+---+     I`
chl_18	My knowledge and skills in planning follow-up work	`--------+         +---+`
chl_11	My interest in the classroom use of ICT	`---+-----+        I   I`
chl_13	My expectation about the educational outcome of using ICT	`---+     +--------+   I`
chl_04	The ability of my class	`---------+            +-----+`
chl_14	The demands on teachers' time and effort in class	`---+                  I     I`
chl_16	Time and effort for planning and preparation	`---+--+--+            I     +-------+`
chl_17	The supervision of pupils' learning on computer	`------+  +------------+     I       I`
chl_15	The impact of school/educational policy e.g. literacy or numeracy hour	`---------+                  I       I`
chl_03	Equipment available for pupil to use	`-------------------+--------+       +----+`
chl_10	Reliability of available equipment	`-------------------+                I    I`
chl_06	The number of pupils in my class	`-----------------+-----------+      I    I`
chl_12	Availability of adults to help pupils on the computers	`-----------------+           +------+    I`
chl_08	Technical support available in school	`-----------------------------+           I`
chl_01	The age of my pupils	`-----------------------------------------+`

By looking at the dendrogram, it appears that these variables can be categorised into four groups. The composition of each of the variable groups and their internal consistency are presented in Table T5-2-2. The alpha statistics show that items in each group of variables have a strong internal consistency. By combining all the 18 items to act as a scale measuring the challenge of using ICT in general, the internal consistency (alpha statistic) of the items is as high as 0.9.

Interestingly, the dendrogram also reveals that the variable groups are linked together in a hierarchical structure. The hierarchical relationship seems to be very useful to help us to understand the pedagogical decision making processes about the use of ICT. The first group of variables refers to teachers' knowledge and skills about hardware, software and pedagogical knowledge about the use of ICT. These can be interpreted as the fundamental issues in the making of pedagogical decisions. The second group of variables refers to teachers' interest, expectation concerning the use of ICT and their concerns about pupils' ability. Further investigation was carried out to validate the relationships between the three variables in the group. It was found that these variables significantly correlated with each other, with the associations of 0.42, 0.46 and 0.61 ($p < 0.01$, two-tailed tests). The following statements may elaborate the role of psychological concern. They were comments made by teachers when they were asked to suggest when ICT should not be used in teaching and learning:

"When teacher (is) uncomfortable with it."

"(children)...need time to get used to routine, then only use computer when fully understand it is not a toy and use it only when given instructions & understand simple programs"

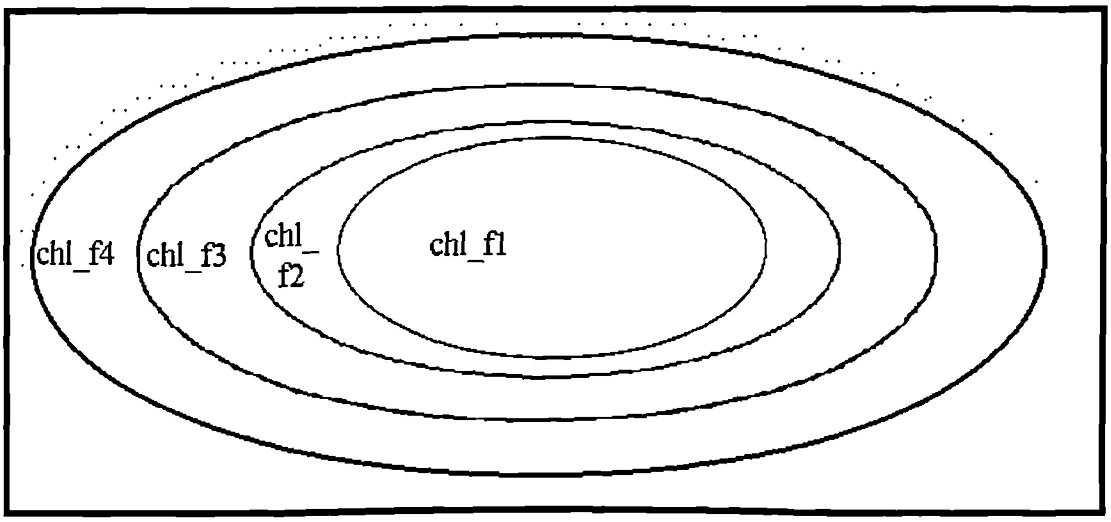
"...it would be much more difficult for the child to work independently if he didn't understand the concept first."

"When the programs are not suitable i.e. too hard / easy, irrelevant to learning objective"

The third group of variables is about teachers' role in the institution, including their duties and workload. This includes the teachers' time and effort in regard to planning, preparation, classroom organisation and supervision and the carrying out of the policy that the school or education authority has assigned to teachers. The last group of variables is a mixture of the practical and resource-related challenges for various types of resource, including reliable equipment, technical support and additional supports in human resources. As the hierarchical relationships between these groups of variables seem to be clear, it is reasonable to speculate that the pattern of relationships will be useful in revealing the relative importance that teachers have paid to these dimensions of pedagogical considerations for the use of ICT in primary classrooms.

If this is true, in considering the challenges of using ICT, primary teachers will tend to put their priority according to the order of importance, as mentioned above. We might speculate that each type of challenge is referring to a stage of teacher development in regard to the use of ICT to support subject teaching and learning. The stages of development can be presented as a concentric model, as presented in Illustration I5-2C. The inner core of the concentric model is represented by the perceived personal challenges. It is followed by the perceived psychological challenges and the perceived institutional and work-related challenges. The outer ring of the concentric model is represented by the perceived practical and resource-related challenges. The descriptions in Table T5-2-2 will tell us the composition and other details about each of those.

Illustration I5-2C: Concentric model showing the four categories of perceived challenges concerning the use of computers for teaching and learning



Keys: ***chl_f1*** refers to "personal challenges", ***chl_f2*** refers to "psychological challenges", ***chl_f3*** refers to "institutional and work-related challenges" and ***chl_f4*** refers to "practical and resource-related challenges".

Comparison of the mean statistics of these four scales indicated that the second scale seemed to be the most favourable group of factors. On average, teachers' incentive toward the use of ICT in the classroom was midway between "favourable" and "okay". They rated themselves as "okay" when considering their knowledge and skills about using ICT. However, issues about the needs for reliable equipment, the technical and extra human resources available, the perceived institutional and work-related challenges seemed to be slightly "unfavourable" factors for the use of ICT.

Table T5-2-2: Four categories of perceived challenges concerning the use of computers for teaching and learning, the compositions and internal consistency of the scale and mean statistics

Var. name	Descriptions of the group of challenges, including barriers and supports	Composition of the scale	N	Alpha	Mean (SE)
chl_f1	Personal challenges i.e. knowledge & skills about using ICT	average of chl_02, chl_05, chl_09, chl_07, chl_18	73	.85	3.06 (.72)
chl_f2	Psychological challenges i.e. personal interest, expectation and concerns	average of chl_11, chl_13, chl_04	68	.74	2.57 (.72)
chl_f3	Institutional and work-related challenges i.e. duties, workload and time available	average of chl_14, chl_16, chl_17, chl_15	73	.84	3.42 (.78)
chl_f4	Practical and resource-related challenges i.e. the need for reliable equipment, technical support and additional supports for pupils	average of chl_03, chl_06, chl_08, chl_10, chl_12, chl_01	72	.73	3.17 (.75)
tchl98	*Challenge variables in general (barriers & supports)*	*average of 18 items about challenge*	*64*	*.90*	*3.10 (.62)*

Remark: The chl_ measures are the names of the "perceived challenges" items. Refer to Chapter 4 section 4-4-C2 for full detail of the items.

(5-2-3) The inter-relationships between perceived challenges concerning the use of ICT for teaching and learning, pedagogy, teacher reflection and the effectiveness of teaching and learning

In the four sections below, we shall explore the potential links between perceived challenges concerning the use of ICT and several issues introduced in the text above. These include pedagogy, teacher reflection and the effectiveness of teaching and learning represented by performance measures of pupil learning outcomes in PIPS.

The ultimate aim is to investigate potential links between various aspects of teachers' characteristics and teachers' perceived challenges concerning the use of ICT. In relation to the theoretical issues about reflective learning and practice described in section 5-1-1 above, the investigation is focused on the links between teachers' theoretical knowledge (or "espoused theory") and their practical knowledge (or "theory-in-use"), and the role that reflection might play in the mechanism of teacher learning and development.

(5-2-3-1) The potential links between measures of perceived challenge concerning the use of ICT for teaching and learning purposes and teachers' personal judgement about the complexity of challenges concerning the use: a correlational study

Due to the similarity of the construct to be measured, the measures about perceived challenges concerning the use of ICT was expected to have close alignment with their personal judgement about the complexity of challenges concerning the use in 1998/99. However, in terms of their role to play in the teaching and learning processes in the model of "effective curricular teaching and learning supported by computers or other types of ICT" mentioned in Chapter 2, the two measures are different from one another. Teachers' judgement about the complexity of challenges concerning the use of ICT is a part of the teachers' characteristics. Their judgement could be interpreted as a conceptual aspect of their own pedagogy, which is a part of the "presage" of teaching and learning. On the contrary, perception of challenge concerning the use of ICT is a part of their experience of the teaching and learning process. It is comprised of practical knowledge about the teachers' own practice environment. It acts as an input-output interface that connects teachers' initiatives and perceived challenges concerning their own teaching and learning environment, and it also plays an essential role in linking teachers' characteristics and behaviour. In other words, the measure of teachers' personal judgement about the complexity of challenges concerning the use is indicator of the teachers' "espoused theory" concerning the use of ICT for their own subject teaching, while the measure(s) of teachers' perceived challenge concerning the use of ICT for teaching and learning purposes is/are the teachers' "theory-in-use". Knowledge of the former is theoretical in nature, while knowledge of the latter is relatively practical. As means for teacher learning and development, there are close connections between the two measures.

Research hypotheses

It was expected that each of the sub-types of perceived challenge concerning the use of ICT (as introduced in section 5-2-2) would be positively related to teachers' personal judgement about the complexity of challenges concerning the use.

Data analysis and discussion

The results of one-tailed correlation tests indicated that there were significant positive relationships between teachers' personal judgement about the complexity of challenges concerning the use of ICT to support subject teaching and learning and:

- the measure of teachers' perceived personal challenges (i.e. knowledge & skills about using ICT) at $p < .01$ level with the Pearson correlation statistic (r) of 0.38,

- the measure of teachers' perceived psychological challenges (i.e. personal interest, expectation and concerns) at $p < .05$ level with the Pearson correlation statistic (r) of 0.20,
- the measure of teachers' perceived institutional and work-related challenges (i.e. duties, workload and time available) at $p < .05$ level with the Pearson correlation statistic (r) of 0.21,
- the measure of teachers' perceived practical and resource-related challenges (i.e. the need for reliable equipment, technical support and additional supports for pupils) at $p < .05$ level with the Pearson correlation statistic (r) of 0.21, and
- the average of all the measures of perceived challenges at $p < .01$ level with the Pearson correlation statistic (r) of 0.31.

For each of the correlation tests, the number of valid cases (N) was 71. It might be worthwhile to note that the first Pearson correlation statistic (r) was the highest among the five Pearson correlation statistics (r) reported above. It might mean that teachers' knowledge and skills about using ICT is closely related to the complexity of the challenges perceived by the teacher concerning its use. The results clearly support the research hypothesis above, which suggested that the greater the extent of perceived challenge concerning the use of ICT, the more complex these challenges would be seen to be.

(5-2-3-2) The potential links between measures of perceived challenge concerning the use of ICT for teaching and learning purposes and the measure of pedagogical preference concerning the use of ICT: a correlational study

As an input and output interface for the pedagogy concerning the use of ICT, there are close relationships between perceived challenge and the pedagogical preference concerning the use of ICT. When the level of perceived challenge concerning the use of ICT is high, teachers will be discouraged from the use of ICT and their pedagogical preference towards its use will be low. On the contrary, when the extent of the perceived challenges is low, pedagogical preference towards using ICT will be high.

Research hypotheses

It was expected that teachers' pedagogical preferences concerning the use of ICT would be negatively related to:

- the measure of teachers' personal challenges (i.e. knowledge & skills about using ICT),
- the measures of teachers' psychological challenges (i.e. personal interest, expectation and concerns),
- the measures of teachers' institutional and work-related challenges (i.e. duties, workload and time available), and
- the measures of teachers' practical and resource-related challenges (i.e. the need for reliable equipment, technical support and additional supports for pupils).

Data analysis and discussion

In referring to the four research hypotheses above, four one-tailed correlation tests were performed. The results of the first correlation test indicated that there was a significant negative relationship between teachers' pedagogical preference concerning the use of ICT and the measure of teachers' perceived personal challenges at $p < .05$ level with N=42. The Pearson correlation statistic (r) was -0.33. None of the other three statistical tests were statistically significant at $p < .05$ level with all the N=42. The Pearson correlation statistic (r) were -.07, -.17 and -.04, respectively. Although the Pearson correlation statistics (r) of these three statistical findings were negative in nature, the sizes of association were too small to support the respective hypothesis. So, the first research hypothesis above was supported by the data, but the three other research hypotheses were not.

(5-2-3-3) The potential links between measures of perceived challenge concerning the use of ICT for teaching and learning purposes and teacher reflection: a correlational study

In relation to the discussion in section 5-1-1-2-1 and 5-1-1-2-2 above, a reflective teacher can be described as a careful observer. Kolb (1985) described that the personal characteristics of using abstract and reflective learning orientations (known as "assimilation" learning style) are matched with the requirement of the teaching profession. It might imply that effective teachers would be people who are critical analysers who want to know the details about teaching. These characteristics imply that they might have better awareness of potential problems or better knowledge about the challenges concerning the use of ICT for their own teaching. The psychological impact of critical analyses of potential problems and challenges might lead to excuses for not using ICT while problems or challenges might be over-exaggerated.

For Boud, Keogh and Walker (1985), all reflective practitioners are able to tackle negative feelings and work for improvements. A critical reflective teacher would be a self-evaluator of personal knowledge. Teachers with these characteristics are good at work-based learning because they are stimulated to learn from the experience of their own and from the experience of others through the awareness of discomforts and the willingness to improve. The stimulus and the ability to learn from practice would also "empower" these teachers with the competence to tackle new challenges encountered in their own practice environment. Teachers who depend highly on a reflective observation learning orientation might have lower perception of challenges concerning the use of ICT.

Research hypotheses

It was expected that each of the measures of perceived challenge concerning the use of ICT for teaching and learning purposes would be:

- positively related to the abstract conceptualisation measure introduced in section 5-1-1-2-1 above,
- negatively related to the reflective observation measure introduced in section 5-1-1-2-1 above,

- negatively related to the habitual action measure introduced in section 5-1-1-2-2 above,
- negatively related to the thoughtful application measure introduced in section 5-1-1-2-2 above,
- negatively related to the critical reflection measure introduced in section 5-1-1-2-2 above, and
- negatively related to the premise self-reflection measure introduced in section 5-1-1-2-2 above.

Data analysis and discussion

Table T5-2-3: The results of one-way correlation tests (Pearson correlation statistics) between perceived challenges concerning the use of ICT for teaching and learning purposes, measures of reflective observation and measures of reflective learning and practice

	chl_f1	chl_f2	chl_f3	chl_f4
Abstract conceptualisation	.09	.23*	.17	.16
Reflective observation	.01	-.12	.01	.03
Habitual action	.15	-.05	.14	.14
Thoughtful application	-.18	-.01	.06	.11
Critical reflection	-.19	-.05	-.02	-.03
Premise self-reflection	-.18	-.27**	-.06	-.03

Key: In each cell, the number of valid cases is 74 and the Pearson correlation statistics (r) are reported. ***chl_f1*** refers to personal challenges i.e. knowledge & skills about using ICT, ***chl_f2*** refers to psychological challenges i.e. personal interest, expectation and concerns, ***chl_f3*** refers to institutional and work-related challenges i.e. duties, workload and time available, ***chl_f4*** refers to practical and resource-related challenges i.e. the need for reliable equipment, technical support and additional supports for pupils. * refers to the result that was found to be statistically significant at $p < .05$ level in one-tailed test, ** refers to the result that was found to be statistically significant at $p < .01$ level in one-tailed test.

In relation to the types of perceived challenge concerning the use of ICT, the potential relationships were explored through four sets of correlation tests. The results are summarised in Table T5-2-3. Each set of correlation tests contains the correlation statistic between a specific type of perceived challenge concerning the use of ICT and the six selected measures related to teacher reflection. The size of association is expressed in terms of Pearson correlation statistics (r). The results indicate that neither the perceived practical and resource-related challenges nor the perceived institutional and work-related challenges concerning the use of ICT are related to any of the six measures related to teacher characteristics, at $p < .05$ level with N=74.

Two associations concerning perceived psychological challenges were found to be statistically significant. The first one is a negative association between the perceived psychological challenges and the abstract conceptualisation measure, at $p < .01$ level with N=74. The Pearson correlation statistic is 0.23. It supports the hypothesis that critical analysers might have better awareness or knowledge of psychological challenges concerning the use of ICT. The second one is a negative association between the perceived psychological challenges and the premise self-reflection measure, at $p < .01$ level with N=74. The Pearson correlation statistic is -0.27. The Pearson correlation statistic between the perceived institutional and work-related challenges concerning the use of ICT and the premise self-reflection measure was also found to be negative, however, the association was not sufficiently strong to be accepted as significant at $p < .05$ level. Further investigation into the potential links between premise self-reflection and other variables addressed in this thesis was carried out. The results of two-tailed correlation tests indicated that premise self-reflection was:

- positively correlated with teachers' perception about the change in pupils' academic achievement as a result of the use of computers to support subject teaching at $p < .01$ with N=63,
- positively correlated with teachers' personal attitudes towards computers at $p < .01$ with N=72, and
- positively correlated with the amount of time that a pupil spent on the computer in a week at $p < .01$ with N=107.

The Pearson correlation statistics were 0.36, 0.37 and 0.25, respectively. So, the fourth research hypothesis above was supported by the results of data analysis. One of the possible explanations for the result is that teacher reflection might have a stronger link (or "impact") on the psychological factors that affect the teachers' use of ICT than the personal factors (i.e. knowledge and skills about using ICT) that affects their use. The second and the third research hypotheses above are not supported by the results of data analysis.

(5-2-3-4) The potential links between measures of perceived challenge concerning the use of ICT for teaching and learning purposes and pupil learning outcomes: a correlational study

The results of Chapter 4 suggested that the perceived institutional and work-related challenge concerning the use of ICT, when working together with other variables - such as teachers' inclination towards using computers, was positively associated with pupil reading attainment. However, the independent relationship between challenges concerning the use of ICT and pupil learning can be regarded as uncertain or complicated. Perceived challenge concerning the use of ICT for teaching and learning purposes functions as an input and output interface between teacher characteristics and teacher behaviour. As an input channel for the formulation and development of teacher characteristics, better perception of challenge concerning the use of ICT would imply greater awareness and concerns. With proper mental effort and action, it would lead to teacher learning and development, as well as to improvement in teaching practice. This would have positive impact on pupil learning attainment and learning gains. As feedback to the teaching and learning environment, a large number of challenges perceived would indicate many difficulties met concerning the use of ICT. The impact of the difficulties met could lead to low academic attainment and low academic gains. As the direction of association is unsure, two-tailed correlation tests are used in the following study.

The awareness of the challenges associated with the use of ICT might have a negative impact on the teachers' attitude toward the resources available to their class or the support they can obtain from the school. This might have direct or indirect negative impact on pupils' attitude toward themselves and the school. Generally speaking, children like using computers at school. They might think computer activities attractive, enjoyable and helpful to their learning. They might associate the experience of using a computer with the feeling of being in fashion, well-resourced and well-thought of. If pupils become aware of or concerned about the insufficiency of ICT resources at school or the lack of support in their own use of ICT, they might begin to lose confidence. For parents who want to choose a school for their child, the amount of ICT resources and the availability of computer experience available for their child could be positively linked with their image of the school as well as their choice or preference.

Research hypotheses

It was expected that perceived challenges concerning the use of ICT for teaching and learning purposes would be:

- associated with pupil learning attainments in maths and reading,
- associated with pupil learning gains in maths and reading, and
- associated with pupil attitude towards themselves and the school, respectively.

Table T5-2-4: The results of two-tailed correlation tests (Pearson correlation statistics) between perceived challenges concerning the use of ICT for teaching and learning purposes and pupil learning outcomes in 1997/98

	chl_f1	chl_f2	chl_f3	chl_f4	chl_98
Maths attainments in 1997/98	-.13	-.02	.09	-.10	-.06
Reading attainments in 1997/98	.03	-.04	.27	.06	.10
Average attainments in 1997/98	-.05	-.03	.19	-.02	.02
Maths learning gains in 1997/98	-.13	.05	-.01	-.05	-.06
Reading learning gains in 1997/98	.11	.02	.28	.19	.19
Average learning gains in 1997/98	-.01	.04	.15	.08	.08
Attitude towards school in 1997/98	-.59**	-.45**	-.53**	-.73**	-.72**

Key: In each cell, the first statistic refers to Pearson correlation statistic (r), the number of valid samples is 36. ***chl_f1*** refers to personal challenges i.e. knowledge & skills about using ICT, ***chl_f2*** refers to psychological challenges i.e. personal interest, expectation and concerns, ***chl_f3*** refers to institutional and work-related challenges i.e. duties, workload and time available, ***chl_f4*** refers to practical and resource-related challenges i.e. the need for reliable equipment, technical support and additional supports for pupils, ***chl_98*** refers to the average of all the items measuring perceived challenges concerning the use of ICT to support teaching and learning. * refers to the result that was found to be statistically significant at p < .05 level in one-tailed test, ** refers to the result that was found to be statistically significant at p < .01 level in one-tailed test.

Due to the lack of valid cases, at the level of valid N > 20, only seven measures of learning outcome were available for the analysis. All the measures referred to pupil learning outcomes in 1997/98, while none of the measures in 1998/99 was available. All the correlation tests was done with valid N=36. The results are summarised in Table T5-2-4. In referring to the table, a clear negative association was found between pupil attitude towards themselves and the school and each of the measures of perceived challenge concerning the use of ICT at $p < .01$ level (two-tailed). The Pearson correlation statistics ranged from -0.45 to -0.73. The direction of these associations was consistently negative. This would mean the higher the extent of the overall challenge and the specific type of challenge perceived by a teacher, the lower their pupils' attitude towards themselves and the school. Alternatively, this would also mean the lower the extent of the overall challenge and the specific type of challenge perceived by a teacher, the higher their pupils' attitude towards themselves and the school. From the point of view of educational intervention, the results would imply that schools might be able to improve their pupils' attitude towards themselves and towards the school through strategies to support the use of ICT for teaching and learning purposes or strategies to reduce the perceived challenges concerning its use. As the size of associations was quite large, these strategies could be regarded as an effective means to promote positive images of their pupils and of schools. Undoubtedly, the present findings would be of interest to many school personnel for making decisions about the planning and the policy concerning ICT development. Nevertheless, the results of this study also suggest another issue that is worth taking into consideration.

The results also indicated that there was no simple pattern or direction of relationships between any measure of perceived challenge concerning the use of ICT for teaching and learning purposes and any of the academic learning outcomes in the study. One of the possible explanations is the complexity of the role that various measures of perceived challenge concerning the use of ICT play. Due to the lack of linkage between the perceived challenge measures and any academic outcomes, whether schools should aim at reducing the challenges concerning the use of ICT or promoting the use of ICT is a debatable question. Should teachers and other school personnel work against perceived challenges concerning the use of ICT for teaching and learning, aiming for a side effect - promoting pupils' confidence about themselves and the schools? Is it appropriate or ethical to help pupils build their confidence on the basis of their experience on expensive or attractive teaching equipment available in school, rather than on their own academic performance?

(5-2-4) The inter-relationships between challenges, pedagogy, teacher reflection and teaching practice supported by the use of ICT (i.e. the frequency, intensity and duration of computer use)

So far, the inter-relationships between challenges, pedagogy and teacher reflection have been addressed in various sections above. In the three sub-sections below, we shall focus on the potential links between each of these issues and teachers' practice concerning the use of ICT, which is represented by three selected measures of computer use. They are the frequency of class computer use, the opportunity for a typical pupil to have a turn on the computer and the duration of time that a pupil spent on a computer in a week. The ultimate aim is to investigate the potential factors affecting teaching practice with the use of ICT.

(5-2-4-1) The potential links between measures of perceived challenge concerning the use of ICT for teaching and learning purposes and teachers' practice concerning the use of ICT (i.e. the frequency, intensity and duration of computer use): a correlational study

As an input and output interface for the pedagogical practice supported by the use of ICT, there are close relationships between perceived challenges concerning the use of ICT and teachers' pedagogical preference concerning its use. When the level of perceived challenge concerning the use of ICT is high, teachers will be discouraged from using it. On the contrary, when the level of perceived challenge concerning the use of ICT is low, teachers will be encouraged to use it.

Research hypotheses

It was expected that perceived challenges concerning the use of ICT for teaching and learning would be negatively related to teachers' practice concerning the use of ICT, in terms of:

- the frequency of class usage of computers,
- the opportunity for a typical pupil in class to have a turn on the computer, and
- the amount of time that a pupil spends on the computer in a week.

Table T5-2-5: The results of one-tailed correlation tests (Pearson correlation statistics) between perceived challenges concerning the use of ICT for teaching and learning purposes and the frequency, intensity and duration of computer use

	chl_f1	chl_f2	chl_f3	chl_f4
ccom98	-.23* (71)	-.30** (71)	-.12 (71)	-.02 (71)
pcom98	-.23* (71)	-.21* (71)	-.26* (71)	-.21* (71)
ptim98	-.23* (70)	-.28** (70)	-.21* (70)	-.16 (70)

Key: In each cell, the first statistic refers to Pearson correlation statistic (r), the second one refers to the number of valid cases. ***chl_f1*** refers to personal challenges i.e. knowledge & skills about using ICT, ***chl_f2*** refers to psychological challenges i.e. personal interest, expectation and concerns, ***chl_f3*** refers to institutional and work-related challenges i.e. duties, workload and time available, ***chl_f4*** refers to practical and resource-related challenges i.e. the need for reliable equipment, technical support and additional supports for pupils. ***ccom98*** refers to the frequency of class usage of computers in 1998/99, ***pcom98*** refers to the intensity of pupil computer usage in 1998/99 (i.e. opportunity for a typical pupil in class to have a turn on the computer), ***ptim98*** refers to the duration of pupil computer usage in 1998/99 (i.e. the amount of time that a pupil spends on the computer in a week). * refers to the result that was found to be statistically significant at $p < .05$ level in one-tailed test, ** refers to the result that was found to be statistically significant at $p < .01$ level in one-tailed test.

In relation to the types of perceived challenge concerning the use of ICT, the negative relationships were explored through three series of correlation tests. The results were summarised in Table T5-2-5. The size of association is expressed in terms of Pearson correlation statistics (r), and all the associations that were found to be statistically significant are marked with asterisks.

The opportunity for a typical pupil in class to have a turn on the computer was found to be negatively related to each of the four sub-types of challenge concerning the use of ICT at $p < .05$ level. The amount of time that a pupil spent on the computer in a week was negatively related to the measure of perceived personal challenge, the measure of perceived psychological challenge and the measure of perceived institutional and work-related challenge at $p < .05$, $p < .01$, and at $p < .05$ level, respectively (as presented in the table). The frequency of class usage of computers was negatively related to the measure of perceived personal challenge and the measure of perceived psychological challenge at $p < .05$ level and at $p < .01$ level, respectively. Although results of other associations were not sufficiently strong to be accepted as significant at $p < .05$ level, the Pearson correlation statistics (r) were all negative. So, all the research hypotheses above were supported by the findings. To sum up, the significant findings above showed that teachers' knowledge and skills about using ICT; and their personal interest, expectation and concerns about its use was related to the extent of actual usage of ICT in primary classrooms.

(5-2-4-2) The potential links between measures of teachers' pedagogy (i.e. their personal judgement about the complexity of the challenges concerning the use of ICT and their pedagogical preferences) and teacher's practice concerning the use of computer (i.e. the frequency, intensity and duration of computer use): a correlational study

So far, two measures about teachers' pedagogy have been introduced in this thesis. These include teachers' personal judgement about the complexity of challenges concerning the use of ICT and their pedagogical preferences. The major differences between the two can be found in section 5-1-2-3 above. It might be sensible to expect that teachers' personal judgement about the complexity of the challenges concerning the use of ICT could have a negative relationship with the extent of computer use. The more complex that the teacher viewed the challenges concerning the use of ICT to support teaching and learning, the lower would be the extent of computer use by the teacher, and vice versa.

Nevertheless, the results of section 5-1-2-2 indicated that the pro-ICT pedagogical preference is positively related to some other pedagogical preferences. It might be reasonable to expect that there are links between computer usage measures and other aspects of pedagogical preference. For example, the extent of computer usage may not only be related to the pro-ICT preference, but it may also be related to the pupil control preference, open activities preference, collaborative work preference or language teaching preference. So, it is appropriate to investigate relationships between the extent of computer usage and each of the pedagogical preferences.

Research hypotheses

It was expected that each of the three aspects of computer use would be:

- negatively related to teachers' personal judgement about the complexity of challenges concerning the use of ICT to support teaching and learning,
- positively related to pro-ICT pedagogical preference,
- positively related to pedagogical preference for pupil control,
- positively related to pedagogical preference for open activities,

- positively related to pedagogical preference for collaborative work, and
- positively related to pedagogical preference for langugage teaching.

Data analysis and discussion

The first hypothesis was investigated by two sets of correlation tests. The first set was comprised of the correlation tests between teachers' personal judgement about the complexity of challenges concerning the use of ICT to support teaching and learning in 1997/98 and each of the three measures of computer use in the same academic year. The second set was comprised of the correlation tests between teachers' personal judgement about the complexity of challenges concerning the use of ICT to support teaching and learning in 1998/99 and each of the three measures of computer use in the same academic year.

No significant relationships were found between the measure of teachers' personal judgement about the complexity of challenges concerning the use of ICT in 1997/98 and each of the three measures of computer use in 1997/98, at $p < .05$ level with N=57, 58 and 57, respectively (two-tailed). The Pearson correlation statistics were 0.11, -0.01 and -0.03, respectively. Similarly, no significant relationships were found between the measure of teachers' personal judgement about the complexity of challenges concerning the use of ICT in 1998/99 and each of the three measures of computer use in 1998/99, at $p < .05$ level with N=57, 58 and 57, respectively (two-tailed). The Pearson correlation statistics were -0.07, -0.08 and -0.07, respectively. So, it is clear that the first research hypothesis above was not supported by the results of data analysis.

Table T5-2-6: The results of two-tailed correlation tests (Pearson correlation statistics) between teachers' pedagogical preferences and the frequency, intensity and duration of computer use

	Pro-ICT preference	Pupil control preference	Open activities preference	Collaborative work preference	Language teaching preference
ccom97	.17 (67)	.10 (67)	.00 (67)	.07 (67)	.27* (67)
ccom98	.13 (71)	-.00 (71)	-.00 (71)	.05 (71)	.03 (71)
pcom97	.22 (70)	.15 (70)	.19 (70)	.23 (70)	-.10 (70)
pcom98	.17 (71)	-.04 (71)	-.07 (71)	.12 (71)	-.09 (71)
ptim97	.29* (69)	.38** (69)	.32** (69)	.10 (69)	-.08 (69)
ptim98	.32** (70)	.28* (70)	.34** (70)	.16 (70)	-.18 (70)

Remark: In each cell, the first statistic refers to Pearson correlation statistic (r), the second one refers to the number of valid samples.

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 that a pupil spends on the computer in a week). * refers to the result that was found to be statistically significant at $p < .05$ level in one-tailed test, ** refers to the result that was found to be statistically significant at $p < .01$ level in one-tailed test.

The other research hypotheses above were investigated in terms of three series of correlation tests. The first series was focused on the relationships between the frequency of class computer use in 1997/98 or 1998/99 and each of the five pedagogical preference measures. Generally speaking, none of the results were found to be statistically significant except the positive relationship between the frequency of class computer use in 1997/98 and the language teaching preference measure at $p < .05$ level with N=67. The Pearson correlation statistic was 0.27. Having said that, no significant relationship was found between the frequency of class computer usage in 1998/99 and the language teaching preference measure at $p < .05$ level with N=71. The Pearson correlation statistic (r) was 0.03, which did not seem to give any support to the significant finding in 1997/98. Further examination of the set of Pearson correlation statistics (r) between language teaching preference and the extent of computer use was carried out. The direction of the association could be summarized as uncertain because the set of Pearson correlation statistics was comprised of positive and negative associations, and none of them were found to be statistically significant except the one mentioned above. The results do not satisfy the requirement of the test of significance for a series of statistical tests at $p < .05$ level, as suggested by Sakoda et. al. (1953). It therefore seems that the significant finding reported above could be a chance effect.

The second series of correlation tests focused on the relationships between the opportunity for a typical pupil in class to have a turn on the computer in 1997/98 or 1998/99 and each of the five pedagogical preference measures. None of the results were found to be statistically significant at $p < .05$ level. So, if the extent of computer use is defined as the frequency of class computer usage or the opportunity for a typical pupil in class to have a turn on the computer, none of the five research hypotheses concerning pedagogical preferences mentioned above were supported by the results of data analysis.

The third series of correlation tests were focused on the relationships between the amount of time that a typical pupil spent on the computer in a week in 1997/98 or 1998/99 and each of the five pedagogical preference measures. The results reported in Table T5-2-6 indicated that this aspect of computer was positively related to:

- pro-ICT pedagogical preference at $p < .05$ level,
- pedagogical preference for pupil control at $p < .05$ level, and
- pedagogical preference for open activities $p < .01$ level, respectively.

Furthermore, the results suggested that the relationship existed in both academic years 1997/98 and 1998/99. The respective sizes and directions of the significant associations seemed to be quite consistent, as reported in the table. So, the results supported the second, the third and the fourth research hypotheses above, but they did not support the fifth and the sixth research hypotheses.

(5-2-4-3) The potential links between measures of teacher reflection and teaching practice concerning the use of computers (i.e. the frequency, intensity and duration of computer use): a correlational study

Further to our discussions in section 5-1-2-2 and other sections above, we might conclude that teachers who have "emancipatory" or "legislative/judicial" thinking styles seemed to be open-minded, enthusiastic, thoughtful and creative toward their own learning and practice. And these personal characteristics seem to be related to the preference for the use of ICT.

It is worthwhile to note that this kind of personal characteristics are similar to the characteristics of reflective practitioners outlined by John Dewey. He stated that the development of reflection was linked with the development of several attitudes and abilities of the practitioner, including open-mindedness, self-direction and whole-heartedness (Dewey, 1933). Compared with other people who perform their job as a routine or habit, thoughtful or reflective teachers are aware of discomforts in their own practice and are willing to learn from experience. The self-evaluation becomes the starting point for self-improvement in the profession. In the long run, they will be well-prepared for or capable of making themselves adapt to new ideas, educational innovations or changes in pedagogy. In particular, teachers who are critically reflective will be good at acting as assessors or reviewers of their own thinking and practice. So, it is expected that teachers' practice concerning the use of ICT will be related to or affected by their own reflection because it plays a role in their learning and development and the use of ICT is one of the fashionable educational innovations.

Research hypotheses

It was expected that each of the three measures concerning the extent of computer use (i.e. the frequency of class computer usage, the opportunity for a typical pupil in class to have a turn on the computer, and the amount of time that a typical pupil spent on the computer in a week) would be:

- negatively related to the measure of habitual action,
- positively related to the measure of thoughtful application,
- positively related to the measure of critical reflection, and

- positively related to the measure of premise self-reflection.

Data analysis and discussion

Table T5-2-7: The results of two-tailed correlation tests (Pearson correlation statistics) between measures of teachers' reflective learning and practice and the frequency, intensity and duration of computer use

	habitual action	thoughtful application	Critical reflection	premise self-reflection
ccom97	.00 (104)	-.11 (105)	-.09 (105)	.24* (103)
ccom98	-.01 (113)	.07 (114)	.06 (114)	.13 (112)
pcom97	.19* (106)	.07 (107)	.01 (107)	.07 (105)
pcom98	-.04 (113)	.02 (114)	-.06 (114)	.13 (112)
ptim97	.07 (102)	-.11 (103)	-.14 (103)	.04 (101)
ptim98	-.05 (108)	.13 (109)	.14 (109)	.25** (107)

Key: In each cell, the first statistic refers to Pearson correlation statistic (r), the second one refers to the number of valid samples. ***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 that a pupil spends on the computer in a week). * refers to the result that was found to be statistically significant at $p < .05$ level in one-tailed test, ** refers to the result that was found to be statistically significant at $p < .01$ level in one-tailed test.

Four sets of correlation tests were performed in relation to the four research hypotheses above. The results are presented in Table T5-2-7. In the first set of correlation tests, habitual action was found to be positively related to the opportunity for a typical pupil in class to have a turn on the computer in 1997/98 at $p < .05$ level with N=106 (two-tailed). The Pearson correlation statistic (r) was 0.19. None of the results of the other correlation tests in this set were statistically significant, at $p < .05$ level. With a closer look at the Pearson correlation statistics (r) of this set, the directions of associations could be described as inconsistent. Although it is unclear whether the finding is a chance effect, it is obvious that the first research hypothesis is not supported by the analysis of data.

The results of the second set and the third set of correlation tests did not suggest any significant relationship between the respective aspects of computer usage and the two measures of reflection at $p < .05$ level. So, the second and the third research hypotheses were not supported by the results of data analysis. In the fourth set of correlation tests, premise self-reflection measure was found to be positively related to the opportunity for a typical pupil in class to have a turn on the computer in 1997/98 at $p < .05$ level and the amount of time that a typical pupil spent on the computer in a week in 1998/99 at $p < .01$ level, respectively. The Pearson correlation statistics were 0.24 and 0.25, respectively. The results of the other correlation tests in this set were not sufficiently strong to be accepted as significant at $p < .05$ level. Although two of the associations were very small in size and close to 0, all the Pearson correlation statistics (r) were found to be positive. And the results have satisfied the requirement of the test of significance for a series of statistical tests at $p < .05$ level, as suggested by Sakoda et. al. (1953). So, it is unlikely that the results happened by chance and the fourth research hypothesis is partially supported by the results of data analysis. To interpret the results, the four measures of reflection refer to four potential modes for transformation of experience uncovered by the transformative learning theory. The results of the data analysis support the claim that premise self-reflection is the only mode for the transformation of experience and that leads to the change in perspective and reinterpretation of the problem, as mentioned in the transformative learning theory (Mezirow, 1991). In addition to the results reported in section 5-2-4-2, the present results suggest that the change in personal pedagogical judgement concerning the use of ICT is linked to the extent of its use through reflective thinking and practice. In other words, reflection is the bridge that links the change in personal knowledge, attitude or belief concerning the use of ICT and the teaching practice concerning the use of ICT. It is the potential link between the theory and the practice concerning the use of ICT for teaching and learning purposes.

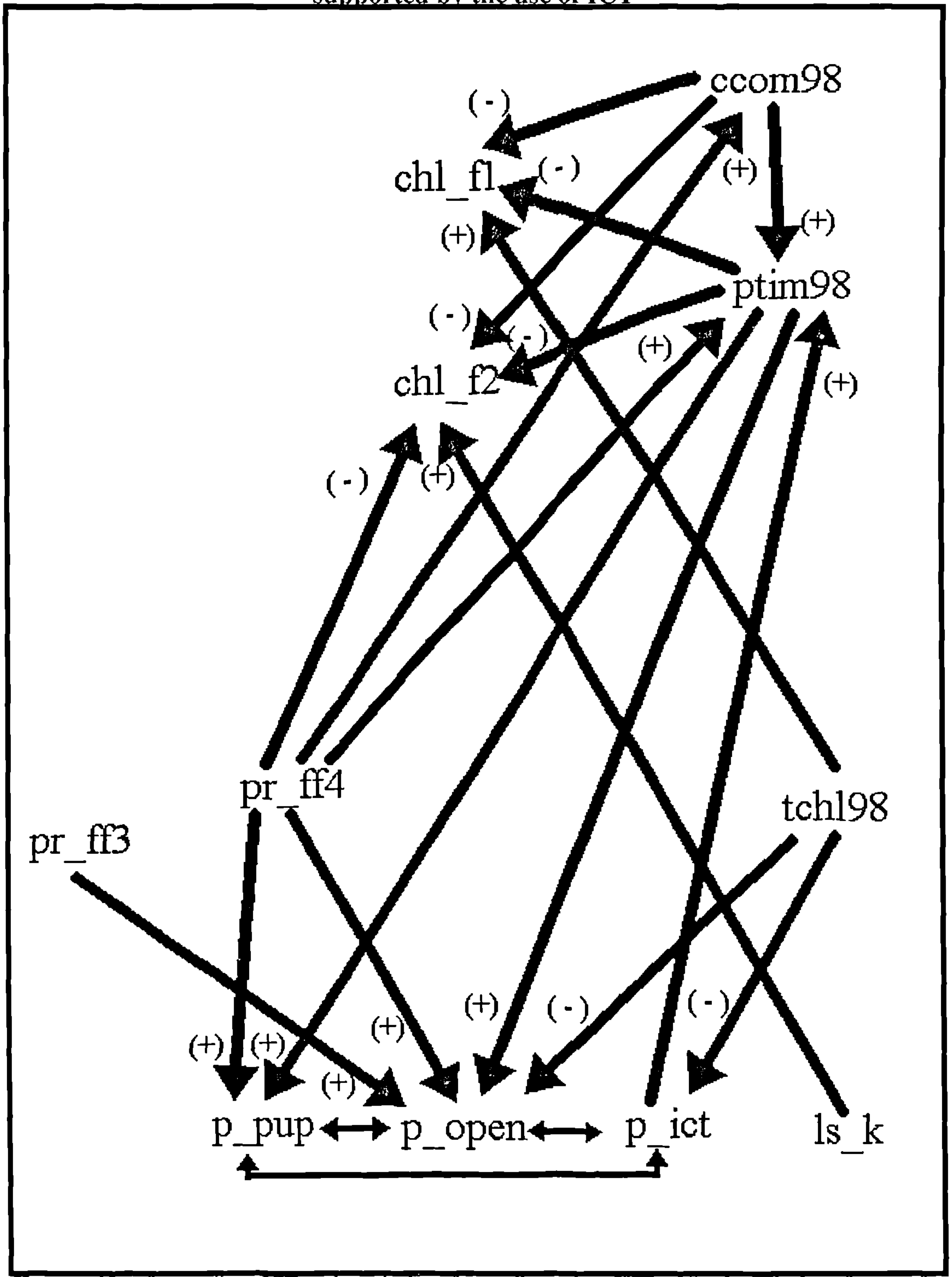
(5-2-5) Linking the results of the correlational studies together: a preliminary path model explaining the development of pedagogy supported by the use of ICT

In this section, we shall try to link the results of the correlational studies together. It will be summarised as a path model explaining the development of pedagogy supported by the use of ICT. The proposed model will be examined against the collected data. The limitations of the model will also be discussed.

(5-2-5-1) Linking the correlation results together as a proposed path model

Instead of integrating all the significant findings of the correlational studies together, it will be straightforward and time-saving to focus on some of the key components of a variable group which appear to have links with components of the other variable groups. The selected components and the proposed links are presented as a proposed path model in Illustration I5-2D. The paragraphs below will try to explain the mechanism.

Illustration I5-2D: A proposed model explaining the development of pedagogy supported by the use of ICT



Keys: ***p_ict*** refers to "pro-ICT pedagogical preference", ***p_pup*** refers to "pedagogical preference for pupil control", ***p_open*** refers to "pedagogical preference for open activities", ***pr_ff3*** refers to "critical reflection", ***pr_ff4*** refers to "premise self-reflection", ccom98 refers to "the frequency of class usage of computers", ***ptim98*** refers to "the amount of time that a pupil in class spends on the computer in a week variable", ***chl_f1*** refers to "perceived personal challenges concerning the use of ICT for subject teaching and learning", ***chl_f2*** refers to "perceived pschological challenges concerning the use of ICT for subject teaching and learning", ***tchl98*** refers to "teachers" personal judgement about the complexity of challenges concerning the use of ICT", ***ls_k*** refers to "abstract conceptualization learning orientation".

The author of this thesis would like to start with the results and discussions reported in section 5-2-4-2 and 5-2-4-3. It has been suggested that teachers' redefinition of the pedagogical problem concerning the use of ICT will lead to a new direction of actions toward their practice concerning the use of ICT. When premise self-reflection (pr_ff4) works together with an increase in the pro-ICT pedagogical preference (p_ICT), they will lead to an increase in the amount of time that a pupil in class spends on the computer in a week (ptim98). For instance, a teacher who rarely uses ICT in his or her own subject teaching may have his or her attitudes toward using ICT changed after the discovery of a wrong personal assumption about using ICT. The change in attitude will also have positive impacts on the extent of computer use.

It is also proposed that premise self-reflection may have indirect and positive impacts on the amount of time that a pupil in class spends on the computer in a week (ptim98) through the frequency of class usage of computers variable (ccom98). This is supported by the results of the two-wave two-variable analysis (2W2V) in chapter 4, which have suggested that the frequency of class usage of computers (ccom98) is a factor affecting the amount of time that a pupil in class spends on the computer in a week (ptim98).

As a form of direct feedback for the learning and development, the amount of time that a pupil in class spends on the computer in a week (ptim98) affects the pedagogical preference for pupil control (p_pup) and the pedagogical preference for open activities (p_open). Alternatively, the feedback may take the form of negative impacts on the perceived psychological challenges concerning the use of computers variable (chl_f2). To expand this, the two measures of the extent of computer usage (i.e. ccom98 & ptim98) are proposed as factors that affect the two challenge variables (i.e. chl_f1 & chl_f2). The proposed relationships originated from the results of section 5-2-4-1, in which all the relationships are negative.

In the proposed model, there are other factors affecting pedagogical preferences. In relation to the correlational results reported in section 5-1-2-5, critical reflection (pr_ff3) and premise self-reflection (pr_ff4) are proposed as positive factors affecting the pedagogical preference for open activities (p_open). And critical reflection (pr_ff3) is proposed as a positive factor affecting the pedagogical preference for pupil control (p_pup). Given that the results of these correlational studies have consistently suggested that reflection plays a key role in teacher learning and development, this chapter will examine whether the proposed cause-and-effect relationships between reflection and the development of pedagogy are supported by the data. In relation to the correlational results reported in section 5-1-2-3, teachers' personal judgement about the complexity of challenges concerning the use of ICT in 1998/99 (tchl98) is proposed as a negative factor affecting the pedagogical preference for open activities and pro-ICT pedagogical preference (p_ict), respectively.

Nevertheless, with reference to the correlational results in section 5-1-2-3, teachers' personal judgement about the complexity of challenges concerning the use of ICT in 1998/99 (tchl98) is also proposed as a positive factor affecting the perceived personal challenges concerning the use of ICT (chl_f1). With reference to the results of section 5-2-3-3, premise self-reflection (pr_ff4) and abstract conceptualisation learning orientation (ls_k) are proposed as factors affecting the perceived psychological challenges concerning the use of computers (chl_f2). The former relationship is negative and the latter relationship is positive in nature. Finally, there are significant associations between the three pedagogical preferences. In relation to the findings reported in section 5-2-2-2, all of them are positive in nature.

(5-2-5-2) Testing the proposed path model explaining the development of pedagogy supported by the use of ICT

The proposed path model is examined by a series of multiple regression analyses. The major difference between the correlation technique and the multiple regression technique is in the relationship between the target variable and the predictor(s). The correlation technique only allows one target variable and one predictor, but the multiple regression technique can allow the target variable to be predicted by one or more than one predictor.

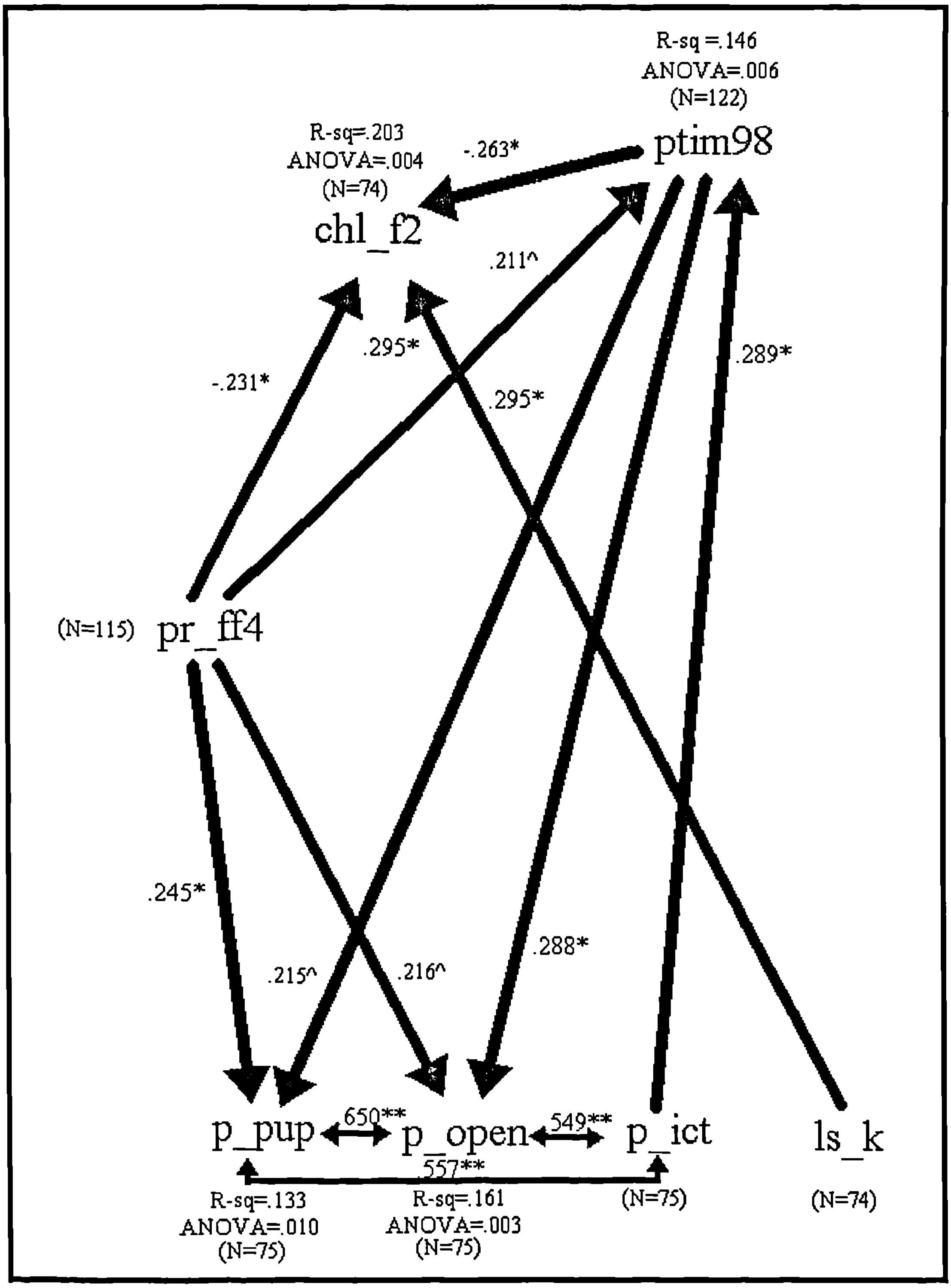
Each of the one-way arrows in the proposed path model is pointing from a predictor to a target variable. It is technically named as a "path". Some target variables in the proposed path model are predicted by one predictor, however, some of the target variables in the proposed path model are predicted by more than one predictor. It may be worthwhile to note that the relationship examined by the multiple regression technique is also correlational in nature. Unlike the relationship examined by the correlation technique, the relationship examined by the multiple regression technique can give us some confidence about the presence of a cause-and-effect relationship, when there are two or more predictors in the regression model. For example, given that a target variable is significantly correlated with three variables independently; when the variance of the target variable is found to be explicable by the simultaneous work of the three variables, the target variable is likely be the effect rather than the cause of the three variables. So, to examine the proposed relationships, the multiple regression technique will be more appropriate than the correlation technique.

Research hypothesis

In relation to the discussion in section 5-2-5-1, it was expected that:

- the dependent variables could be explained by the simultaneous work of the group of independent variables in the proposed path model, and
- the polarity of each of the paths would match with the respective polarity specifications as presented in the proposed path model.

Illustration I5-2E: A preliminary model explaining the development of pedagogy supported by the use of ICT



Keys: ***p_ict*** refers to "pro-ICT pedagogical preference", ***p_pup*** refers to "pedagogical preference for pupil control", ***p_open*** refers to "pedagogical preference for open activities", ***pr_ff4*** refers to "premise self-reflection", ***ptim98*** refers to "the amount of time that a pupil in class spends on the computer in a week variable", ***chl_f2*** refers to "perceived pschological challenges concerning the use of ICT for subject teaching and learning", ***ls_k*** refers to "abstract conceptualization learning orientation".

Data analysis and discussion

The results of data analysis are summarised in Illustration I5-2E. It is formed by the results of four multiple regression models. Only paths that were found to be statistically significant are reported. Paths that were not found to be statistically significant have been dropped from the model. Apart from that, some other multiple regression analyses were performed to clarify the direction of paths. All the test results had been checked against collinearity and they were accepted at a specific statistical level of significance. The statistical findings at:

- $p < .01$ level are considered as good and acceptable,
- $p < .05$ level are considered as acceptable, and
- $.05 < p < .10$ level are considered as marginally acceptable.

The first multiple regression model was formulated by using the premise self-reflection variable (pr_ff4) and pro-ICT pedagogical preference variable (p_ict) to predict the amount of time that a pupil in class spends on the computer in a week, variable (ptim98). The results of ANOVA indicated that there is a significant linear relationship between the group of predictors and the target variable, at $p < .01$ level. The two predictors can predict 15% of the variance of the target variable. The path coefficients are .289 and .211, and coefficient estimation is accepted at $p < .05$ level and at $.05 < p < .10$ level. The details of the results are presented in Table T5-2-8.

The second multiple regression model was formulated by using the amount of time that a pupil in class spends on the computer in a week, variable (ptim98), abstract conceptualization learning orientation variable (ls_k) and premise self-reflection variable (pr_ff4) to predict the perceived psychological challenges concerning the use of computers variable (chl_f2). The results of ANOVA indicated that there is a significant linear relationship between the group of predictors and the target variable, at $p < .01$ level. The two predictors can predict 20% of the variance of the target variable. The path coefficients are -0.263, 0.295 and -0.231, and coefficient estimation is accepted at $p < .05$ level, at $p < .01$ level and at $p < .05$ level, respectively. The details of the results are presented in Table T5-2-8.

Table T5-2-8: The results of two multiple regression models

Target variable (N)	R-square	ANOVA sig.	Predictors (N)	Beta	Sig.
ptim98 (122)	.146	.006	p_ict (75)	.289	.015
			pr_ff4 (115)	.211	.073
chl_f2 (74)	.203	.002	ptim98 (122)	-.263	.025
			ls_k (74)	.295	.010
			pr_ff4 (115)	-.231	.046

So far, it might be worthwhile to note that some other statistical analyses were performed to clarify the direction of the paths. Some of the results of these multiple regression analyses are not statistically significant, however, it will be good to consider them as alternatives to the two other multiple regression models to be reported in the sub-sections below. The results of the rejected model are particularly useful for the examination of the direction of the paths and the clarification of cause-and-effect relationships.

(5-2-5-2A) Investigation into the cause-and-effect relationships between two measures of the extent of computer use and two measures of perceived challenge concerning the use of ICT

The path pointing from the amount of time that a pupil in class spends on the computer in a week, variable (ptim98) to the perceived psychological challenges concerning the use of computers, variable (chl_f2) has been tested empirically before deciding on its direction. Basically, two sets of two alternative models were formed. The two alternative models in each set have specified paths in opposite directions. The results of the statistical work are reported in Table T5-2-9.

Table T5-2-9: The results of multiple regression analyses that facilitate the identification of cause-and-effect relationships between two measures of the extent of computer use and two measures of perceived challenge concerning the use of ICT

Target variable (N)	R-square	ANOVA sig.	Predictors (N)	Beta	Sig.
chl_f1 (74)	.096	.035	ptim98 (122)	-.211	.075
			ccom98 (128)	-.211	.074
chl_f2 (74)	.241	.001	ptim98 (122)	-.249	031
			ccom98 (128)	-.201	.078
			pr_ff4 (115)	-.205	.075
			ls_k (74)	.248	.032
ccom98 (128)	.093	.086	chl_f1 (74)	-.063	.677
			chl_f2 (74)	-.243	.118
			pr_ff4 (115)	.051	.673
ptim98 (122)	.191	.090	chl_f1 (74)	.061	.770
			chl_f2 (74)	-.253	.213
			pr_ff4 (115)	.153	.331
			p_ict (75)	.300	.070

The decision to be made is to identify the target variables with the help of the results of multiple regression analyses. The choices to be considered are the two sets of variables. The results will determine whether the two perceived challenge measures or the two measures on the extent of computer use are relatively appropriate to be used as target variables. By checking the results in the ANOVA significance column and the (Beta) significance column, it is clear that the two perceived challenge measures are affected by the two measures on the extent of computer use. So, the decision to treat the perceived psychological challenges concerning the use of computers variable (chl_f2) as the target variable and the amount of time that a pupil in class spends on the computer in a week variable (ptim98) as the predictor is backed up by the results of this statistical work.

(5-2-5-2B) Investigation into the cause-and-effect relationships between the amount of time that a pupil in class spends on the computer in a week, pedagogical preference for pupil control, pedagogical preference for open activities and premise self-reflection

Two sets of two alternative models were formed to investigate the cause-and-effect relationships between the amount of time that a pupil in class spends on the computer in a week, pedagogical preference for pupil control, pedagogical preference for open activities and premise self-reflection. The two alternative models in each set have specified paths in opposite directions. The results of the statistical work are reported in Table T5-2-10.

Table T5-2-10: The results of multiple regression analyses that facilitate the identification of cause-and-effect relationships between the amount of time that a pupil in class spends on the computer in a week, pedagogical preference for pupil control, pedagogical preference for open activities and premise self-reflection

Target variable (N)	R-square	ANOVA sig.	Predictors (N)	Beta	Sig.
p_pup (75)	.133	.010	pr_ff4 (115)	.245	.044
			ptim98 (122)	.215	.076
p_open (75)	.161	.003	pr_ff4 (115)	.216	.070
			ptim98 (122)	.288	.017
pr_ff4 (115)	.105	.027	p_pup (75)	.193	.217
			p_open (75)	.164	.293
ptim98 (122)	.169	.019	p_open (75)	.190	.239
			p_pup (75)	-.006	.968
			pr_ff4 (115)	.172	.164
			p_ict (75)	.194	.186

By checking the results in the ANOVA significance column and the (Beta) significance column, it is clear that the premise self-reflection variable (pr_ff4) and the amount of time that a pupil in class spends on the computer in a week variable (ptim98) are more likely to be the factors affecting the pedagogical preference for pupil control (p_pup) or the pedagogical preference for open activities (p_open) than the other way round. So, the third and the fourth models accepted in "the preliminary path model explaining the development of pedagogy supported by the use of ICT" was formulated by using the the premise self-reflection variable (pr_ff4) and the amount of time that a pupil in class spends on the computer in a week variable (ptim98) as predictors. The pedagogical preference for pupil control (p_pup) was the target variable for the prediction made in the third model and the pedagogical preference for open activities (p_open) was the target variable for the prediction made in the fourth model. Lastly, in the model, there are correlations between the three pedagogical preferences. The Pearson correlation statistics are 0.65, 0.56 and 0.55.

Nevertheless, in the "preliminary path model explaining the development of pedagogy supported by the use of ICT", it might be worthwhile to note that all the paths that link premise self-reflection (pr_ff4) are going outward because premise self-reflection is a form of meta-cognitive activity. Given that meta-cognition often functions as a manager or organiser of other cognitive activities, we should also note that premise self-reflection can be affected by some of the activities mentioned in the model. For instance, it is possible that both the perceived psychological challenges concerning the use of computers (chl_f2) and the premise self-reflection (pr_ff4) are linked with one another simultaneously; however, this type of "bi-directional" relationship cannot be addressed by the path modelling technique. If we assume that the relationship between the two variables is bi-directional, the reasons for ending up with a negative polarity in the proposed path model could be accounted for by the combination of a large negative effect and a small positive effect. On this basis, we can speculate that the cause-to-effect relationship between premise self-reflection (pr_ff4) and the perceived psychological challenges concerning the use of computers (chl_f2) is positive in nature, as supported by findings in section 5-2-3-3. The impact of the latter on the former, if there is any, could be interpreted as a form of psychological feedback of the perceived challenges concerning the use of ICT to support subject teaching and learning. And the relationship would be positive in nature because it acts as a stimulus or a trigger for premise self-reflection. And the discussion leads us to think about the limitations of the multiple regression technique or the path modelling technique, which is going to be extended in the section 5-2-5-3.

(5-2-5-3) Limitation of the preliminary model and conclusion

Limitation of the preliminary model

Having said that, the preliminary model has its limitations. Generally speaking, the size of path coefficients is small. It might reflect teachers' lack of an active and positive attitude toward professional development. Many teachers in this country would like to put the teaching topics and methods in a yearly plan. To change what had been set in the plan, such as incorporating the use of ICT, could be viewed as "innovative". Extra efforts or initiatives are needed to facilitate teachers to move a step forward from their existing practice. Alternatively, the low effect size could be due to the limitation of equipment and resources available for schools. If this is true, an ideal experimental environment with rich-resources and inputs might lead to a large effect size.

In the path modelling technique, the cause-and-effect relationship is described as a one-way flow system. The proposed direction of the path, rather the other way round, is believed to be the major impact pointing from the cause to the effect variables. However, the assignment of direction seems to be subjective and arbitrary. Since the path modelling technique does not allow researchers to consider the potential relationships in a bi-directional way, it becomes a major limitation of the technique. In fact, similar to the confirmatory factor analysis technique, the path modelling technique is a special form of structural equation modelling method, which can examine cause-and-effect relationships in a bi-directional system. It is the recommended research method for future researches of this type.

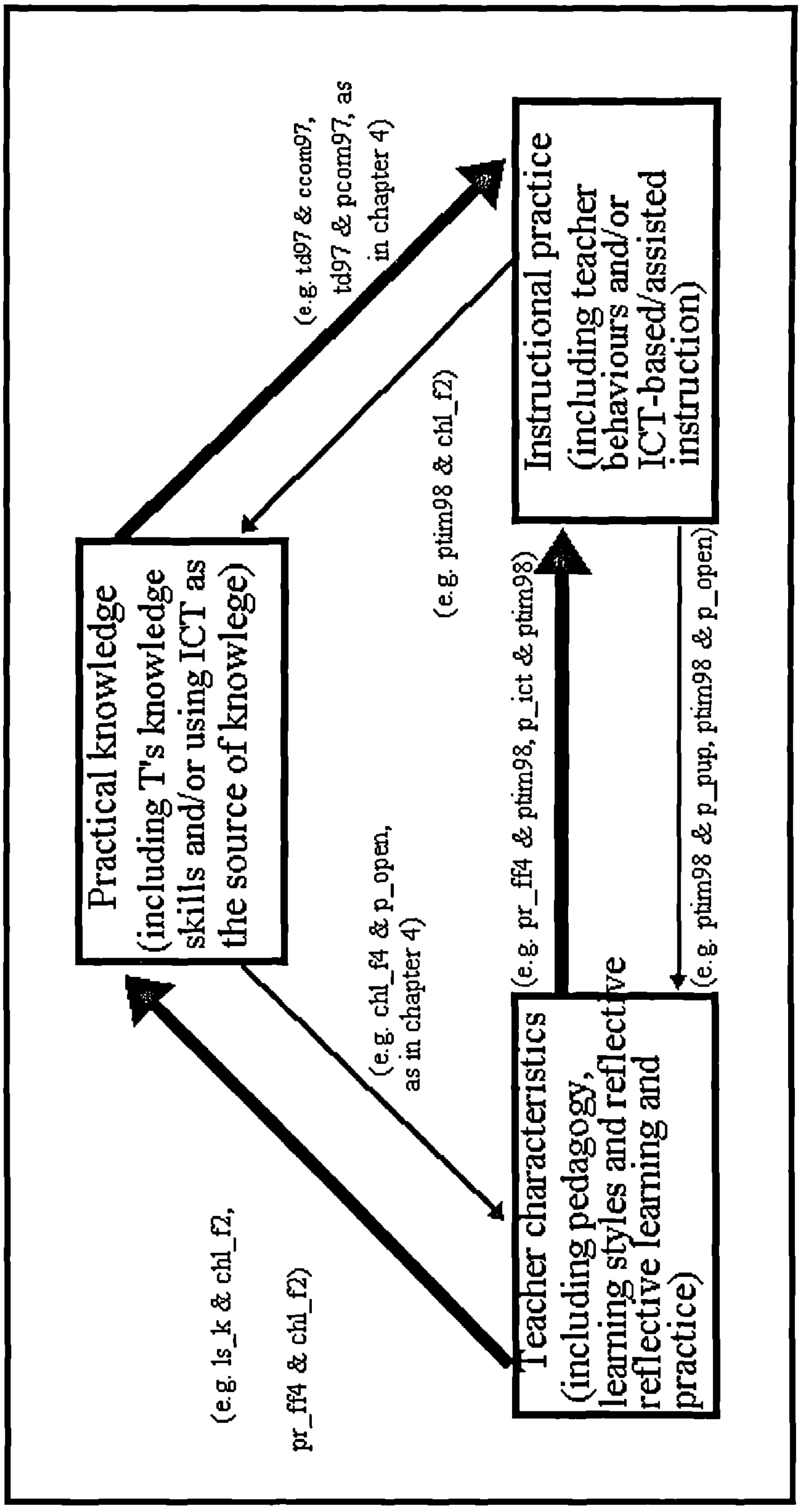
The results of the model have successfully confirmed the polarity of each of the paths specified in the proposed model. The path estimations and the direction of the paths addressed in the model seem to be useful for our understanding of pedagogy, a pedagogy that is supported by the use of ICT. However, although attempts were made to clarify the direction of the paths (e.g. statistical validations, dropping the uncertain ones), the preliminary model would inevitably contain paths with mis-specified direction. So, it would be unwise to ignore the potential of paths in the reversed direction, which could have been rejected by the result of data analysis. It is hoped that the direction issue and the preliminary model can function as a spark for future research on pedagogy supported by the use ICT.

Conclusion

This chapter has made attempts to explore the inter-relationships between pedagogy, teacher reflection, perceived challenges concerning the use of ICT and the extent of computer use through a series of correlational studies. To establish the ground for these statistical explorations, examinations were made of the reliability of measurement, as well as of the structure and the composition of the factors. Then, the results of correlational studies were summarised as a proposed model explaining the development of pedagogy supported by the use of ICT. The fitness of the proposed model was examined through further data analyses reported in this chapter. Finally, a preliminary model is formulated, with theoretical and empirical grounds. Together with some other findings in the thesis, the results reported in this chapter give support to the relationships between pedagogy, practical knowledge and instructional practice presented by "the model of effective curricular teaching and learning supported by computers or other types of ICT" introduced in chapter 2.

The results of this chapter and those of chapter 4 support the hypothesis that there are direct and indirect bi-directional cause-and-effect relationships between teacher characteristics and instructional practice through practical knowledge. As examples of some of the paths presented in the diagram, significant findings concerning the cause-and-effect relationships are presented in the diagram. The results are summarised in Illustration I5-2F.

Illustration I5-2F: Inter-relationships between teacher characteristics, practical knowledge and instructional practice



Remark/Keys: ***ls_k & chl_f2*** refers to "abstract conceptualization learning orientation & perceived pschological challenges concerning the use of ICT for subject teaching and learning", ***pr_ff4 & chl_f2*** refers to "premise self-reflection & perceived pschological challenges concerning the use of ICT for subject teaching and learning", ***td_97 & ccom97*** refers to "teacher's tendency towards using computers & the frequency of class usage of computers" (refer to findings in Chapter 4), ***td_97 & pcom97*** refers to "teacher's tendency towards using computers & opportunity for a typical pupil in class to have a turn on the computer" (refer to findings in Chapter 4), ***pr_ff4 & ptim98*** refers to "premise self-reflection & the amount of time that a pupil in class spends on the computer in a week variable", ***p_ict & ptim98*** refers to "pro-ICT pedagogical preference & the amount of time that a pupil in class spends on the computer in a week variable", ***chl_f4 & p_open*** refers to "perceived practical and resource-related challenges concerning the use of ICT for subject teaching and learning & pedagogical preference for open activities" (refer to findings in Chapter 4), ***ptim98 & chl_f2*** refers to "the amount of time that a pupil in class spends on the computer in a week variable & perceived psychological challenges concerning the use of ICT for subject teaching and learning", ***ptim98 & p_pup*** refers to "the amount of time that a pupil in class spends on the computer in a week variable & pedagogical preference for pupil control", ***ptim98 & p_open*** refers to "the amount of time that a pupil in class spends on the computer in a week variable & pedagogical preference for open activities".

Summary of chapter 5

- No links between the measures of reflection on the basis of experiential learning theory and on the basis of transformative learning theory were found in this study. The results suggest a difference in the definition of "reflection" and "transformation" in the two theories.
- Pro-ICT pedagogical preference was negatively related to pupil learning attainment and learning gains in maths and reading. It implies that positive attitude towards using ICT for subject teaching, without careful consideration and without sufficient teacher efforts, could have negative impacts on pupil learning.
- Four categories of perceived challenges concerning the use of ICT for teaching and learning purposes were identified. These include:
  - personal challenges e.g. knowledge and skills about using ICT;
  - psychological challenges e.g. personal interest, expectation and concerns;
  - institutional and work-related challenges e.g. duties, workload and time available; and
  - practical and resource-related challenges e.g. the need for reliable equipment, technical support and additional supports for pupils.
- There are inter-relationships between various aspects of teacher characteristics, teacher's practical knowledge and instructional practice (e.g. pedagogical preferences, teacher reflection, and the perceived challenges concerning the use of ICT in practice). The results give support to the "model of effective curricular teaching and learning supported by computers or other types of ICT" introduced in Chapter 2.

- The results for the major research hypotheses or major study focuses in this chapter are summarised in the table below:

Remark:
"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 and "~" refers to uncertain. "Des." refers to results of descriptive statistics, "Corr." refers to the results of correlation test(s), "One-way" refers to the results of one-way analysis of variance (ANOVA), "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]
5-1-1-2-1	It examines the internal consistency of 2 sets of 2 measurement scales (i.e. AC-CE, AE-RO, AC+CE and AE+RO) concerning adaptive competence. A scale with alpha statistic > or = 0.7 is reasonably good.	Each of the 4 scales has good internal consistency, with alpha statistics between 0.83 to 0.89. [T5-1-4]
5-1-1-2-2	It was expected that the results of confirmatory factor analysis would demonstrate the goodness of fit of the four-factor model of reflection.	Chi-sq: * (explaining 61% of the total item variance)
5-1-1-3	It investigates the potential links between two theories of reflection and transformation. It was expected that: • the measure of reflective observation learning orientation would be positively related to the critical reflection or premise self-reflection measures, and • the measure of active and reflective learning orientation (or adaptive competence) would be positively related to the critical reflection or premise self-reflection measure, and • the measure of active experimentation would be positively related to the habitual action measure.	[T5-1-8] Corr.: x x x x x
5-1-2-1	It was expected that more teachers in the 1997/98 survey would think challenges concerning the use of ICT for subject teaching is a problem than in the 1998/99 survey.	[T5-1-9] Des.: 76.9% in 1997/98 66.2% in 1998/99 T-test: **
5-1-2-2	It was expected that the results of factor analysis would show the existence of five aspects of pedagogical preference embedded in the data. It was also expected that pro-ICT preference would have a positive relationship with the other 4 pedagogical preferences, respectively.	Clearly supported [T5-1-10] Sig. corr.: pupil control preference ** open activity preference ** collaborative work preference **
5-1-2-3	It was expected that teachers' personal judgement about the complexity of challenges concerning the use of ICT to support subject teaching would be: • negatively related to pro-ICT preference, • negatively related to pupil control preference, • negatively related to open activities preference, • negatively related to collaborative work preference, and • positively related to language teaching preference.	Corr. (i.e. concerning the use of ICT in 1997/98): ** x * x *

5-1-2-4	It was expected that:	Corr. (concerning 1997/98 and 1998/99):
	• the abstract conceptualisation learning orientation would be negatively related to the measures of the complexity of challenges concerning the use of ICT to support subject teaching in section 5-1-2-1 above,	x x
	• the reflective observation learning orientation would be negatively related to the measures of the complexity of challenges concerning the use of ICT to support subject teaching in section 5-1-2-1 above,	x x
	• the critical reflection measure would be negatively related to the measures of the complexity of challenges concerning the use of ICT, and	x x
	• the premise self-reflection measure would be negatively related to the measures of the complexity of challenges concerning the use of ICT.	x x
	It was also expected that the four groups of teachers with different changes in personal judgement about the complexity of challenges concerning the use of ICT between 1998/99 and 1997/98 (as mentioned in section 5-1-2-1 above) would have different:	One-way ANOVA:
	• extent of usage of critical reflection, and	* (or ~ *)
	• extent of usage of premise self-reflection.	x
5-1-2-5	It was expected that each of the five aspects of pedagogical preference (i.e. pro-ICT preference, pupil control preference, open activities preference, collaborative work preference, language teaching preference) would be:	Corr.:
	• related to the reflective observation measure,	x x x x x
	• related to the critical reflection measure, and	x x * x x
	• related to the premise self-reflection measure.	x * * x x
5-1-3-1	In relation to Kolb's ideas about the characteristics of the teaching profession, it was expected that:	Corr. (with 6 outcome measures) [T5-1-11]:
	• the measure of "concrete experience" (CE) learning orientation would be negatively related to the learning outcome measures above,	* * * x * x
	• the measure of "active experimentation" (AE) learning orientation would be negatively related to the learning outcome measures above,	x x x x x x
	• the measures of "reflective observation" (RO) learning orientation would be positively related to the learning outcome measures above, and	x * * x * *
	• the measures of "abstract conceptualisation" (AC) learning orientation would be positively related to the learning outcome measures above.	x x x x x x

	In relation to the conceptions and interpretations of adaptive competence in section 5-1-1-2-1 above, it was expected that:	Corr. (with 6 outcome measures) [T5-1-11]:
	• the difference between abstract conceptualisation and concrete experience (AC-CE) learning orientation would be related to the learning outcome measures above,	x x x x x x
	• the difference between abstract experimentation and reflective observation (AE-RO) learning orientation would be negatively related to the learning outcome measures above,	x x x x ~* x
	• the sum of abstract conceptualisation and concrete experience (AC+CE) learning orientation would be positively related to the learning outcome measures above, and	~* ~* ~* x ~* ~*
	• the sum of abstract experimentation and reflective observation (AE+RO) learning orientation would be positively related to the learning outcome measures above.	~* ~* ~* x ~* ~*
5-1-3-2	It was expected that (12 measures of outcome in 1997/98 and 6 measures of outcome in 1998/99):	Corr. [T5-1-13] (a total of 18 outcome measures):
	• the extent of use of habitual action would be negatively related to various learning outcome measures, as mentioned in chapter 4 section 4-1	x x x x -* x x x x x x x x x x x x x
	• the extent of use of thoughtful application would be positively related to the learning outcome measures above,	x x x x x x x * x x x x x * * x x x
	• the extent of use of critical reflection would be positively related to the learning outcome measures above,	x x x x x x x x x x * x x x x x x x
	• the extent of use of premise self-reflection would be positively related to the learning outcome measures above, and	x x x x x x x x * * x x x x x x x x
	• the extent of use of reflection (i.e. including thoughtful application, critical reflection and premise self-reflection) would be positively related to the learning outcome measures above.	Supported * (i.e. 6 significant findings out of a series of 54 tests)

5-1-3-3	• It was expected that teachers' personal judgement about the complexity of challenges concerning the use of ICT to support subject teaching would be negatively correlated with each of the measures of pupil learning outcomes.	Corr. [T5-14]: (7 measures of outcome in 1997/98) * ** * x * * x
5-1-3-4	It was expected that: • pro-ICT preference would be negatively related to measures of pupil learning outcome, • pupil control preference would be negatively related to measures of pupil learning outcome, • open activities preference would be negatively related to measures of pupil learning outcome, • collaborative work preference would be negatively related to measures of pupil learning outcome, and • language teaching preference would be negatively related to measures of pupil learning outcome.	Corr. [T5-1-15]: (6 measures of outcome in 1998/99) * ** ** ** ** ** ** * * x x x x x x x x x * * * x x x x x x x x x
5-2-2	The purpose of this section is to group favourable and unfavourable factors affecting the use of ICT into clusters.	4 groups of factors are formed, each with reasonable internal consistency (i.e. alpha statistics ranged from 0.73 to 0.85) [T5-2-1 and T5-2-2]
5-2-3-1	It was expected that each of the sub-types of perceived challenge concerning the use of ICT would be positively related to teachers' personal judgement about the complexity of challenges concerning the use.	Corr.: ** * * *

5-2-3-2	It was expected that teachers' pedagogical preferences concerning the use of ICT would be negatively related to:	Corr.:
	• the measure of teachers' personal challenges (i.e. knowledge & skills about using ICT),	*
	• the measures of teachers' psychological challenges (i.e. personal interest, expectation and concerns),	x
	• the measures of teachers' institutional and work-related challenges (i.e. duties, workload and time available), and	x
	• the measures of teachers' practical and resource-related challenges (i.e. the need for reliable equipment, technical support and additional supports for pupils).	x
5-2-3-3	It was expected that each of the measures of perceived challenge concerning the use of ICT for teaching and learning purposes would be:	Corr. [T5-2-3] (4 types of perceived challenges):
	• positively related to the abstract conceptualisation measure introduced in section 5-1-1-2-1 above,	x * x x
	• negatively related to the reflective observation measure introduced in section 5-1-1-2-1 above,	x x x x
	• negatively related to the critical reflection measure introduced in section 5-1-1-2-2 above, and	x x x x
	• negatively related to the premise self-reflection measure introduced in section 5-1-1-2-2 above.	x ** x x
5-2-3-4	It was expected that perceived challenges concerning the use of ICT for teaching and learning purposes would be:	Corr. [T5-2-4] (4 types of perceived challenges):
	• associated with pupil learning attainments in maths and reading,	x x x x
	• associated with pupil learning gains in maths and reading, and	x x x x
	• associated with pupil attitude towards themselves and the school, respectively.	** ** ** **
5-2-4-1	It was expected that perceived challenges concerning the use of ICT for teaching and learning would be negatively related to teachers' practice concerning the use of ICT, in terms of:	Corr. [T5-2-5] (4 types of perceived challenges):
	• the frequency of class usage of computers,	* ** x x
	• the opportunity for a typical pupil in class to have a turn on the computer, and	* * * *
	• the amount of time that a pupil spends on the computer in a week.	* ** * x

5-2-4-2	It was expected that each of the three aspects of computer use (i.e. as mentioned in section 5-2-4-1) would be: • negatively related to teachers' personal judgement about the complexity of challenges concerning the use of ICT to support teaching and learning, • positively related to pro-ICT pedagogical preference, • positively related to pedagogical preference for pupil control, • positively related to pedagogical preference for open activities, • positively related to pedagogical preference for collaborative work, and • positively related to pedagogical preference for langugage teaching.	Corr. (3 aspects of computer use in 1997/98 and 1998/99, respectively) [T5-2-6]: x x x x x x x x x x * ** x x x x ** * x x x x ** ** x x x x x x * x x x x x
5-2-4-3	It was expected that each of the three measures concerning the extent of computer (i.e. as mentioned in section 5-2-4-1) would be: • negatively related to the measure of habitual action, • positively related to the measure of thoughtful application, • positively related to the measure of critical reflection, and • positively related to the measure of premise self-reflection.	Corr. (3 aspects of computer use in 1997/98 and 1998/99, respectively) [T5-2-7]: x x * x x x x x x x x x x x x x x x * x x x x **
5-2-5-1	The purpose of this section was to integrate some of the significant findings in the above sections to form as a proposed hypothetical model explaining the development of pedagogy supported by the use of ICT.	Special attention was paid on the polarity of the cause-and-effect relationships between the variables in the model.
5-2-5-2	The purpose of this section was to examine and refine the proposed model above. It was expected that: • the dependent variables could be explained by the simultaneous work of the group of independent variables in the proposed path model, and • the polarity of each of the paths would match with the respective polarity specifications as presented in the proposed path model.	MR [T5-2-8]: a preliminary model is formed (i.e. significant paths were kept and insignificant paths were dropped) all the polarity of the significant paths above were supported (i.e. consistent with those in the proposed model)
5-2-5-2a	The purpose of this section was to examine several variables of the proposed model, in relation to the cause-and-effect relationships.	MR [T5-2-9]: some variables of the proposed model were dropped
5-2-5-2b	The purpose of this section was to examine several variables of the proposed/preliminary model.	[T5-2-10] MR: some variables of the proposed model were kept and some were dropped

Chapter 6

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

The aims of this chapter are to:

- provide a framework for supporting primary teachers and pupils for effective classroom-based learning through the use of ICT (Section 6-1),
- report four case studies about effective use of ICT in teaching and learning of literacy and numeracy through classroom-based research and development projects (Section 6-2, Section 6-3, Section 6-4 and Section 6-5), and
- examine and refine the framework for supporting primary teachers and pupils for effective classroom-based learning through the use of ICT proposed above (Section 6-6).

- A list of the sections in Chapter 6 –

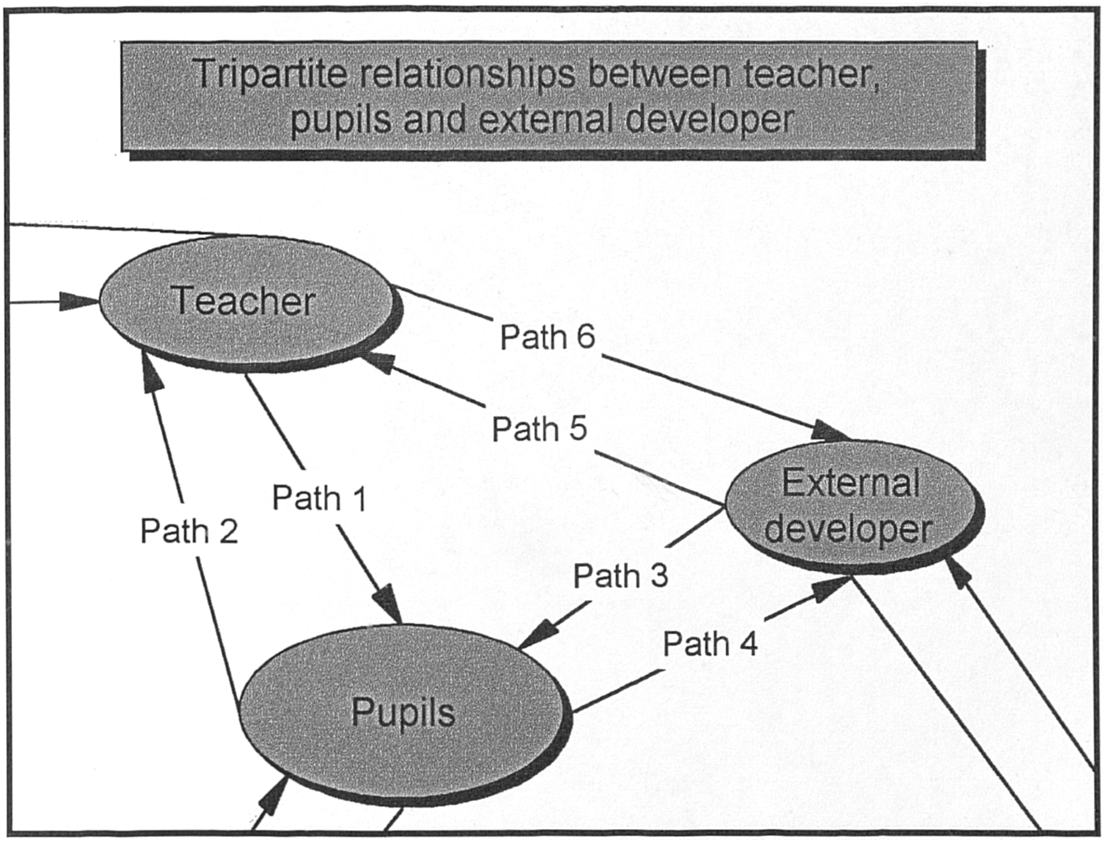
- End of the list -

(6-1) A proposed framework for supporting primary teachers and pupils for effective classroom-based learning through the use of ICT

The purpose of establishing a framework for supporting primary teachers and pupils in effective subject teaching and learning through the use of ICT is to provide a description of the inter-relationships between the teacher, the pupil(s) and the external education developer. It is hoped that the framework can serve as the reference for the development work to be reported in the case studies in this chapter, and that the experience from these case studies can provide some form of validation and refinement of the proposed framework.

Briefly, the framework comprises three major parties: the teacher, the pupil(s) and the external education developer. The inter-relationships between them are illustrated in the diagram below.

Illustration I6-1A: The inter-relationships between the teacher, pupils and external developer(s) for effective classroom-based learning with the use of ICT



Each of the one-way arrows on the diagram is called a "path" in this framework. It shows the influence of one party on another. It might be worthwhile to note that path 1, path 3 and path 5 represent the major activities; while path 2, path 4 and path 6 represent the feedback concerning these activities. So, the text below will start with some descriptions and examples of the major activities before the feedback concerning these activities is introduced. As the aim of the development work is to support effective subject teaching and learning with the use of ICT in primary classrooms, the text below will focus on activities related to the use of ICT. In other words, these activities could be viewed as interventions to facilitate the use of ICT for effective teaching and effective learning.

Path 1

This path represents the influence of the teacher on the pupils. The teacher plays an important role in helping pupils to learn with ICT. This may include:

- arranging the physical environment,
- providing hardware & software,
- making decisions concerning the use of ICT e.g. the usage focus,
- preparing and planning,
- acting as a demonstrator, a facilitator, a manager and/or a supervisor,
- equipping pupils with the required ICT skills,
- giving technical and operational support, and
- checking progress and record keeping.

Path 3

This path shows the direct influence of the education developer on pupils. Perhaps the term "instructional facilitator" might give a precise description of this role when he/she provides direct service for the pupil(s). There are things that he/she can do to help pupil learning with the use of ICT, which may include:

- preparing a user-friendly computer interface for pupils e.g. extra-support to facilitate the access to software might be useful (or needed by some pupils),
- ensuring an error-free hardware and software environment e.g. technical support,
- providing written instructions, and
- teaching essential operational skills.

Path 5

This path shows the influence of the external developer on the teacher. In fact, the term "staff supporter/developer" could be a precise description of this role when working with teachers. Examples of these activities include:

- supporting teachers with extra resources e.g. teaching and learning material, human resources,
- working as a co-ordinator between teachers e.g. facilitate sharing between teachers, promoting effective practice and collaborative problem solving, and
- acting as a staff developer.

So far, the paragraphs above have provided some descriptions and examples of major activities. The text below will also provide some descriptions and examples of the feedback concerning these activities.

Path 2 and path 4

The two paths are feedback given by pupils to the teacher or to the education developer. It may include:

- information about personal characteristics e.g. age, sex, ability, attitudes, experience in ICT, learning style/approaches,
- positive and negative feedback during the learning process e.g. problems or difficulties encountered, motivation, satisfaction; and
- feedback concerning learning outcomes e.g. learning attainment, gains, change in attitudes.

Path 6

This path represents the influence of teachers on the education developer. This would certainly include the feedback provided by the teacher to the external developer concerning the instructional support. In fact, the teacher and the education developer may work closely together. Often, there are communications and exchanges of ideas which have taken place before the classroom actions are administered by the teacher or the education developer. Examples of the activities include:

- the teacher's expression of needs and intentions,
- the development of the relationship between the teacher and the educational developer, and
- other feedback given by the teacher.

Purposes of case studies and their relationship with the proposed framework

So far, the findings in Chapter 3, 4 and 5 gave various support (as well as posing challenges) to the "model of effective curricular teaching and learning supported by computers and other types of ICT" proposed in Chapter 2. We need to know more about how these pedagogical and instructional factors operate in everyday classroom practice and to what extent teachers and educational developers might make contributions to improve the learning environment associated with the use of ICT.

On this basis, this chapter is going to report some classroom-based research and development work carried out as quasi-experiments. This will include various features of the ICT and the match with various types of support for an effective teaching and learning environment. Besides supporting pupil learning of the primary curriculum, some of these projects also supported teacher development as well as enhancing our knowledge and understanding of the various features of an effective teaching and learning environment supported by ICT.

It was hoped that the experience learnt from the research work would:

1. improve our awareness and our concern when planning for interventions and the experience learnt from the development work would provide us with some examples of good practice, and
2. validate the proposed theoretical framework for supporting primary teachers and pupils in effective practice through the use of ICT.

Each of the case studies to be reported in section 6-2 to 6-5 has its own research aims. Furthermore, each of them also functions as a sub-project through which the proposed framework is validated. To facilitate readers to access the related documents of each project, the related documents and/or materials of each section will be put in the "Appendices" section at the end of this thesis, starting from Appendix 4A to Appendix 8B.

Research design and methodology

According to the aims and the design of the specific case study, the collected data included quantitative data, qualitative data or both. Data of the former type were collected mainly through the administration of standardised tests and questionnaires. They were analysed through reports of descriptive statistics, correlational statistics, pre-tests and post-tests...etc. Data of the latter type was collected mainly through classroom observations, interviews and researcher's note taking. They were analysed with the help of computer applications such as spreadsheets and the NUDIST software application.

The case studies will be reported in Section 6-2 to Section 6-5. The pupils in these studies ranged from Year 3 to Year 6 classes. There were two major reasons for the sampling:

1. The author of this thesis was involved in school-based research and development work for middle and upper primary classes in the TTA-ICT project.

2. It was expected to be easier and more reliable to obtain data from pupils in upper primary than from pupils in lower primary levels.

It might be worthwhile to note that there were other highly successful projects that the author of this thesis had directly worked on, but which are not reported here. The major reason was the limitation in terms of the amount of time and resources available. And the projects to be reported in this chapter are used as examples to demonstrate various pedagogical and instructional considerations associated with the use of ICT.

A brief overview of the case studies

As a signpost for readers, Table T6-6-1 below is a brief summary of the research and development projects to be reported in this chapter. There are similarities and differences between them, in terms of the curriculum areas, the feature of ICT, the focus of research and development work and the method of study.

Table T6-6-1: Similarities and differences between the four case studies in Chapter 6

	Curriculum area to be addressed	Features of ICT to be addressed	Focus of research and development	Method of study / data collection and evaluation
Case study 1 (Section 6-2)	Y4 Numeracy: Mental calculation	Speed Accuracy Automaticity	Support pupil learning with ICT Support teacher development through reflection	Classroom observations Pre-test Post-test Interviews
Case study 2 (Section 6-3)	Y4-6 Literacy: Reading and spelling	Provisionality Interactivity Automaticity	Support children with SEN and low achievers Support teacher development	Pre-test Post-test Classroom observations Interviews
Case study 3 (Section 6-4)	Y6 Literacy and Science: Reading, Understanding how things work	Interactivity Capacity Range of functions e.g. multimedia, hyperlink, animation	Support socially neglected pupils Gender issues in group/pair work with the computer Support pupil learning with ICT	Pre-test Post-test Pupil questionnaire Interviews
Case study 4 (Section 6-5)	Y3 Literacy and IT: Writing, spelling and IT capability	Portability Provisionality	In-class & Out-of-class learning Use of equipment Support pupil learning with ICT	Pre-test Post-test Pupil questionnaire Parents questionnaire

(6-2) Using spreadsheets on portable computers to develop mental calculation skills through prediction of number patterns in Year 4

The school

The year 4 class in this illustrative study was a part of a suburban primary school. It was located within a former village and most of the pupils came from advantaged backgrounds. In an OFSTED inspection in 1994, it was identified that the majority of pupils were achieving above national expectations.

The teacher

The teacher has been at the school for two and a half years, since he started his teaching career. He taught Year 4 and Year 5. He took the responsibility of IT co-ordinator. Among the respondents of the teacher surveys (i.e. about 250 teachers in 1997/8 and about 100 teachers in 1998/99), he was in the top 10% in terms of these areas. The teacher:

- had very strong confidence in his IT skills,
- had very strong motivation to use ICT for developing pupil IT skills,
- had an exceptionally high extent of computer usage (i.e. highest frequency of class computer usage and longest duration of pupil computer usage),
- was exceptionally high in the perception of workload as a result of using computers for subject teaching and learning, and
- was exceptionally low in the perception of personal and motivational challenges concerning the use of ICT for subject teaching.

The teacher also had a critically self-reflective character and he was good at learning by abstract conceptualisation. He enjoyed having the freedom to explore and learn himself, and was studying part-time for a Master degree in Education.

> "I think that being given sufficient free rein to try things out in my classroom has supported my development because I can then see what works and doesn't work. I think that the staff here have supported my development, in that they're allowed me to pursue my own interests."

His willingness to improve himself and to learn from experience also affected his teaching style. He prefered giving pupils activities that were open-ended in nature as well as letting pupils take responsibility for their own learning.

> "Although closed activities have their place, open activities are far more beneficial for all children through learning because they aren't just learning one particular thing. They are learning a wide variety of things."

The pupils

The pupils came from relatively advantaged backgrounds and there were no pupils on the SEN register in the class. The number of pupils in class who used a computer at home was exceptionally high. The teacher liked to ensure that each of the pupils achieved to their full potential. The initial baseline test for the project indicated that although the level of arithmetical skills of most of the pupils was good, about one fifth of the children scored below average on the standardised test. This was the starting point for the development work in the school.

The aim of the development project

The major aim of the development work was to enhance pupils' mastery of the properties of numbers. The computer-based activities were used to facilitate the development of mental calculation skills in addition, subtraction, multiplication and division. The aim was set in a discussion between the teacher and the researcher, who acted as an external developer in this project. The discussion began with clarification of pupils' learning needs and their prior knowledge. As the pupils were reasonably confident with addition and subtraction mentally up to 20, the aim of the development project was to encourage them to use multiplication and division facts more effectively. The aim was set for the first phase of the development work in 1997/98 and was repeated in the second phase in 1998/99.

Pedagogical and instructional considerations: hardware, software and teaching focus

A spreadsheet software application was chosen as a teaching and learning aid for the topic. The software application enables the generation of a number pattern in very short interval. It also reduces the chance of making mistakes, particularly cumulative ones, compared with paper and pencil activities. Both the teacher and the external developer expected that the pupils could take advantage of the speed and accuracy that ICT offers.

A spreadsheet was recognised as a systematic way of presenting number patterns. When operated properly by pupils, the computer can perform addition and subtraction for them. It was expected that the process could greatly reduce the time and effort that pupils put into routine calculation so that they could concentrate on finding out the relations between these numbers. Initially, the teacher wanted this to develop an understanding of number patterns. Then, once pupils understood some specific patterns, they could use this knowledge to identify and predict other similar patterns that would involve them in using mental calculation skills more effectively. This would therefore support his teaching of strategies as well as pupils' ability at calculating.

Portable e-Mates were chosen to be the development tool. They were chosen because this type of computer had some special features and was believed, by the teacher and the external developer, to be an ideal tool for the particular teaching and learning environment. The special features were:

1. portability – it was fairly easy to fit in the crowded classroom to be used by pupils on their tables,
2. touch screen access – the precision of the recognition of hand-written input was good and user-friendly, and could avoid difficulties in typing on the keyboard, and
3. auto-calculation capability of the software application – the facility to copy a formula from one cell into others was a powerful feature of a spreadsheet (Mann & Tall, 1992).

Six portable e-Mates were provided for the pupils in class through the co-ordination work done by the external developer. All the teaching was carried out in ten workshop sessions conducted by the teacher. The external developer also acted as an independent observer in one of these workshops.

Putting educational initiatives into practice

These workshops were conducted in the summer term in 1997/98 and were repeated in the autumn term in 1998/99. The teacher wanted to support both subject teaching and pupils' IT capability. So, when compared with other content-specific software application, a generic software application was a better choice for the teacher.

"I strongly believe that we should use ICT. We should, how can I put it, we should be saying, where is literacy and numeracy within ICT; rather than, where is ICT within literacy and numeracy because it is one of the core subjects. It should be placed alongside literacy and numeracy, not within literacy and numeracy, and it needs to be taught in its own right."

The teacher introduced the activity when pupils had a set of results obtained from their work on division. The teacher gathered a group of pupils and showed them how to use spreadsheet as a checking tool. For example, when checking the result of 32 / 4 = 8, the teacher first put 32 on the top left cell on the spreadsheet. Then in the cell below, he took away 4 from 32. By repeating the deduction process, the teacher ended up with a series of numerical operations as shown in Table 6-2-1:

Table T6-2-1: Investigating relationships between addition, subtraction, multiplication and division

32	36	40	44	48	52	56	60
28	32	36	40	44	48	52	56
24	28	32	36	40	44	48	52
20	24	28	32	36	40	44	48
16	20	24	28	32	36	40	44
12	16	20	24	28	32	36	40
8	12	16	20	24	28	32	36
4	8	12	16	20	24	28	32
0	4	8	12	16	20	24	28

The aim of this activity was to develop pupils' understanding of the relationship between division and subtraction and to teach that division is more efficient. The relationship between multiplication and addition was also introduced in the same way. Later on in the project, the teacher decided to let pupils choose any number between 1 and 10 as a starting point and to generate a series of numbers by adding a particular number repeatedly. The target was to get 50 or 100.

Table T6-2-2: Repeated addition from a starting number to reach a target of 50

4	7	6	5		
8	14	12	10		
12	21	18	15		
16	28	24	20		
15	35	30	25		
20	42	36	30		
24	49	42	35		
28		48	40		
32			45		
36			50		
40					
44					
48					

The aim of this activity was to enhance pupils' understanding of factors and multiples. The pupils generated a series of numbers in the first column by repeated addition of a number, between 1 to 10. On the basis of the first set of numbers, the high ability group was encouraged to generate another set of numbers in the second column. The lower ability group focused their attention on finding out the numbers that were factors of 50 or 100. With reference to the numbers in the previous column, a new series of numbers was formed in each attempt. An example of a completed spreadsheet on the computer is presented in Table T6-2-2.

When the group of six pupils were working with e-Mates, the rest of the class was working on other addition and subtraction tasks. The teacher walked around the classroom to provide assistance for all those who needed help. The eMate activity was repeated until everybody in the class had completed a number grid using the computer. The pupils were grouped according to their maths attainment because the teacher could plan specific activities to support their mental capabilities, and ensure an effective level of challenge for each of the pupils.

Evaluation of the first phase of development work

The Group Maths Test (Young, 1996) was administered twice in the class. The first time was in early June 1998 and the test was repeated in mid July 1998. There were 27 pupils who did the first test and the re-test. The mean raw score on the first test was 49.7 and that on the re-test was 51.4. The difference in means was statistically significant at $< .05$ level (two-tailed). Unfortunately, many pupils scored near the ceiling of the test. So, a proper evaluation of the gains could not be made. Nevertheless, among the 6 pupils who did not reach the average standard in Maths attainment for their age, it was found that 4 of them had a higher score at re-test and 1 of them had the same score on both occasions. One pupil had a lower score in the second test than in the first test.

Generally speaking, the choice of hardware and software was found to be appropriate to achieve the aim of development work. The computers were technically reliable and as a form of feedback for the external developer, the teacher expressed that there was "no technical problem at all."

Experience learnt and the second phase of development work

With the initial success in the first phase, it was decided that the second phase of development work would be carried out with the same teacher and in the same class in the academic year 1998/99. The ability of pupils was roughly the same as those in the first phase. A discussion was set up between the teacher and the external developer before it began. To improve the effectiveness of the development work, two major changes were made:

1. In addition to the verbal instructions given by the teacher, some written handouts (see Appendix 4-B) were prepared by the external developer for training pupils' computer operation skills for the maths tasks.

2. The duration of development work was longer than expected. It started from mid September and continued to early December in 1998. However, due to the OFSTED inspection around the first week of November, the development work was delayed for about three weeks. The major reason for the arrangement was to support independent work in maths, while reducing the teachers' time and effort to be spent making responses to questions from pupils about the operation of portables and software application.

Nevertheless, in an interview, the teacher revealed that talking with the external developer was a way of facilitating his thinking. It could be interpreted as a positive attitude towards the support given by the external developer through his self-evaluation and self-improvement.

"It (involving in the project) makes me think, because people are coming into my classroom. It makes me think more what I'm doing, but it also gives me a link with outside of school. It means that I can develop my thinking by talking with others."

Evaluation of the second phase of development work

Two parallel forms of Basic Number Screening Test (Gillham & Hesse, 1996) were administered in the class. The test form A was used in late September and the test form B was used in early December 1998. There were 29 pupils who did both forms of the test. The mean number age on the first test was 118.9 months and on the second test was 123.9 months. The difference in means was statistically significant at < .05 level. The results suggest that pupils made an average of 5 months gain in their number age within a period of 2 months. Furthermore, the pupils enjoyed the teaching and learning activities with the use of portable computers.

"They love them. Absolutely love them. Because it is portable and because, I think, they find it very easy to use...And the enthusiasm that was created, and when they got to 100, the cries and jubilation was lovely to see."

The contribution of portable computers was not limited to the ICT group, but their contribution could extend to the learning of the class. In other words, pupils in the computer group could share their experience with the rest of the class. The computer activities and non-computer activities were complementary.

"They would bring the e-Mates with them onto the carpet as a plenary session and go through the work with the class."

Nevertheless, the teacher showed genuine interest and appreciation in the experience that he gained in the development project. He found sharing of ideas useful for his own professional development. The initiatives, alternative strategies and potential problems raised by the external developer(s) had stimulated his thinking and reflection. The teacher also found the successful experience of other development projects useful for his development because they told him about the extent that abstract ideas or theoretical concepts could actually work in daily practice.

"And it's been fascinating from a sort of professional development point of view, talking about how things have worked in the classroom...because it made me think."

Reflection, conclusion and implication

In spite of the success mentioned here, the teacher mentioned in an interview that his involvement in this development phase was not as active as it was in the first phase. The actual length of time that pupils spent with the e-Mates was shorter than the first phase. And it might make a difference if the second development phase were carried out at the end of the summer term when the pupils had some experience with their IT skills.

"I seem to have had more time last year with the e-Mates than I have had this year...the class that I had last year had had some spreadsheet experience. Possibly because of the timing...Whereas this year, we haven't got that far yet."

To sum up, this classroom-based research project provides insight into how to make use of various features of a portable computer to support the teaching and learning of a topic in Maths and the development of IT skills. The results of the two development phases are consistent. The effectiveness of the development project was not restricted to pupils' academic and attitudinal gains, but there was a positive impact on the teacher's learning and development. The reasons for this success in teacher development are bound up with his/her personal characteristics. In particular, he had the firm opinion that activities using ICT should support both subject specific skills and pupils' IT capability wherever possible.

"I strongly believe that we should use ICT, and we should be saying, 'Where is literacy and numeracy within ICT?' rather than, 'Where is ICT within literacy and numeracy'."

He is a critically reflective practitioner who learns and improves himself from practical experience. The improvement that he made was not focused on the knowledge and skills of using ICT; instead there was a development in his pedagogy in which the use of ICT was incorporated as an integral part. It was obvious that he had changed the way he considers using ICT for subject teaching. Instead of thinking about it from the perspective of technology, his attention was shifted to the subject teaching pedagogy.

"Recently, because we've introduced this numeracy (ICT project), I thought very carefully about how I was looking at maths in the classroom and completely changed my ideas. In that I hadn't used enough practical work, I hadn't used enough investigative work, and this is something that I short of realised and changed the practice completely."

"I've changed my ideas, both in sort of a reflective and a critical sense. We don't have any, well, I suppose I do, habitual routine in ICT...I don't think I reflect as much with ICT."

He thought teachers needed to reflect on their own use of ICT for subject teaching, however, he was used to reflecting more on the subject than on the technology. His success in using ICT for subject teaching is attributed to the effort that he put in his planning and classroom practice. It explains the level of workload perceived by him as a result of using ICT. He felt that he could manage with the challenges concerning its use, in relation to his personal skills and motivation. The results of the teacher survey showed that the extent of his perceived institutional and work-related challenges was medium-sized and the extent of perceived practical and resource-related challenges that he perceived was high. If challenges concerning the use of ICT take place according to the concentric model presented in chapter 5 section 5-2-2-2, then the teacher will be in the third or the fourth stage of teacher development in regard to his use of ICT to support subject teaching and learning. With the IT skills and the positive attitude towards using computers that he has, the teacher is freed from personal and motivational challenges. The amount of workload, the availability of reliable equipment and the concern about the responsibility of the equipment are the major challenges that he has to tackle for promoting his own use of ICT.

> "The portability was something, taking them home was something that has been mentioned, and I was wary…I was assured that they were designed to be dropped and to work again, but I still didn't believe that."

Portability is one of the special features of e-Mates. To maximise the extent of this advantage, the teacher was encouraged to let pupils bring the computer home for extended learning. However, the teacher clearly expressed his reservation, as illustrated by the statement above. It was clear that he had concerns about the lack of control about the handling and the usage of equipment. We shall address some other issues concerning out-of-school usage of portable computers in section 6-5 below.

Final remark

Part of this study has been published in the report by Moseley, et. al. (1999) "Ways forward with ICT: Effective pedagogy using information and communication technology for literacy and numeracy in primary schools. ISBN 0-7017-0086-6. (refer to Appendix 1 for section 6-1 for further detail).

(6-3) 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

The school

The school was a 7-11 Junior school situated in the west end of a large city. The local catchment area was varied, ranging from areas comprising council and privately rented accommodation to city suburbs with privately owned houses. Some of the children were from homes with no adult in employment, and a number of pupils live with only one parent. The social and economic circumstances of a large part of the catchment area resulted in the attainment of pupils on entry being lower than average and 35% of pupils being eligible for free school meals. The buildings dated from the 1950s.

The teacher

The teacher was the deputy head and mathematics co-ordinator of the school with 22 years of teaching experience. She taught a group of low achievers in literacy in the school, as well as being a class teacher. She has received some training in the use of ICT, including two learning support courses provided by the LEA and an Internet course provided by the University. However, most of her skills were self-taught and sometimes through the process of problem solving.

"I would love to go an IT course, but it would have to be, say, once a month...I've actually taught myself in the classroom and at home, where the children have pressed the wrong key or they've done something wrong or they've lost it. I've had to find out for myself, oh, how do I bring that back."

Among the respondents of the teacher surveys (i.e. about 250 teachers in 1997/8 and about 100 teachers in 1998/99), she was in the top 10% in terms of a very high usage of abstract conceptualisation learning orientation and a very high perceived workload as a result of using computers. Her IT skill was better than average, but her inclination towards using computers to support subject teaching and learning reported in 1997/98 was below average. However, her inclination towards using computers to support subject teaching and learning reported in 1998/99 was among the top 10% of all the respondents. She paid special attention to maximizing the use of computer equipment. According to her schedule, each pupil in her group would have the highest opportunity to have a turn on the computer. The extent of her perceived psychological challenges concerning the use of ICT was medium sized, while the other three types of challenge (as mentioned in chapter 4 and 5) were low.

The pupils

In the first phase of the project, all the pupils involved were from a group of 20 low achievers in literacy in Year 4. In the second phase of the project, the pupils involved were from a group of 18 low achievers in literacy in both Year 4 and Year 5. The number of pupils identified according to the Code of Practice as having special educational needs was particularly high in 1998/99. About one third of the year 4 and

5 pupils in the school were statemented according to the Code of Practice. Out of the 18 pupils of the specific teaching group, 13 of them were statemented.

The teacher had a literacy session with the special teaching group every day when the rest of her class became part of another teaching group. The majority of her literacy group could be best described as having limited academic abilities as reflected in their reading ages. Many of them lacked the ability to concentrate for extended periods. Compared with other teachers who responded to the questionnaire, the number of pupils with special educational needs in the 1997/98 group was among the highest 30%, of all the respondents. The number of pupils with special educational needs in the 1998/99 group was among the highest 10% of all respondents in the questionnaire.

The aim of the development project

In the first phase of the project, the major aim was to support the existing teaching material being used in the class with text-to-speech support facilities on the computer. It was hoped that it would help the development of pupils' reading, vocabulary and spelling.

Negotiating for an easy start: the first phase of development work

The work started in the second half of the summer term in the academic year 1997/98. An electronic version of the existing teaching material was prepared by the external developer as a supplementary teaching aid to be used on the computers. The decision was made after a discussion between the teacher and the project developer. It seemed to be an easy start for the teacher to be involved in the development work because she didn't need to make big changes to the planned curriculum.

Texts which formed part of the teacher's planning for the Literacy Hour were prepared in TextEase format for pupils' use on the computer. The material was used as reinforcement for the Literacy Hour. Two computers were available for the class as supplementary learning material, with the use of text-to-speech facilities available from the "TextEase" software application. It meant that the teacher could schedule time slots throughout the week for paired work with differentiated activities. And it was used at various times of the day throughout the school week.

Basically, the printed material to be used in the classroom was prepared by the teacher. She used to prepare it during the week before they were being used in the classroom. The external developer had to collect the material and get it prepared in electronic format to be used with the TextEase software application. In terms of literacy focus, there were two major types of activity on the computer:

- text comprehension – passages were prepared in electronic format and they were read aloud by the synthesized speech facilities on the computer, and
- word level work – the focus was placed on the meaning and spelling of some key words of the passages. They were introduced in the form of a word recall exercise. The pupils' main task was to click on the box where the key word was hidden. The computer displayed the hidden word and simultaneously read it aloud. Pupils had to type the word on spaces provided on the screen.

The teacher, without the presence of the external developer, conducted all the lessons. All the pupils in the group had a turn on the computer after the teacher introduced the printed version of the material. Several weeks after the development phase began, during an informal talk with the external developer, the teacher mentioned that some pupils had spent quite a long time in finding the right file to be used. In response to the teacher's statement, the external developer added in "icons" on the first page of the computer screen. They allowed pupils to access to these files immediately when the computer was booted up.

Evaluation of the first phase of development work

The Hodder Reading Progress Test was administered twice in the class. The first time was in the last week of May in 1998 and the test was repeated in mid July. The mean reading age on the first test was 8 years 1 month and on the re-test was 7 year 8 month. The difference in means was not found to be statistically significant at $p < .05$ level.

Experience learnt in the first phase

The major difficulties could be classified at two levels, including the link between the external developer and the teacher, as well as the actual challenge of implementing these ideas in the classroom. With technical and operational errors, there were times when the teacher involved was faced with a dilemma, as stated by the teacher:

"If we've got the computer in the classroom, I'm wanting to support the children on the computer, but I've also got to think of the other sixteen children who I also have to support. So, it's really juggling the time between to-ing and fro-ing."

It was found that the time gap for getting the printed material transformed into electronic format was extremely short. As the teaching material was newly prepared, it was impossible to have all the printed material ready well before the project was started. With these in mind, the teacher tried to get the printed material ready soon before the date when it was used. The time pressure increased the teacher's workload.

However, the amount of time available for the external developer to work on this development project was insufficient because of unexpected events. For example, due to the limitation of technology, some words were mis-pronounced by the text-to-speech facilities. Extra time was spent on finding out the mis-pronounced words and making modifications. Extra time was spent on exploring the use of an integrated learning system for maths learning in this class. Extra time was also needed to find a proper means of communication between the teacher and the external developer at the initial stage of the project. For example, attempts were made at communication by post as well as communication through the internet. The limitation of the number of computers available was another, as it affected pupils' length of time on the computer. As the IT skills of the pupils were below average and some pupils also had learning difficulties, the level of difficulty was increased.

Having said that, the practice of having "icons" of the files to be used ready on the computer interface seemed to be very effective in reducing the length of the time that pupils needed to access these files. The frequency of pupils asking the teacher for technical assistance was greatly reduced. The text-to-speech support seemed to be valuable in supporting the children's learning and helping in their motivation, as reported by the teacher and identified by the external developer during an observation of one of these lessons. On critical reflection by the external developer, the lack of progress on the Reading Progress Test (RPT) could reflect that:

1. the development phase was too short, especially when complex technical and operational steps were involved. Furthermore, in the initial stage of using ICT to support teaching and learning, it might not be surprising to have a decrease in the actual attainment before it goes up, and
2. improvement could be made by reducing the number of objectives to be achieved in this class. To be effective, it was found that there was a need to reduce and to avoid the excessive workload of the teacher and the external developer.

When looking back on the experience critically, these problems were not completely unexpected. Some of them emerged as a result of the focus of the aims to be achieved and the limitation of the time and resources available for teacher support. Nevertheless, through active contacts with a supportive attitude, the external developer had successfully established a collaborative working relationship with the teacher. With the experience learnt in the first phase, both were ready for the planning of work in the next development phase.

Planning for the second phase of development work

The second phase of the project was started in the autumn term of the academic year 98/99. The development work continued to use the text-to-speech support facilities on the computer. Special attention was paid to developing phonemic awareness skills because it has been identified as important in the development of reading and spelling (e.g. Rayner & Pollatsek, 1989; Pumfrey & Elliott, 1990). It was introduced through a series of dictation tasks with the use of electronic worksheets on the computers and with the use of paper and pencil. The instructional material was chosen from the book "Phonemic Awareness Training" by Jo Wilson (1994).

Apart from this, it was decided that pupils' work on the computer would be recorded by a software application after a negotiation between the teacher and the external developer. The idea was to provide more information about the work of each pupil for research and development purposes. As a result of the arrangement, there were concerns about the increase in the complexity of the IT skills required to perform the dictation tasks on the computer. To facilitate the work, the computer operation steps required for the dictation tasks were printed on a sheet of paper. Students were asked to follow the steps in order to avoid problems met in the computer operation. A copy of the instructions is presented in Appendix 5-A.

The aim and the practice of the second phase of development project

The aim of this development phase was to foster pupils' phonemic awareness through the use of text-to-speech support facilities on the computer. As a result of this, it was hoped that their performance in reading and spelling would be improved.

The development work actually began before the start of the academic year 1998/99. A copy of the book was obtained and was transferred into an electronic format with the permission of the author. When the instructional material was put on the two computers in the classroom, some icons were added on the screen of the computer. They were used as shortcuts for accessing the right file that the pupils needed because it was found to be effective in saving access time and in reducing technical errors/difficulties. Special attention was paid to the start level of individual pupils. It was set on the basis of the results of a spelling test before the second phase of the development work actually began. Each pupil received the right level of challenge from the dictation tasks on the computer.

External developer: "I put an icon on the screen. All they (pupils) have to do is just click on the folder and get the right file rather than using (Window 95) explorer."

The teacher: "Oh, it was brilliant...It was good for them, and it was good for me. It was quick, easy access, brilliant."

The development work lasted for twelve weeks in autumn term 1998/99. It began by a demonstration of the dictation task by the external developer on an individual basis, and with explanations on the instruction sheets. Each pupil had a go at the first dictation exercise with the help of the external developer. Then every two weeks, pupils were asked to finish a set of dictation exercises. One was done individually on the computer and the other was done on a whole-class basis with paper and pencil. Every two weeks, the teacher spent about a quarter of an hour teaching phonemic awareness. It was conducted as whole class teaching, in which the teacher encouraged the pupils to give examples of words that had similar sounds. Besides teaching phonemic awareness, the teacher worked on other language tasks set in the curriculum. Children would be asked to work on the computer for the phonemic awareness exercise during the group work time. The teacher and the external developer identified a pupil helper. He/She was responsible for assisting his group mates in technical and operational problems associated with the dictation task. The idea was to reduce the teacher's workload in common technical and operational problems. When a pupil could not manage to work independently on the dictation tasks on the computer, the helper would sit beside him/her and offer assistance when necessary. Some pupils required the service provided by him the first or second time they did the exercise on the computer. When pupils in the class were familiar with the computer operational steps, the number of help requests was reduced.

It was hoped that the text presented and read aloud by the computers could provide phonemic and visual input for individual pupils at their level of attainment and at their own learning pace. Each of these exercises consisted of five sentences with words that contained similar sounds. For example, "The drink is in the sink", "They like to play in the sand", "Jump into the pool to stay cool"...etc. When pupils were working on the computer, these sentences were invisible when they were first presented. To see the sentence with the texts read aloud by synthesized speech technology, pupils had to click on the appropriate box where the sentence was hidden. The texts turned invisible again immediately after the sentence was completely read by the computer. Pupils had to type the sentence in the given space. They were also encouraged to click on the appropriate box to see and hear the text again whenever they felt the need to do so. The arrangement was to make use of the provisionality feature as well as the accurate text-to-speech facility offered by the computer.

Evaluation of the second phase of development work

The Hodder Reading Progress Test was administered twice in this development phase. The first time was in mid September 1998 and the test was repeated before Christmas time. Among the 18 pupils in the class, 14 pupils did the first test and the re-test. The mean reading age on the first test was 6 years 10 months and that on the re-test was 7 years 10 months. The difference in means was found to be statistically significant at < .05 level. An increase of 12 months of reading age within 3 months is certainly encouraging.

External developer: "Do you think the (test) information that was given back to you was useful?"

The teacher: "Oh yes, very useful. It helps with my own assessment that I find out in the class."

Pupils were also asked to do a piece of writing as the baseline for the second development phase. The same writing task was repeated at the end of the phase. Nine pupils did both pieces of writing. The collected samples were analysed and the results were reported according to the categories below:

1. The length of the writing sample in terms of the number of words used. The mean number of words used in the first writing sample was 70.00 and that of the second one was 73.33.
2. The percentage of spelling errors. The mean percentage of spelling errors made in the first writing sample was 17.84% and that of the second one was 14.35%.
3. The score for content and organisation, which is expressed in a seven point scale. The mean content score received in the first writing sample was 3.78 and that of the second one was also 4.00.

Among the 3 aspects of writing analysis, the difference between the mean of the percentage of spelling errors was found statistically significant at $p < .05$ level. In line with this, the Young's Parallel Spelling Test was also administered twice in this development phase. Among the 18 pupils in the class, 14 pupils did the first test and the re-test. The mean spelling age on the first test was 7 years 9 months and that on the re-test was 8 years. The difference in means was not found to be statistically significant at $< .05$ level, valid N=14. Given that the number of writing samples collected was small, further investigation was carried out at pupil (or individual) level. The summary of the findings were summarized in Table T6-3.

Table T6-3: **Summary of results of pupils in the group in 1998/99 (second development phase)**

	Year group	SEN Code of Practice	Read Test 3	Read Test 4	Spell Test 3	Spell Test 4	Spell +/-	Remark about dictation exercises on the computer
P01	5	Stage 1	21	24	13	16	+3	- from 30 to 15 mins
P02	4	Stage 3 (Specific Learning Difficulty)	6	13	7	12	+5	- stay around 10 mins - did better when working on the computer than not on it
P03	5	Stage 2A (was 3)	3	7	9	13	+4	- 20,30 mins to 15 mins - consistently agree better attention on the exercise
P04	5		24		25			- 30 mins to 15 mins
P05	5		23		37			- 20 to 10 mins
P06	5	Stage 1 (Behaviour)	13	25		15		- 25,26 mins to 10,11 mins
P07	5		24		7			- 25 to 14 mins
P08	5		28	29	33	34	+1	- 20 and 41 mins (only did the exercise twice)
P09	4	Stage 3 (behaviour, learning)	11	11	13	13	0	- 33,40 to 25 mins - not clear about what to do
P10	4	Stage 2 (was 3) (Behaviour)	17	15	10	16	+6	- 13,10 mins only
P11	4	Stage 1 (Behaviour)	16	20	21	30	+9	- around 7 to 10 mins
P12	4		16	29	15	19	+4	-10 to 15 mins
P13	5	Stage 1	13	23	28	24	-4	- 20,10 mins. - felt tense when working on the exercise
P14	5	Stage 1 (Truancy and behaviour)	14	14	30	34	+4	- 30 to 10 mins
P15	5	Stage 2	18	29	19	17	-2	- 30 to 15 mins.
P16	5	Stage 1		16	21	15	-6	- 15,18,15 mins
P17	4	Stage 2A (was 3)	13	11	8	11	+3	- 10,12,20,14 mins
P18	4	Stage 2A (was 3)	9	11	9	8	-1	- 30 to 20 mins

Keys: ***Read Test 3*** - refers to results of the first reading test, ***Read Test 4*** - refers to results of the second reading test, ***Spell Test 3*** - refers to results of the first spelling test, ***Spell Test 4*** - refers to results of the second spelling test.

Two patterns of relationships were identified from the results reported in Table T6-3. Firstly, all the pupils made an improvement in the speed of completing the dictation exercise on the computer. The exception was that pupil P8, who only had the dictation exercise twice on the computer. He managed to complete the first exercise on the computer in twenty minutes with the assistance of the peer helper in class, but he needed forty minutes to complete the second exercise on the computer on his own. Secondly, generally speaking, pupils who did not have special educational needs and pupils who were on Stage 1 of the Code of Practice performed reasonably well in reading or spelling. On the contrary, except pupil P15, pupils that were on Stage 2 of the Code of Practice or above did not perform very well in reading or spelling tests. The results reported in the table seem to indicate that the extent of special educational needs has a negative impact on academic performance.

All the pupils with emotional and behavioural difficulties benefited from the exercise. The exception was pupil P09 who had difficulties in behaviour as well as in learning. The pupil required a long time to complete the dictation exercise on the computer, ranging from 25 to 40 minutes. A video clip showed that, in addition to the mistakes in operational steps, there were periods of inaction, pauses and unnecessary actions when he worked on the exercise on the computer. So, the evidence might imply that he lacked good IT skills and the ability to concentrate. Furthermore, he said more than once that he was not sure what the exercise required him to do. On the contrary, pupil P11 had a very good gain in reading and in spelling. The speed and accuracy of his dictation work on the computer was among the top of the group.

The IT skills of pupil P17 were not good enough for the dictation task. He received assistance from the helper during the first two dictation exercises on the computer. He managed to finish the two exercises within twelve minutes. The major weakness in his IT skill was that he often used a click when he was required to perform a double click.

The negative impact of the weakness emerged when he worked on the computer on his own. As a result of the mistake made in the selection of objects, the computer not only read the target sentence that was hidden on the screen, but it read all the hidden sentences on screen. The duration of time to complete the job was longer than expected and the redundant information could become a form of distraction for him. The lack of appropriate IT skills could have prevented him making further improvement in reading.

Pupil 16 had a lower score in the second spelling tests than the first. A video clip showed that he was doing well in the first dictation exercise on the computer, in terms of speed and accuracy. However, his performance in the other dictation exercises on the computer was not as good as the first one. It might be worthwhile to note that he was the helper in class, as mentioned above. He succeeded to maintain good IT skills and high accuracy in all the exercises that he did on the computer, however, there were pauses between operational steps. Presumably, these were not caused by spending time thinking about the sentence or the words that he was working on because some of the pauses were after the completion of a sentence and before the beginning of a new sentence. One of the possible reasons for that was a loss of interest in the exercise. As a helper, he was so familiar with these exercises that he might become bored. His lack of concentration when working on these exercises, may have affected his performance in the second spelling test. This might explain why the record indicated that he quitted doing the dictation exercise before the end of the development phase. In fact, after the middle of the development phase, the teachers took over the job of the helper in assisting pupils using the computers. The problem with the pupil helper could have been avoided if the teacher or the external helper had been more sensitive to his feeling and performance and intervened at an earlier stage of the development work. Alternatively, the situation could have been better if there had been more than one helper in the group.

> The teacher: "It was a good idea (to have a peer helper)...but STU (the helper) is very slow and lazy at doing his work. So he was opting out of doing work in the classroom, written work with pen and paper, to help with the computer...I found initially STU was missing out on doing his normal work, so that is when I started taking over and putting children on."

Pupil P10 had a drop in his performance in reading, but his spelling increased sharply. The recorded video clip showed that there was a two-minute period of inactivity shortly after he opened the exercise on the computer. It might mean that the length of time that he needed to read the instruction on the computer screen was relatively longer than those required by his peers. The video clip also showed that he often required the computer to read the sentence twice before he began to type the sentence. No spelling errors were identified in his dictation. In contrast, pupil P13 made an improvement in reading, while his performance in spelling dropped. Two video recordings of his work were studied. In a video clip that recorded his early work on the computer, it was found there were mistakes in computer operation. These include using a click when a double click was required. He managed to get some of the operational problems solved by referring to the written instruction on the screen. He could type fast, but, there were mistakes in spelling and pauses in between words. Presumably, he was thinking back over the sentence he read. The second video clip was taken in the middle of the development phase. Fewer mistakes in operational steps were identified, although there were mistakes in spelling as well as pauses in between words. Both of the dictation exercises were finished in a reasonable length of time. Furthermore, in both dictation exercises, the pupil did not refer back to the hidden sentence at all. This might be the reason why spelling mistakes were left unidentified.

From the point of view of teacher development, there were two major sources of input that were associated with the improvements made by the teacher. The first one is the support given by the external developer, which led to the increase in the teacher's confidence in attempting to integrate the use of computers in the teaching of literacy. The second one was the encouragement and satisfaction that the teacher received from the pupils. So, both the teacher and the pupils benefited from the development work.

> "I am not computer literate...This was a fun way for children to learn, using the computer, being interactive...It (the development work) made me more confident with the computer...so I thought, well, if a child can do it, I can do it. And I was quite pleased I was able to do that. So, I've improved my skills, too...I feel more confident to attempt things...but I wouldn't have attempted that if I hadn't been able to get the initial support from ABC (the developer)."

The success in teacher learning and development through participation in the project is reflected by the statements made by the teacher and is also identified by the external developer through classroom observations. When the development project started in summer term in 1997/1998, pupils who worked on the computers were sitting in a corner of the classroom. As the teacher could hardly see the information on the computer screen, her actions towards the computer group was rather re-active e.g. offered technical assistance when pupils came to ask for help. In contrast, the computers were located at the back of the classroom during the development project in 1998/99. With the screen facing the teacher, she was able to take an active role in managing and offering assistance to the pupils who were on the computer. So, the computer group and the non-computer groups were nicely organised and integrated together in the classroom. The ideas for these arrangements were initiated by the teacher, not by the external developer.

The ideas of having icons put on the screen to help pupils to access the computer seemed highly successful. The use of the instruction sheet was also found to be useful, however, further improvement could have been made.

External developer: "How can I get it (the instruction sheet) easier to use?"

The teacher: "The sheet of instructions was very helpful for me...there is too much writing on. Maybe just double click and a picture of the folder...Reducing the words and the text."

Having said that, the interaction between the external developer and the teacher was also a useful channel for the external developer to make improvement. For instance, the teacher can act as a lay person who suggests ways in improving the service that the external developer provides to the pupils.

Summary

The paragraphs above reported the use of text-to-speech support facilities provided by the computer in developing pupils' reading and spelling. The experience in the two development phases contributed to a change of the teacher's confidence and inclination towards using computers to support subject teaching and learning. The interactions between the teacher, the external developer and the pupils appear to have been a key factor affecting the effectiveness of instruction.

(6-4) Using two multimedia software applications to foster the reading development and the understanding of science topics in Year 6

The school

The class reported in section 6-2 above and the year 6 class in this study originate from the same primary school. It is located within a former village and most of the pupils come from advantaged backgrounds. In an OFSTED inspection in 1994, it was identified that the majority of pupils were achieving above national expectations.

The teacher

The teacher took part in the development work partly because her colleague recommended to her that the use of ICT to support teaching and learning could be effective for her pupils. The teacher also wanted to support and to learn from new educational initiatives. Further detail about the development project in her colleague's class has been reported in section 6-2.

The teacher had an average level of IT skills. Her usage of computers for teaching and learning purposes was rather occasional. Before the project began in her class, the pupils in her class often used the computer for about fifteen minutes per week. Her daily teaching could be described as routine or habitual. With previous experience in teaching year 6 children, she was generally satisfied with the way she taught her pupils and did not feel the need for any sharp change in her pedagogy. However, as an open-minded person and with the encouragement given by her colleague, she was eager to gain further experience in using computers through participation in this project.

The pupils

The year 6 class comprised 31 pupils. The pupils came from relatively advantaged backgrounds and none of them was on the SEN register. There was only one computer in the classroom and it had multimedia facilities. Most of the pupils in class were good at using computers. And the number of pupils in class who used a computer at home was exceptionally high among the 250 classes that were involved in this thesis. Beside the teacher, it was rare to have any other adult to help the class with teaching and learning. So, the target of the project was to make use of the computer as a provider of knowledge.

The aims of the project

This project had three aims set for research and development purposes.

The aim of development was to foster pupils' reading development and understanding of two science topics. It did not aim at enhancing the development of pedagogy supported by ICT.

The first aim of the research was to investigate the effectiveness of the two software applications in terms of pupil learning attainment/gains. The second research aim was to investigate the gender issue during group work or pair work on the computer.

The research and development work

The research and development project took place from the middle of September to late December in 1998. Pupils were asked to group in pairs to work on the computer for two chosen topics about science. The two topics were "Airship" and "Microwave Ovens". Each of the topics was described by two passages on the computer. One of the passages was an electronic text originated from the book "How it works" (H) and the other one was originated from a multimedia CD-ROM "The way things work" (W). The two topics were chosen after a short discussion between the teacher and the external developer. In some ways, besides being a reading activity in the language curriculum, the teacher found these topics were related to the science curriculum.

The content of the passages did not vary greatly in terms of the level of difficulty in reading or the clarity of the presented information (refer to Appendix 6-A for details), but the formats of presenting the information were different. The electronic passages of H were prepared by converting the original printed text into electronic text, with the optical character recognition facilities on the computer. The two passages were presented through the use of a software application with a text-to-speech support facility. The two passages of W were presented with hyperlinks and animations. The hyperlink feature of the software application was used to provide further details or explanations of some key concepts and the motion pictures of the software application were used to illustrate how the machine works.

The two software applications were introduced to the pupils by the external developer. It took place as six computer-based demonstration sessions in the school library. In each session, pupils were withdrawn from their class in a group size of four to six. The major reason for the arrangement was that there was only one computer available to the class. The group size had to be small so that each pupil could have a clear view of operational steps showed on the computer screen. The content of the demonstration included the instructions of each computer operational step required for the use of the two software applications and the changes in the computer screen resulting from these operational steps. To enable consistent instructions for all the groups, the content of the demonstration was pre-recorded as a video clip on the computer. The playback of the video clip on the computer became the major part of the training in preparing pupils for the use of the two software applications. The computer was used as a presentation tool.

Pupils were asked to work in a corner of the classroom with the two computer software applications during the small group teaching time or during the time for independent work. Some pupils did it in literacy lessons and some did it in science lessons. After completing the exercise on the computer, pupils were also asked to read the printed version of the text that had been presented on the computer quietly in their own seats. As the activities on the computer were supposed to be a form of independent learning through the access to informational database, it was not necessary for the teacher to pay special attention to their learning on the computer. Having said that, the teacher worked closely together with the external developer in preparing for the computer-related learning environment for the pupils. She was responsible for the following instructional arrangements:

- organising a corner of the classroom for the computer activities,
- arranging pairs of pupils to use the computer according to the schedule,
- managing pupils on the computers and other pupils not on the computer, and
- administering questionnaires and reading tests.

At the early stage of the project, individual pupils who felt confident in using the two software applications were asked to demonstrate the computer operational steps in front of the class. The pair work began when all the pupils felt confident in using the two software applications. Pupils were expected to complete the task on their own without referring to any written instruction about the operational steps. When working on the first topic, the grouping or pairing of pupils was based on friendship or the teacher's choice. The grouping was either based on pupils' initiation or being assigned by the teacher into groups or pairs. At the same time, a questionnaire survey was carried out in the class. It gave information about the sociometric data about the grouping and social status of the pupils in class. The collected data enabled the developer to identify pupils who were socially popular as well as those who were socially neglected by their peers (refer to Appendix 3-C for further detail). When working on the second topic, the results of a sociometry survey were used to make decisions about the grouping or pairing on the computer. The instructions about the activity and the grouping are presented in Appendix 6-B. According to the gender of the pupils in class, there were three kinds of groupings or pairings. These included:

- Four boy pairs
- Three girl pairs
- Eight mixed gender pairs/groups

The grouping of boys or girls was to pair a pupil who was socially neglected (i.e. with 0 or 1 choice received in question 8 of the sociometric survey, as mentioned in Chapter 3) with the person(s) he or she preferred to work with. The grouping of the mixed gender pairs/group was to pair a pupil who did not make or receive any opposite choice with a partner of the opposite gender. The selection of the potential partner was initiated by the external developer and was agreed by the teacher in an informal meeting. The selected partner would likely be a friendly person or a person with good IT skills.

Evaluation of software applications

So far, the two case studies above have demonstrated the successful use of ICT to support effective learning and instruction. It is still difficult to know if the learning attainment or learning gain, if there is any, is attributable to the effect of ICT or to the instructional arrangements associated with using ICT. Furthermore, the quality of the instructional environment provided by ICT is believed to be an important factor that affects the effectiveness of use, but the issue has not been addressed. It was relevant to set up a study to compare the effectiveness of two different software applications and to investigate what features of the software applications were linked with learning attainment and learning gain.

For the specific purposes above, a questionnaire was designed and administered to all the pupils in the class in early December, 1998. Out of the 31 pupils in class, 30 pupils completed and returned the questionnaire. The high return rate was due to the support of the teacher. There were 31 statements on the questionnaire. They are presented in Appendix 6-D. The questionnaire items could be sub-divided into three types, including:

- the interactivity and operational aspects of the two software applications,
- the affective, attentional or mind-engaging aspects of the two software applications when they were used, and
- the cognitive and academic impacts of the two software applications.

Items concerning software interactivity were constructed with reference to the attributes of interactivity described in Milheim (1996) and items of the other scales were constructed on the basis of the researcher's experience. To reduce the size of the data analysis, all the items of the same types were tested for internal consistency. During the process, some of the items were transformed in a reversed scale and some of the items were dropped. Three measurement scales were eventually formed. The details of the composition and the internal consistency are presented in Table T6-4-1. The alpha statistics vary from 0.70 to 0.84, which seem to be reasonably acceptable.

Table T6-4-1: The composition and internal consistency of the three measurement scales in this study

Focus of measurement	Original proposed items (statement number)	Final items ('p' = reversed scale)	Alpha of H	Alpha of W
Interactivity and operational	3, 5, 9, 11, 15, 17, 21, 23, 26, 27, 28, 29, 30, 31	5, 11, 21p, 26, 27, 28p, 30	.70	.74
Affective and mind-engaging	1, 2, 4, 7, 10, 13, 16, 19, 22	4, 7, 13, 16	.76	.71
Cognitive and academic	6, 8, 12, 14, 18, 20, 24, 25	6, 8, 12, 18, 20, 24, 25	.83	.84

Remark: Refer to "Appendix 6-D" for the content of the statements.

Keys: **H** refers to items measuring the electronic text originated from the book "How it works" and **W** refers to items measuring the text originated from a multimedia CD-ROM "The way things work".

The internal consistency of the three scales provides the basis for making a comparison between the two software applications. The results are summarised in Table T6-4-2. The results indicate that the software application H was found to be less interactive, less attractive and less helpful for academic learning than the software application W. The differences between the two software applications are obvious because significant differences are found between each of the items of the respective scale at $p < .05$ level. A paired t-test was also carried out to investigate if the difficulty of the reading text of the two software applications differed from each other. Since no significant difference was found at $p < .05$ level, it was concluded that there was no significant difference between the difficulty of the text on the two software applications.

Table T6-4-2: The results of t-tests comparing the two software applications

Type of measurement	T-test comparing the difference between the rating for software H & software W
Interactivity and operational	It doesn't seem to be interactive or easy to use for me/unsure & it seem to be interactive or easy to use for me **
Affective and mind-engaging	It doesn't seem to be attractive for my attention in learning/unsure & it seems to be attractive for my attention in learning **
Cognitive and academic	It doesn't seem to be helpful for my subject learning & unsure/it seem to be helpful for me subject learning **

Keys: The ** refers to statistical significance at $p < .01$ level (two-tailed).

The Hodder Reading Progress Test was administered twice in this development phase. The first time was in the middle of September in 1998 and the test was repeated in the middle of December in 1998. There were 30 pupils who did both tests. The mean reading age on the first test was 11 years 7 months and that on the re-test was 12 years 8 months. The difference in means was found to be statistically significant at < .01 level (two-tailed). Although the making of a 13 months progress in reading age in about three calendar months seems to be making remarkably good progress, it is not sure whether the results should be attributed to the use of ICT or to the instructional arrangements associated with using ICT. Therefore, further analyses were done to investigate the possible links between the features of two software applications and pupils' reading attainments and reading gains.

Significant correlations between software features and reading attainment are reported in Table T6-4-3. The major findings are presented in part A of the table. Pupils' pre and post reading attainments were negatively related to the 'affective and mind-engaging' measure of software H and the 'cognitive and academic' measure of software H, respectively. Pupils with high reading attainments did not find software application H interesting and were not happy when working on it, while pupils with low reading attainments found software application H interesting and were happy when working on it. Pupils with high reading attainments did not find software application H helpful to their academic learning, while pupils with low reading attainments found software application H helped them to remember the presented facts, to read more and to develop further inquiry about the topic.

The results indicated that reading attainments were positively related to the "interactivity and operational" measure of software W. Pupils with high reading attainments noticed that software W gave quick responses, gave them a lot of chance to take part in learning, did not required a lot of teacher's attention when it was being used, and they were confident to use it again on their own. In contrast, pupils with low reading attainments noticed that software W did not give quick responses, did not give them a lot of chance to take part in learning, required a lot of teacher's attention when it was being used, and they were not confident to use it again on their own. On the basis of this, we might speculate that pupils with low reading attainments did not use (or used infrequently) the hyperlink and the animation features of the software as a form of further inquiry of the topic.

Findings presented in Part A are supported by findings presented in Part B and Part C of the table. All the items addressing the 'affective and mind-engaging' measure and the 'cognitive and academic' measure of software H are negatively related to reading attainments, and all the items addressing the 'interactivity and operational' measure of software W are positively related to reading attainments. The results confirm the findings presented in Part A. Software H was good for pupils with low reading attainments because it motivated them and helped them to learn. Software W was good for pupils with high reading attainment because they used the hyperlink and animation features of the software for further inquiry about the topic.

Table T6-4-3: Significant correlation (2-tailed) between software features and reading attainment

Part A: Measurement scale i.e. the composition of the scale is presented in Table T6-4-1		Cor. with Test 1-RA	Cor. with Test 2-RA
The 'affective and mind-engaging' measure of software H		-.43*	-.38*
The 'cognitive and academic' measure of software H		-.41*	-.36^
The 'interactivity and operational' measure of software W		.32^	.37*
Part B: Measurement item (statement) addressing software application H	**Reference to scale**	**Cor. with Test 1-RA**	**Cor. with Test 2-RA**
This is the type of software that I like. (01)		-.60**	-.64**
I was quite happy when I worked on this software. (07)	affective & mind-engaging	-.38*	-.38*
This software was interesting to me. (13)	affective & mind-engaging	-.38*	-.35^
This software helped me to pronounce the reading text. (14)		-.40*	
This software helped me to remember the presented facts. (18)	cognitive & academic	-.43*	-.48**
This software encouraged me to read more. (20)	cognitive & academic	-.43*	-.34^
This software encouraged me to develop further inquiry about the topic. (24)	cognitive & academic	-.32^	-.40*
I think I can operate this software again independently. (26)	interactivity & operational	.36^	.37*
This software could make appropriate responses according to users' needs or requests. (27)	interactivity & operational	-.34^	-.42*

Part C: Measurement item (statement) addressing software application W	**Reference to scale**	**Cor. with Test 1-RA**	**Cor. with Test 2-RA**
The reading text of this software was difficult for me. (02)		-.54**	-.61**
The use of this software required reasonable computer operation skills. (03)		-.35^	-.44*
This software gave me quick responses. (11)	interactivity & operational		.41*
This software requires good computer operational skills. (15)		-.48**	-.48**
This software encouraged me to read more. (20)		.33^	.44
I had little control over the sequence of information presented by this software. (23)		-.38*	-.40*
I think I can operate this software again independently. (26)	interactivity & operational	.44*	.47**
Using this software required a lot of teacher involvement. (28)	(reversed) interactivity & operational	-.41*	-.35^
This software gave me a lot of chances to take part in learning. (30)	interactivity & operational		.38*

Remark: The numerical figures reported in the table are Pearson correlation statistics. The composition of the scales in section A are presented in Table T6-4-1.

Keys: ***Test 1-RA*** refers to the reading age noticed from the results of the first reading test and ***Test 2-RA*** refers to the reading age noticed from the results of the second reading test. The ** refers to statistical significance at $p < .01$ level (two-tailed), * refers to statistical significance at $p < .05$ level and ^ refers to statistical significance at $p < .10$ level.

It was interesting that pupils with high reading attainment found reading text of the software W was not difficult for them. In fact, the results of an analysis of the readability of these passages found that the second passage presented by the software application W was relatively difficult when compared with the second presented by the software application H. Such a difference was not found between the first passage of the two software applications. Further detail of the readability analysis of the passages can be found in Table T6-4-4. Given that the qualitative analysis of the first question in the pupil questionnaire suggested that all the pupils in class preferred software W to software application H, the choice about which of the two passages to be read first was not a significant factor affecting their software preference in this study. So, a possible reason for that is pupils with high reading attainments preferred passages presented by software application W to passages presented by software application H. If this is true, it would mean that a well-designed computer presentation can motivate pupils to deal with challenging text. For further investigation, a comparison between the effect of different computer-based presentation methods with the use of the same passage is recommended in future research.

Table T6-4-4: Results of readability analysis of the passages presented by the computer

Software application & the presented topic	H passage 1 (Airship)	W passage 1 (Airship)	H passage 2 (Microwave Oven)	W passage 2 (Microwave Oven)
Words	54	74	45	61
Characters	279	376	209	307
Paragraphs	2	3	2	3
Sentences	4	4	3	4
Sentence per paragraph	4.0	4.0	3.0	2.0
Words per sentence	13.2	14.5	14.3	14.7
Characters per word	4.9	4.6	4.4	4.7
Passive sentences	75%	25%	33%	0%
Flesch Reading Ease	60.8	63.7	72.2	57.0
Flesch-Kincaid Grade level	8.0	7.9	6.7	8.9

Remark: Standard average of Flesch Reading Ease is between 60 and 70. So, a score between 50 and 60 would mean slightly difficult and a score of 70 to 80 would mean slightly easy.

Further analyses were done to investigate the possible links between the features of two software applications and pupils' reading gains. The latter included gains in reading age as well as gains in the scores of the reading test and the retest. The significant findings were reported in Table T6-4-5.

Table T6-4-5: Significant correlation (2-tailed) between software features and reading gains (reading age & reading test score)

Software application: Measurement item (statement on parent's questionnaire)	Gain in test score
Measure of software H: I paid a lot of attention on the pictures and graphics presented by this software. (16)	.38*
Measure of software H: The operation of this computer software was complicated. (21)	.32^
Measure of software W: This is the type of software that I like. (01)	-.49**

The results indicate that the use of software H was positively related to the extent of learning gains. Although they found the operation of software H complicated, pupils with high learning gains paid a lot of attention to visual elements presented by the software. In contrast, for those who did not pay attention to the visual elements presented by the software, their learning gains were low and they did not find the operation complicated. Pupils who thought that software W was the type of software that they like had low reading gains, while pupils who were not sure whether software W was the type of software that they like had high reading gains. Having said that, it is inappropriate to say that software W was less effective to enhance learning gains, while software H was effective to enhance learning gains. We need to consider learning attainments and learning gains together. This is illustrated in Table T6-4-5.

Table T6-4-6: Results of the crosstabulation between reading attainment and reading gain (reading test scores)

	Pupils with low reading gain (change in test score)	Pupils with high reading gain (change in test score)	Total
Pupils started with low reading attainment	6	11	17
Pupils started with high reading attainment	10	3	13
Total	16	14	30

Remark: The numerical figures presented in the table refer to the number of pupils.

In table T6-4-6, pupils in class are divided into two groups according to the results of the first reading test and according to the increase in the test scores, respectively. The same number of pupils in the first group is roughly the same as the number of pupils in the second group. The results of chi-square statistics showed that the distribution pattern was statistically significant at $p < .05$ level (two-tailed). As the number of pupils in the two groups were not exactly the same, further statistical analyses were done to confirm the pattern of relationship. These include chi-square tests with 14 pupils in the low reading gain group and 16 pupils in the high reading gain group, and 13 pupils in the low reading attainment group and 17 pupils in the high reading attainment group, respectively. The results confirm that pupils with low reading attainments tend to have high reading gains, while pupils with high reading attainments tend to have low reading gains. In linking with the results above, the results seem to be matched with the contributions that the two software applications made. It leads to the speculation that many pupils with low reading attainments made high reading gains because software H was used. In contrast, many pupils with high reading attainments made low reading gains because software W was used.

This leads to the speculation that software H was effective for pupils with low reading attainments. They made high learning gains with the use of the text-to-speech support facility provided by the software. In contrast, software W was effective for pupils with high reading attainments because they made further inquiry into the topic through the use of the hyperlink and the animation features of the software. However, their extent of learning gains was lower than expected. It is possible that the features of the software provide the opportunity and encourages pupils to read more, but these fascinating features may also divert their attention away from the focus of the learning task. Therefore, fore inexperienced learners, the software features may become a source of motivation and/or distraction. Upon speculation, it is also possible that the increase in motivation originating from the use of the software was extrinsic in nature. It is different from the intrinsic motivation that pupils with high reading attainments and high reading gains had. This is the group of pupils who were not sure whether software W was the type of software they liked. Nevertheless, for some reasons e.g. the lack of computer skills, there are pupils with low reading attainments and low reading gains. The computers did not make an effective contribution to their learning. Anyway, generally speaking, the results reveal the importance of software selection for learning.

Qualitative data were also collected through the administration of an open-ended questionnaire immediately or shortly after each pupil had completed the second passage of the two software applications. A copy of the questionnaire is presented in Appendix 6-C. The results of qualitative data analyses showed that all the 31 pupils in class preferred software application W to software application H because it was "more exciting", was "more interactive", was "more fun and interesting", was "more entertaining", had "better graphics", had "pictures that moves" and let "you (pupils) get more involved".

Question: "Which software do you prefer, H or W? Why?" Answer: "I like W because it's more interactive."

Out of the 31 pupils in class, 18 of them reported that software application W was more successful in encouraging them to read more than software application H because "of the funny pictures", "it is really interesting", "it is more exciting". It is interesting to find that one of the pupils reported that the personal reason for reading more was that "some things are and some aren't read out to you", and another pupil reported that "there is less to read". These statements imply the motivational value of having some of the text read aloud by the computer, leaving some of the text to be read by pupils. In referring to the social psychology of learning, the learning environment is supported by the modelling work of the computer. On the other hand, pupils who reported that software application H was more successful in encouraging them to read more than software application W because "it's in writing...so you (they) have to read it". It implies that the importance of giving pupils the chance to practise reading, rather than making the computer read for them.

Question: "Which software encourages you to read more? Why?" Answer: "W because some things are and some aren't read out to you."

Being asked to choose which of the two software applications made them feel easier to read, 12 pupils named the software application H. They explained that it was because "it reads (by) itself and mark(s) (where) they are up to", "the robot reads out" and "lights up the word it is reading". On the other hand, the 19 pupils who chose software application W explained that "it also shows you (them) how it works", "it has more pictures" and "it's funny and got more things to do".

Question: "Which software presentation is easier to read? Why?"

Answer 1 (from a pupil with the reading age of 8 years 1 months): "H because it reads (by) itself and mark(s) (where) they are up to."

Answer 2 (from a pupil with the reading age of 15 years 10 months): "W because it also shows you how it works."

Interestingly, one of the pupils provided the reason for his preference of software application W to H was that "it has no robot sound". One of the possible explanations for this would be the quality, usefulness or effectiveness of the text-to-speech facility provided by the computer software application H. The mental age of the pupils in class would be around 10 to 11 and their average reading age at the beginning of the project was 11 years 7 months. It would be reasonable to doubt the effectiveness of using text-to-speech support facilities. Only one third of the pupils in class had a reading age of below 10 years old, where the text-to-speech support facilities might be most useful. In other words, more than half of the class would have been competent enough to read the text independently on their own. As the quality of the synthesised sound was not good enough, it is possible that the text to speech facility was a hindrance for the competent readers. Generally speaking, pupils also found software application W easier to use than software application H.

Evaluation of grouping/pairing

When considering evaluation strategies for the above grouping arrangements, there were queries concerning whether pre-test and post-test measures might not be appropriate. As the pupils selected for intervention were those who were socially neglected or those who did not choose or receive any choice of the opposite gender group, the ceiling effect could be a potential source of the measurement errors. On this basis, a quasi-experimental design and a qualitative evaluation approach were adopted. The data were collected from pupils' written feedback to the open-ended questionnaire, which was filled in immediately or shortly after they had completed the pair or group work on the computer. The data were then transformed into an electronic text on a spreadsheet and were also imported into the NUDIST software application for further analysis.

Uni-gender grouping/pairing

Three out of the four boys' groups reported that the grouping seemed fine for them. The boys seemed to be working together well in different degree of collaboration, from working collaboratively together to turn taking. In the last boys' group, the target pupil who was identified as socially neglected felt "good" about his working partner. He preferred working with a partner than working alone on the two computer software applications. On the contrary, his partner described that he "felt disgusted" about his working partner. He preferred working alone on the two computer software applications, as he wanted to look at what he wanted to look at.

Evaluation: "Please write about your feeling when working with your partner." Feedback 1 (from a socially neglected pupil): "Good." Feedback 2 (from the partner of the socially neglected pupil): "I fell (felt) discusted (disgusted)." Evaluation: "When working on the two computer software, do you prefer to work alone or in pair? What are the major differences?" Feedback 1 (from the socially neglected pupil): "In partners." Feedback 2 (from the partner of the socially neglected pupil): "Alone look at what you want to look at."

Being "dominated" in the control of computer learning activity could also be a potential threat for successful group work. Often the act of domination took place sub-consciously. This gives reason for the discrepancy between the feeling of the two partners. The occurrence of domination might be more serious when a boy with good IT skills works with a girl on the computer. This can be demonstrated by the statement of the boy who received the highest number of choice in terms of being good at using the computer, "one boy and one girl...I will be more dominated".

All the three girls' groups seemed to be working well together. The girls' feeling about their partners could be described as comfortable, enjoyable and relaxed. One of the girls mentioned that "it was very boring working on the computer", but she was alright with the experience of the pair/group work "because J was working (with her)". Another girl expected that she would behave differently if she had a different partner. Again, preference still went to girls, as she stated that "when you are with girls you know what they are like, unlike boys".

Mixed-gender grouping/pairing

The uni-gender grouping preference also applies to boys. It can be demonstrated by the comment made by one of the members of a boys group. When being asked whether he would behave differently if he had a different partner, the boy stated, "I think it might be different because a boy and a girl might argue".

Out of the eight pairs or groups, only three groups could be described as successful in mixed gender grouping. The boys who succeeded in working together with girls were described as "funny", "happy" and/or "helpful", while the girls who succeeded in working together with boys were described as "friends", "helpful", "funny" and/or "good to work with". So, boys or girls who succeeded in working together with pupils of the opposite gender group had similar personal characteristics.

The mixed gender grouping was not quite successful in the other five groups. The most offensive remark was made by a boy, "Not very good. She is nasty". In a mixed gender group, the boy complained, "I think my partner is hussy and bossy and does not let you try something that she has not tried before", while the girl in the group complained, "XYZ wanted to do everything and would not let me have a go. Typical." The qualitative data showed that sometimes boys were either too bossy or dominating in computer operations and tensions were created when girls did not allow the boys to do so. Boys who had good IT skills were more likely to be dominating in computer operations when working with a girl than with a boy. However, in this study, none of the girls who had good IT skills was found to be dominated in computer operations.

The results lead to the reflection on the suggestion made by Pryor (1995) who stated that children, especially boys, had to be encouraged to focus on their partners as well as the task on the computer.

For boys, their over-domination of activities on the computer seemed to be a 'natural' or 'taken-for-granted' event. It could still happen when the IT skills of the boy were not as good as the girl in his group or pair. In another mixed gender group, the boy stated, "It wasn't very good because she's not really my friend, but she was quite good on the computer." And the girl in his group commented, "He wasn't very good because he kept bossing me around". Both boys and girls in the mixed group stated that they could perform better if the partner was a member of the same gender group.

Evaluation: "Please write about your feeling when working with your partner."

Feedback 1 (from a boy): "It wasn't very good because she's not really my friend but she was quite good on the computer."

Feedback 2 (from a girl, his partner): "He wasn't very good because he kept bossing me around."

Linking the results together

Boys and girls found difficulties in working with pupils in the opposite gender group. Such a problem could be common in mixed gender groups when working on activities supported by the computer as well as activities without the computer. Having said that, it seems to be easy for boys with good IT skills to dominate the control of the computer when they work together with a partner from the opposite gender group. No complaint of this kind was received in this study when girls with good IT skills were working together with another boy with average IT skills.

The strategy of grouping/pairing socially neglected pupils with the most preferred working partner seemed to be effective in bringing a positive group learning environment for the target pupils. And the strategy seemed to work well among boys' groups and girls' groups. Having said that, attention should be given to the choice of partner named by the target pupils. The experience of this study indicated that not all the named partners enjoyed the group/pair working experience with the target pupils, although most of them worked together well as a group/pair. It leads to the implication that extra care is needed when considering pairing a socially neglected pupil with a working partner from the opposite gender group.

Pupils' comments about the two software applications implied that there were strengths and weaknesses of the text-to-speech support. For some pupils in class, especially pupils with low reading ability, the text-to-speech support helped them to understand the text. However, the text-to-speech support might reduce pupils' chance of practising reading on their own and the speed and the quality of the electronic voice could be a hindrance for competent readers. The use of motion pictures was found to be useful in motivating pupils and in demonstrating the process or how a machine worked. As a form of audio-visual aid, they were useful to help readers understand the presented text. Texts presented by hyperlinks seemed to be well accepted by readers because it provided the reader with further information that they needed or found interesting. In other words, the hyperlink activities provided readers with a range of choices of extended topic of interest.

Summing up

The present study has found that various features of software application have significant associations with learning attainments and learning gains, respectively. The results indicated the effectiveness of some software features for a specific group of pupils, and some software features on another. This underlines the importance of software selection.

Given that features of software applications have significant impact on pupil learning, teachers are advised to evaluate the features of software applications. The choices they make have significant impact on pupil learning. There are reference sources of criteria for software evaluation available on the web, such as:

- Software Evaluation Criteria prepared by College of Education, University of Tennessee (http://www.it.utk.edu/~jklittle/edsmrt521/soft_eval_eric.html),
- FreshPond's Treasures: Resources for K-12 Educators (http://www.freshpond.net/treasures/technology/softreviews/softeval.htm), and
- Scholastic Technology Guide (http://apps.scholastic.com/schooltechguide/home.asp).

Alternatively, the results might imply that the frequency and intensity of the use of ICT are not high enough to make significant changes in reading gain. Further investigation on this topic is needed. For instance, how much time is needed and what is the optimal time? The results imply that the software designer plays a significant role in affecting the effectiveness of learning and instruction.

To a certain extent, the intervention strategy for helping the socially neglected seems to be successful. It is recommended that attention be paid to the interest and the satisfaction of all the pupils in the group or pair. The exploration of gender issue in group or pair work on the computer is only the tip of the iceberg. As our society consists of both gender groups, further investigations are needed before a proper intervention policy can be set up. The use of computer-based video for demonstration was also found to be an effective way of introducing the tasks on the computer. As it contained the screen at every operational step, pupils found it easy to follow. The technique is recommended for the delivery of standardised instructions of high quality.

(6-5) Using computers for in-class and out-of-class learning in Year 3

The school

The year 3 class in this study was part of a large first school with over 350 pupils. It was located on the western edge of a large city in the northern part of England. The pupils were from families of mixed socio-economic background. About 20% of the pupils were eligible for free school meals and about the same percentage of the pupils were from single parent families.

The teacher

The teacher took part in the TTAICT project aiming at developing pupils' writing skills with palmtop computers in the academic year 1997/98 and 1998/99. During the period, he was the teacher of a Year 4 class and a Year 3 class, respectively.

By 1998/1999, the teacher had taught in the school for 4 years. He had average IT skills, but he had a positive view towards using ICT and was keen on incorporating it into his literacy teaching. Compared with the other 250 teachers who responded to the survey 1997/98, the teacher was one of the teachers who had the highest preference for using ICT for developing pupils' IT skills. He was also among the top 10% of the respondents who had perceived an improvement in pupils' academic performance as a result of using ICT.

Although the teacher thought that ICT could be an effective tool for pupil learning, he believed that it had to be used in a planned and purposeful way. The statement below illustrates how he made use of the palmtop computers for redrafting purposes.

"I wrote out a poem and then a couple of the pupils for revision, just for twenty minutes, went through it putting in full stops, capital letters, speech marks. They like that because, it didn't involved copying work. It was effective in term of time, and at the end they could show it, and read it, to the class."

The pupils and the development work of the TTAICT project

The present research study is focused on the Year 3 class that the teacher taught in 1998/99. There were thirty pupils in the class. No pupils were on the special educational needs register. About a quarter of the pupils in class had a computer at home. The results of the teacher survey showed that the pupils used ICT for about two hours per week in 1998/99, which meant that they were among the top 10% of the 250 teaching groups reported in the teacher survey.

The development work of the TTAICT project in this class began in the middle of September in 1998 and lasted for about three months. The main focus was to enhance the pupils' writing skills with "PSION" palmtop computers. Pupils were divided into three groups of ten pupils. They were introduced to the functions of the palmtop computer. After the first workshop session, pupils were reasonably confident with the basic operation of the palmtop computers for their writing tasks, which included how to turn it on, how to create and choose a file and to type in their work, and how to save their work. In each workshop session, pupils were given a paper slip as a reminder of what they learnt. The content of the slip was made up of sections 1, 2, 3 and 5 of the "Appendix 7-B". Then ten palmtop computers were provided for the use of a group of ten pupils for a week, according to the schedule presented in "Appendix 7-D". Pupils in the computer group were asked to bring the palmtop computers with them everywhere for the writing purposes during the week. Pupils were excited by the idea of taking the palmtop computers home and they found the arrangement increased their motivation to write.

Each of the pupils in class was asked to complete two writing tasks on the computer and a writing task on paper. The computer activities included a note-taking exercise on the palmtop computer to be done at any time available to them during the week when the palmtop computer was available for the pupil's use and a weekly writing assignment by the end of the week. According to the schedule, the pupil was also asked to complete another writing assignment with paper and pencil. The proposed topic for both of the writing assignments was to "describe an event that interested you most in this week". A copy of the instructions for the "weekly news" writing is presented in "Appendix 7-C". The writing exercises continued according to the schedule until every pupil had completed two written assignments on the palmtop computer and two written assignments on paper.

During the development period, intensive support services were provided to pupils from a team of workers. It included an academic who acted as an adviser in teaching and learning literacy, two project officers and the class teacher. Some parents also offered informal support to their child when working on the palmtop computer at home. In every week, a group of ten pupils were withdrawn from the class for forty minutes for a palmtop computer session led by two project officers. As mentioned above, the first session was to prepare pupils with the basic operational skills for starting their writing tasks on the palmtop computers. The second session was a practical problem-solving session to help pupils with difficulties and problems met when they actually used the palmtop computers for their writing tasks. The third session was another workshop session to teach pupils some editing skills and the use of the spell-checker. The fourth session was another practical problem-solving session. Throughout the project, the pupils in the palmtop computer group were encouraged by the teacher to write their own diary notes on the computer at any time in his teaching sessions, which included literacy, numeracy and science and history lessons. He found his pupils were very keen to use palmtop computers as a writing tool. This applied to pupils of different ability. To encourage the writing activities, all the completed writing assignments were "downloaded" by the project officers. A copy of the printout was given to the teacher, who was responsible for selecting some of the work to be published on the notice board in the classroom. The selection was made on the basis of the communicative value and the quality of the writing. Nice work done on paper was also published. The major difference was that this was hand-written, not presented in print.

Pupils' improvement in reading skills was assessed by the administration of a standardised reading test at the beginning and by the end of the development work. Twenty-six pupils completed both tests. The results of the first test showed that their average reading age was 8 years and 9 months. And the result of the retest showed that their average reading age was 11 years and 1 month. A full account of the development work was published in the report by Moseley, et. al. (1999). For reference, a copy of it is presented in "Appendix 7-A".

The aims of the present study

Instead of focusing on the development work with the use of palmtop computers, this study investigated the use of computers by Year 3 pupils for in-class and out-of-class learning. The research work was carried out at the same time as the development work of the TTAICT project. The major aims of the study were to:

1. investigate the amount of time that the group of Year 3 pupils spent on computers at school and at home,
2. evaluate whether the use of computers for the group of Year 3 pupils was effective for their learning, and
3. suggest what teachers, project officers and parents can do to facilitate or promote the effective use of palmtop computers for learning outside the classroom.

The formulation of research focuses

To meet the emerging challenges of the twenty-first century, Bentley (1998) suggested that it is important for young people to connect what happens in schools to wider opportunities for learning. We need to prepare our children for the need of society by extending their learning beyond the classroom setting.

One of the traditional ways of extending learning beyond the school is to give pupils homework assignments. However, the findings of Farrow et. al. (1999) reported that pupils who reported doing homework 'once a month' in each of the core subjects had higher attainment than those who reported doing homework 'more frequently than once a month'. The author suggested that more serious considerations should be given to the nature and frequency of homework setting in primary schools.

Having said that, the results of development work for the group of Year 3 pupils suggested that the use of palmtop computers for homework seemed to be highly successful in motivating pupils to write. It might be worthwhile to note that the group of pupils also used other computers at school during the development period as well as having other non-computer-based learning. So, there is a need to give a full account of the use of computers among the group of year 3 pupils during the development period and to investigate whether there is a link between the amount of time on computers and the effectiveness of learning. In this study, the first research aim was investigated by addressing the questions below:

- For how long did the group of Year 3 pupils normally use computers at school?
- For how long and for what purposes did the group of Year 3 pupils normally use their computers at home?
- For how long did they use palmtop computers when they were available to them for a week?

The second research aim was investigated by addressing the two questions below:

- Was there a link between pupils' time on the computer and their learning attainment or learning gains?
- In parents' view, what impact did the use of palmtop computers bring to their child?

Finally, the present study also considered some work that teachers, external people and parents might do to facilitate or promote the effective use of palmtop computers for learning outside the classroom.

Research design, methodology and data collection

To achieve the above aims of the study, suitable research instruments were designed and administered. The first set of instruments comprised two questionnaires for pupils. One of them was administered at the beginning of the development project and the other one was administered at the end of the project. Out of the 30 pupils in class, 28 pupils completed both questionnaires. The second instrument was a standardised reading test. The test was administered to the pupils at the beginning of the development project and the re-test was also administered at the end of it. Eventually, 26 pupils completed the test and retest. The two questionnaires are presented in "Appendix 7-F" and "Appendix 7-G".

During the development work, pupils were also asked to fill in two logbooks. They were used to record their activities and the media within the specific time slot of the day, including school days and non-school days. Each of them lasted for a fortnight. A sample of the logbook is presented in "Appendix 7-H". So, the data in each logbook provided information about the amount of time that a pupil spent on each activity or each communication medium during a fortnight. For example, the data could tell us the duration of time that pupils spent on reading, spelling, writing or computer activities within the week when palmtop computers were provided for their use as well as within the week when they were not available. Only data collected from the second logbook were used for analysis in this study. Due to the frequent absence of a pupil in class and the loss of a logbook by another pupil, 28 pupils returned the logbooks. The return rate was 93%. Compared with the data obtained from the first logbook, the data collected from the second logbook is more reliable. The major reasons for that were listed as below:

- With the experience of filling in the first logbook, pupils were more accustomed to the habit of filling in the logbook.
- With the experience gained from the first logbook, the design of the second logbook was improved.

Lastly, an open-ended questionnaire was administered to the parents. It was focused on the impact on pupil learning resulting from the use of palmtop computers. The questionnaire also collected suggestions about what teachers and external developers might do to facilitate or promote the use of computers for learning outside the classroom. A copy of the questionnaire is presented in "Appendix 7-J". The questionnaire was sent to the parents of 28 pupils in the class on the last day of the development project. Eventually, 24 completed questionnaires were collected. This gave a return rate of 86%. The high return rate might mean parents were supportive of the use of palmtop computers for learning outside the classroom.

Clarification of terms about in-class and out-of-class learning

Before moving onto the data processing stage, clarification of the conceptions of some terms about in-class and out-of-class learning is needed. This was as a refining stage for various measurements to be reported in this study. They are listed below:

- "In-class time" refers to the amount of time a child spent in an activity when he or she was at school.
- "Out-of-class school time" refers to the amount of time a child spent in an activity at break times and lunch times.
- "Out-of-school time" refers to the amount of time spent a child spent in an activity when he or she was not at school.

So, "out-of-class time" comprises out-of-class school time and out-of-school time.

Data treatment

The line scale of the first set of questionnaires was converted into a seven-point measurement scale. Here is a list of the codes and the respective descriptions:

-3 refers to “definitely not agree”,

-2 refers to “strongly disagree”,

-1 refers to “disagree”,

0 refers to “not sure or not appropriate”,

1 refers to “agree”,

2 refers to “strongly agree”, and

3 refers to “definitely agree”.

The scripts of the reading tests were marked and the scores were converted into reading ages. The data collected from the logbook were converted into measures of the amount of time. For example, if the pupil reported that writing and eating were the major activities during the time slot 7:00 p.m. to 9:00 p.m. on Wednesday, the information would be treated as spending an hour on writing and an hour on eating. On this basis, the aggregated amount of time spent on each activity during the week could be computed. Having said that, the total amount of time spent on each activity during the fortnight was also divided into blocks of aggregated time measures. The main purpose for the division was to distinguish between the amount of time spent:

- on in-class learning, out-of-class school learning and out-of-school learning,
- during the week when palmtop computers were available for their use and the week when palmtop computers were not available, and
- during school days (i.e. Monday to Friday) and non-school days (Saturday and Sunday).

The responses to the questionnaire were typed into the MS Excel software application. And the data were also transferred into a qualitative research computer software application for further processing.

Time spent on the computer at school and time spent on the palmtop computer

The results of descriptive statistics showed that the average "in-class time" that a typical pupil in this class spent on the computer at school in a normal week (i.e. in the week when palmtop computers were not available) was 0.49 hours. The average "in-class time" that a typical pupil in this class spent on the computer at school in the week when palmtop computers were available to the pupil was 0.37 hours. And the average "in-class time" that a typical pupil in this class spent on the palmtop computer in the week when it was available to the pupil was 1.26 hours.

The results of a paired t-test further showed that the "in-class time" that a typical pupil in this class spent on the computer at school in a normal week was significantly smaller than the "in-class time" that a typical pupil in this class spent on the palmtop computer in the week when it was available to the pupil, at $p < .05$ level (two-tailed) with $N=27$. In other words, it means that the amount of time pupils spent on palmtop computers during the project development period was significantly higher than the amount of time that they normally spent on school computers. It means that the "in-class" usage of palmtop computers, when compared with the usage of school computers, was relatively intensive.

The results of descriptive statistics also showed that the average "out-of-class school time" that a typical pupil in this class spent on the computer at school in a normal week was 0.02 hours. The average "out-of-class school time" that a typical pupil in this class spent on the computer at school in the week when the palmtop computer was available was 0.09 hours. And the average "out-of-class school time" that a typical pupil in this class spent on the palmtop computer in the week when it was available was 0.06 hours. The results indicated that pupils did not spend more time on palmtop computers than they normally spent on school computers during their "out-of school class time". It might lead to the conclusion that when pupils were at school, palmtop computers did not seem to be more attractive than the computers at school. And they did not spend more time on palmtop computers than they did on the computers at school.

The amount of time spent on computers when the pupils were out-of-school and the usage of computers at home by a group of pupils

The results of the logbooks showed that the average "out-of-school time" that a typical pupil in this class spent on the palmtop computer during the five weekdays (i.e. Monday to Friday) when the palmtop computer was available was 2.24 hours. And the average "out-of-school time" that a typical pupil in this class spent on the computer in a normal week was 1.16 hours. No significant difference between the two was identified in the result of paired t-test at $p < .05$, with $N=27$ level (two-tailed). The average "out-of-school time" that a typical pupil in this class spent on the palmtop computer during the weekend (i.e. Saturday and Sunday) when the palmtop computer was available was 1.3 hours. And the average "out-of-school time" that a typical pupil in this class spent on the computer during a normal weekend was 1.04 hours. No significant difference between the two was identified in the result of paired t-test at $p < .05$, with N=27 level (two-tailed). So, it is not clear whether the pupils had a higher usage of palmtop computers during the weekend than they normally did with other computers during a normal weekend. Instead, some of them might have used the palmtop computer for out-of-class learning more than they normally did with other computers, while some might not. The results of a paired t-test also showed no significant difference between the amount of "out-of-school time" that a typical pupil who did not have a computer at home spent on the computer and on the palmtop computers, at $p < .05$ level (two-tailed) with N=16. The results apply to the amount of time spent during school days and weekends.

In the returned questionnaire for parents, only 6 of the respondents reported that a computer was available at home. It was found that the computer at home was used by the member(s) of the family for about 10 hours every week. The maximum number of hours of computer use for various purposes other than electronic games was 24 and the minimum was 2. Except one, all the other 5 pupils who had a computer at home were allowed to use the computer in the week when the pupil questionnaire was carried out. The results of the logbook further showed that the average number of hours per week that the 5 pupils spent on the computer at home was 1.6, and the average number of hours that they spent on the palmtop computer at home was also 1.6. The result implies that pupils who owned and used the computer at home did not have a higher usage of the palmtop computer than they normally did with their home computer. It might be attributed to the limitations of palmtop computers. The screen of the palmtop is small. It can't display colours other than black and white and it hasn't got multimedia features. These are the possible reasons for making palmtop computers less attractive than other standalone computers.

According to the results of the survey of parents (see "Appendix 7-K" for detail), the highest frequency of computer use at home by these pupils was for entertainment purposes such as computer games. On average, the activity took place several times a week. A group of computer activities took place between once a fortnight and once a week. These included using home computers:

- as an electronic reference e.g. dictionary,
- for learning and practice about computers,
- for word processing,
- for other educational learning and practice, and
- for graphical work or drawing.

Computer activities that were found to be infrequent among those pupils who used their computers at home included:

- doing school assignments,
- learning and practising spelling,
- learning and practising numbers,
- learning and practising reading,
- learning and practising art and music work,
- learning and practising foreign languages, and
- e-mail.

On average, each of the computer activities in the list above took place about once a fortnight. Nevertheless, none of the pupils in this Year 3 class was found to use the internet during the week when the survey was carried out. The findings of the survey showed that doing writing tasks on the computer did not seem to be new for the group of pupils who had a computer at home. They were used to working on similar computer activities at least once a fortnight.

An evaluation of the effectiveness of using palmtop computers

It might be straightforward to expect that the effect of using palmtop computers would result in an increase in confidence in using computers. The data is available from the two pupil questionnaires. The investigation was carried out through a series of eight paired t-tests. The results are summarised in Table T6-5-1.

Table T6-5-1: Paired t-test (two-tailed) results comparing the difference between questionnaire 1 and 2

Statement on questionnaire 1 and 2	Mean (average) of survey 1	Mean of survey 2	Paired t-test (two-tailed)
I think the computer is easy to use.	Agree	Agree/ not sure	Not significant
I usually get frustrated when things go wrong with the computer.	Not sure	Not sure/ disagree	Not significant
I am very confident in using the computer software in my class.	Agree	Agree	Not significant
I have common sense about computer related equipment.	Disagree/ not sure	Agree/ strongly agree	Significant at $p < .01$ level
It is easy to find the right key on the keyboard.	Not sure	Agree	Not significant
I am familiar with using the mouse.	Strongly Agree	Agree/ not sure	Significant at $p < .01$ level
I am confident in using e-mail and internet.	Strongly disagree/ disagree	Disagree	Not significant
I have a lot of experience in using spreadsheets on computer.	Definite disagree/ strongly disagree	Disagree	Significant at $p < .01$ level

Remark: The number of valid pupil samples for the statistical tests above was between 26 to 28.

The first significant result in the table showed that pupils generally had common sense about computer related equipment by the end of the project, while they generally felt not sure or did not have that at the beginning of the development project. Such an increase was also noticed by some parents who responded to the questionnaire administered immediately after the development project.

Parent of S: "S is now more aware of computers and what they are capable of."

Parent of R: "More confident in using a computer."

Parent of T: "He is much more enthusiastic about a computer now."

Parent of M: "...gives a basic start to being computer literate."

The last significant result in the table also indicated an increase in pupils' confidence toward using spreadsheets. It seemed that they were quite sure that they were inexperienced in using spreadsheet at the beginning stage and were still aware of their inexperience in it at the ending stage. As spreadsheet was available on palmtop computers, the results might be explained by the pupils' exploration of various features of palmtop computers - including spreadsheets. Alternatively, the transfer of skills and confidence of typing on palmtop computers might be a possible explanation.

The alternative explanation above doesn't seem to be supported by the results of the significant finding concerning the use of mouse. The result in the table showed that pupils had a decrease in their confidence or skills in using the mouse. The reason for that, when referring to the use of palmtop computers, was that pupils had less chance of using the mouse. Pupils' tasks on palmtop computers were writing activities, and palmtop computers do not have a mouse.

The use of palmtop computers not only affects improvement in pupils' IT skills and knowledge, but also pupils' academic work and their personal development. Many parents noticed the positive effects on pupils' motivation and behaviour towards learning. Here are some typical quotations:

> Parent of R: "It has made R very aware of computers and she was very interested in the study."
>
> Parent of D: "D enjoyed the computer time he had and has quite good effect on his school work."
>
> Parent of K: "It has made K interested in keeping a diary and encouraged her to check her spellings."
>
> Parent of E: "She enjoyed writing stories on it, it gave her confidence."

When being asked about the effects that they thought the use of palmtop computers had brought to their child, the feedback from some parents suggested that the experience had some impact on their personal development.

> Parent of M: "M gained experience using the PSION and independent learning. M was keen to work on the computer on his own."
>
> Parent of C: "It has made C more responsible...C became a lot more patient."
>
> Parent of M: "M liked the responsibility of looking after the PSION."

It might be debatable whether some of the effects mentioned by the parents above can be attributed to the functionality of the computer equipment. For example, the reason for the increase in responsibility or being patient could have nothing to do with the functionality of equipment. The increase in the pupil's sense of responsibility could have resulted from the experience of looking after an expensive piece of equipment. It might be that the same outcome could be achieved by making the child responsible for a piece of jewellery, rather than a palmtop computer. The pupil who became more patient developed the habit of engaging himself in a learning task. Palmtop computers cannot make a child patient. The implication is that educators should not only pay attention to the provision of hardware and the quality of software, but also to the instructional environment in which the computer activity takes place. In other words, educators need the pedagogy associated with the use of ICT.

Having said that, some comments made by parents revealed that the portability feature of palmtop computers had played a role in their out-of-school learning.

Parent of D:	"Given him use of (the chance of using) something he wouldn't have at home."
Parent of A:	"Benefits is working at a computer at home is like ourselves (as if it belongs to us). There are a lot of people who cannot afford to buy one."
Parent of T:	"The benefits of the PSION computer at home was that we could all share it with T."
Parent of M:	"...helps (child) at an early age to understand and learn at an easy place - outside 'classroom' environment."

In relation to the discussion above, simply providing a portable computer for home use is not sufficient to realise the aim of promoting or facilitating out-of-school learning. Pupils need effective instruction about the computer activity to be achieved and the computer is only a tool for the activity. According to the results of the qualitative evaluation in this study, asking pupils to do homework on the computer seemed to be one of the effective ways. Interestingly, doing homework on the palmtop computer also functioned as a challenge for a pupil who had restricted or narrowed the usage of the computer at home to entertainment purposes.

Parent of C: "I think it was a successful learning tool as it seemed to be more interesting than homework of the written nature."
Parent of M: "M was very keen to do his homework on the Psion more so than he would have using pen and paper. No failures."
Parent of S: "She found it interesting and 'different' to normal homework which made her keen to use the PSION."

In the survey, parents were also asked to comment on the potential pitfalls of using palmtop computers outside the classroom. With various positive comments about the benefit of using palmtop computers at home, several parents stated that "I don't think there are any pitfalls" or "I couldn't see any pitfall". This might reveal the positive support from parents. Having said that, some pitfalls and some limitations about the use of palmtop computers were detected by some other parents.

Parent of L: "It was just a worry because it didn't belong to L in case anything happened to it."

Parent of K: "The danger is that the child's relationship with the computer could become more important than their human relationship."

Parent of A: "I still think that a one to one learning from teachers is best and not from electronic aids."

Parent of A (another pupil): "If a home does not own a PC then PSION computers would be of benefit."

The most common pitfall of using palmtop computers outside the classroom reported by parents was about the responsibility of the expensive equipment. There were chances of it being broken, lost and stolen. This was not an invalid concern. For example, one of the palmtop computers was found faulty during the development project and it took about six weeks to have it replaced. Although the palmtop computers were designed to survive accidental dropping, there were also other potential causes of failure. In future projects with the use of computers at home, project team members need to avoid or alleviate this type of worry by having proper equipment guarantee arrangements and making the information available to the pupils and their parents.

It might be interesting to note that the last comment above was made by a parent who had a computer at home. The comment leads to the query whether parents were keen on helping their child with their work on the palmtop computers, given that they had an PC at home. The investigation was started by looking at the descriptive statistics of the questionnaire. It happens that pupils who did not have a computer at home received help from members of the family in using PSION for an average of 2.13 hours during the week when the equipment was available for them, but pupils who had a computer at home received such a help for an average of 0.78 hours during that week. A one sample t-test was then performed. The results suggested that a typical pupil in this class who had a computer at home received significantly less help from members of the family than the help received by other pupils during that week at $p < .05$ level, with N=24. In other words, the ownership of a computer at home could be a potential factor that might limit the impact of using portable computers for out-of-school learning. Clarification about the interaction effect could be made by future research with ANOVA design.

If we have a critical look at the comments about pitfalls of using palmtop computers, we might query the validity of the concerns. So far, there was no research evidence suggesting the computer is a threat to human relationships. As we are not sure, the uncertainty might be solved by future research addressing this issue. Alternatively, the comments might mean that parents lacked knowledge about computers. If educators are keen on facilitating or promoting the use of computers outside the classroom, it is an area that needs to be addressed.

In addition to the qualitative evaluation of the impact of using computers for out-of-school learning, some statistical tests were carried out to investigate the potential link between the amount of time spent on a computer and pupils' reading attainments or reading gains. The results of correlation tests suggested that there was no significant association (at $p < .05$ level, two-tailed with N=24) between reading attainments/gains and the amount of:

- in-class computer time at school,
- out-of-class computer time at school, or
- out-of-school computer time.

However, a positive correlation was found between reading gains and the number of hours spent on palmtop computers during weekends at $p < .05$ level, with $N=24$ (two-tailed). The Pearson correlation statistic was 0.43. If this is not a chance result, it suggests that the amount of time spent on the assigned learning activity during weekends was highly effective. Two possible explanations are suggested. Firstly, some pupils were really keen on using palmtop computers. They were willing to spend time on writing and editing activities with palmtop computers during weekends at the expense of some other leisure activities. As the computer activity was targeted for learning, the extent of motivation (or positive attitude) to learn was linked with the extent of learning gains. Secondly, the adult(s) at home was more likely to be available to help or to attend to the child in doing the homework on the palmtop computers during weekends than during weekdays. Proper guidance, encouragement and/or expectation to learn could be a potential cause for learning gains. In the survey, 80% of the parents indicated that they had spent time with their child when working on the palmtop computers at home. So, the use of palmtop computers may have raised the parents' and the pupil's awareness of learning outside the classroom. Their expectation, motivation and positive attitude could have positive impacts on the pupil's academic performance and behaviour.

Facilitating or promoting the use of computers for learning outside the school

For pupils, their parents and other members of the family are one of the major sources of support for the use of computers for learning outside the school. Analysis of the parent questionnaire showed that the average number of hours that the pupil received help from members of the family in using the palmtop computer was 1.79 hours. The maximum was 6 hours and the minimum was 0, which means that there were big discrepancies between families.

Another source of support is available from the class teacher. From the parent's point of view, there are things that teachers can do to facilitate or promote the use of palmtop computers for learning outside the school. Here is a list of these, with the quotations originating from comments made by parents:

- setting "goals for the children",
- teaching children some "basic computer skills",
- giving "more instructions" and "different assignments",
- giving out "certification as some kind of reward",
- setting up "a school computer club", and
- organising "open evenings or days to find out more about computers".

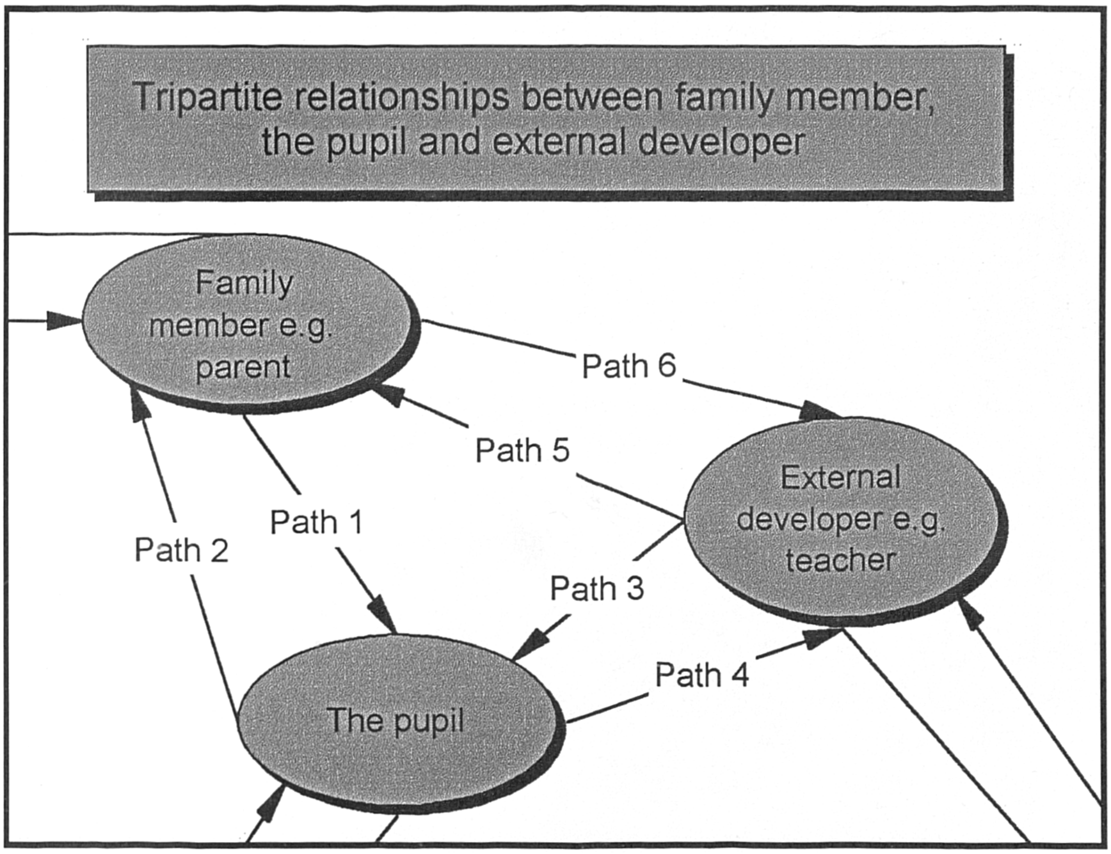
There are also things that external developers can do. Here is a list of these, with the quotations taken from comments made by parents:

- "make computers more widely available",
- "set tasks or homework where computer has to be used",

- provide "funding" for updating and upgrading computer-related equipment,
- "have computer skills as part of curriculum at an early age", and
- organise "community projects" to promote "computer education, such as competition and fun games.

The external developer may perform the things-to-do on the teachers' list and the teacher may perform the things-to-do on the external developers' list. And they have to work collaboratively with parents to support the pupil's out-of-school learning with the use of computers. The inter-relationships between them are summarised in Illustration I6-5A.

Illustration I6-5A: The inter-relationships between family member, the pupil and external developer in supporting the use of ICT for out-of-school learning



In Illustration I6-5A, the role of the teacher is merged with the role of external developer. It is assumed that often the teacher is not physically present in the place where out-of-school learning occurs. Often one or more than one members of the family are physically present in the place where it occurs. It may be more appropriate to assume that members of the family have greater responsibility for the pupils' out-of-school learning than the teacher has. So, in the context of out-of-school learning, the teacher can also be regarded as an external person.

The illustration suggests that either the teacher or other external persons can make direct contributions to promote and facilitate pupils' use of computers for out-of-school learning. They can also make an indirect contribution to their learning through supporting parents. To facilitate or promote out-of-school learning, it is important for the external developer to work together with parents, as it opens an indirect channel of supporting pupils outside the school. Such a need can be illustrated by some of the suggestions made by parents about the things that teachers and external developers can do to facilitate or promote children's effective use of computers for learning outside the classroom. Here are some of the typical ones:

"Promote help for parents in how to help their children."

"Provide a idiot's guide for parents so we can solve 'dad what's happened' or 'I've lost me work'."

"The involvement of parents, regarding computer training sessions, would create a better understanding of computers. Therefore, great help to the pupils in general."

Conclusion

The present study made comparison between the normal use of computers by Year 3 pupils and their use of palmtop computers for in-class and out-of-class learning under planned and supported conditions. A significant discrepancy between the amount of "in-class time" spent on the two types of computer equipment was found. It is likely that simply providing equipment for pupils to use is not enough to promote the usage of equipment. To be used effectively for learning purposes, the equipment provision has to be accompanied with a well-designed activity and clear instructions.

The results of a qualitative analysis of parents' comments confirmed the effectiveness of the use of portable computers for doing "weekly news" writing as a form of homework assignment. The amount of time spent on using palmtop computers during the weekend was positively related to reading gains. Given that writing and editing skills are reasonably different from reading skills, it is difficult to attribute the learning gains to the features that the computer equipment provided e.g. editing and spell-checking functions. Instead, the learning gains can probably be attributed to a combination of the following factors:

- pupils' willingness, motivation and positive attitude towards learning,
- parents' help and expectations towards their learning, and
- the instructional help and support services provided by the teacher and the external developers.

In other words, the learning gains are attributable to collaborative efforts made by the pupil, the parent(s) and the external developer (i.e. the teacher and the project officers). Effective teaching and learning supported by ICT took place when adequate provision and use of equipment were nicely matched with well-planned activities and clear instructions. The completion without complaint of pupils' weekly writing on paper as a form of homework assignment was indeed another successful outcome of the project.

To the small group of pupils in class who had a computer at home, the impact of the use of computers could be limited. Doing homework on the computer did not seem to be new to them. They were used to working on similar activities with the computer at home. They spent the same amount of "out-of-school" time on the palmtop computers as they normally did with their home computers during weekdays. Their parents spent less time in helping them to work on the palmtop computer than parents who did not have a computer at home.

Besides cognitive learning gains, the instructional arrangements concerning the use of palmtop computers for in-class and out-of-class learning has various positive impacts on pupil. These include the improvements in IT skills and knowledge, the development of responsibility and the opportunity to learn outside the classroom. The study also identified things that teachers and external developers might do to facilitate or promote the use of computers for learning outside the classroom as well as ways of tackling some potential pitfalls.

(6-6) A qualitative evaluation of the proposed framework for supporting primary teachers and pupils for effective practice through the use of ICT

The paragraphs below will provide a brief review of the four case studies above in relation to the proposed framework for supporting effective teaching and learning through the use of ICT in primary classrooms. This will be followed by the analysis of comments about the proposed framework collected from teachers. The section will conclude with a refined framework for supporting primary teachers and pupils in effective practice using ICT.

Linking the experience gained from the case studies above with the framework proposed in section 6-1

In the framework proposed in section 6-1, pupils are the primary focus of attention. They are the ultimate consumers of education. Teachers and external developers are indeed supporters who facilitate pupil learning. Depending on the context of teaching and learning, sometimes teachers play an important role in initiating, supporting and evaluating pupil learning. Sometimes external developers take the lead in doing these.

The development project described in section 6-2 is a typical example of high teacher involvement and low external developer involvement. The initiation of the computer activity, the choice of hardware and software were made by the collaborative effort between the teacher and the external developer. It was the teacher who prepared and managed the instructional setting, did all the teaching and evaluation as well as solving the technical problems that pupils faced when the portable computers were used. Most of the time, the external developer worked at the back of the stage. He acted as a provider of equipment, a morale supporter, an external link and a staff developer. In this learning context, pupils' feedback about computer learning went to the teacher. For instance, when pupils encountered technical or operational problems, they asked the teacher for help.

On the contrary, the research and development project presented in section 6-4 is a typical example of high external developer involvement and low teacher involvement. The external developer initiated the computer activity, made decisions on the choice of hardware and software, and gave learning instructions to pupils. Having said that, the teacher's contribution was essential. The decisions on the teaching topics, the equipment allocation and the grouping of children were made through the collaboration between them. In this learning context, the external developer received feedback about computer learning from the pupils. These included their opinion about the software and their experience of the group work with the use of computer. The experience gained from the project has shown that effective learning with ICT can occur and can be promoted without supporting teacher development. Therefore, from the pupils' point of view, the role of external developer should not be restricted to an "instructional facilitator", as introduced in the paper for comment. An external developer may also take up the teacher's role.

The development project described in section 6-3 had a different start. In the first phase of the project, the content of the computer activity was completely based on the written handouts prepared by the teacher. It was obvious that the teacher took the lead in making the decision about what to do with the computers. Decisions about implementation were made through collaboration between the teacher and the external developer. The involvement of the teacher was high, as she was responsible for the preparation of the learning setting, the allocation of computer-related resources, the teaching and learning with (and without) the computer, the provision of technical and operational support and the evaluation of progress. At that stage of the project, the external developer was not directly involved in the teaching. Instead, his impact on pupil learning was rather implicit or indirect, as a "facilitator" of instruction. During the process, there were close interactions between the teacher and the external developer. For example, the external developer received feedback about the quality of the sound provided by the text-to-speech support facility of the software application and the external developer also shared with the teacher ideas about ways of making technical adjustment through talks and through demonstration.

The approach was changed in the second phase of the project. The effects of the support services provided to the pupils began to emerge when both the teacher and the external developer became highly involved. The external developer was directly involved in the teaching and learning with computers. When pupils were working together with the external developer in the first dictation exercise, the statements they made or the questions they asked served as evaluative feedback for the external developer to make instructional adjustments or improvements. The recording of the pupils' work on the computer during the learning process was another channel for giving feedback. For example, technical adjustments were made shortly after the external developer noticed that a scroll bar of the educational software was blocked by Window 95's scroll bar in auto-hide mode.

Without the interactions between the teacher and the external developer, the effectiveness of using ICT could have been greatly reduced or have become insignificant. Through the practical experience gained from personal observations and from the interactions, the teacher was eager to accept and to use ICT as a form of instructional innovation. The success in teacher development has demonstrated the importance of 'modelling' in teacher training and development. It often happens that ideas that are theoretically sound are not sufficient to win the acceptance of the teacher. It is clear that what they need is not (or 'not only') something theoretically sound, but something the teacher can perceive as 'effective' after putting ideas into practice.

It was the confidence developed and accumulated through frequent interactions between the teacher and the external developer that made significant impact on changing the teacher's conceptions and her practice in using computers. The impacts include the change in the conceptions and her practice of using computers. In other words, the experience that the teacher gained led to the development of her pedagogy, in which the use of computers became an integral part.

Interestingly, a framework was suggested at the end of section 6-5. It is similar to the framework proposed in section 6-1 in many ways, however, there are differences between them. Perhaps the latter one (i.e. the framework proposed in section 6-5) can be named as "a preliminary framework for promoting the use of ICT for out-of-school learning".

First of all, unlike the role that the teacher plays in an out-of-learning context, members of the family are the most important persons who affect the pupil's learning. Secondly, in the latter framework, the teacher and/or other external person play(s) the role of 'external developer' because they are not physically present in the place where out-of-school learning occurs. In the context of out-of-school learning, the teacher's role is different from his/her role in school. Therefore, the framework proposed in section 6-5 can be regarded as an application or extension of the framework proposed in section 6-1 to the context of out-of-school learning.

An examination of the proposed framework

Apart from the experience gained in the four case studies reported in this chapter, a qualitative evaluation of the framework was carried out. It was administered as an open-ended questionnaire section in the third questionnaire for teachers. In that section teachers were asked to comment on the paper "A preliminary model of promoting the use of ICT to support teaching and learning of literacy and numeracy in primary schools", and they were invited to participate in the development and refinement of the model. Out of the 83 teachers who received the questionnaire, a total of 26 teachers responded to this section. It made a total return rate of 31%. The low return rate was expected because teachers were told that the section was not a part of the questionnaire so that they could feel free to not to make any comment. The researcher believes that the arrangement helped to collect high quality data from teachers. As a reference, a copy of the instruction for this section is presented in Appendix 8-A.

Comments and suggestions on the list of activities in path 1

The comments made by teachers indicated good agreements with the list of roles that teachers play in facilitating or helping pupils mentioned in path 1 of the model. Here are some typical comments:

"I feel we follow path 1, but often encounter difficulties with software or the hardware."
"Agree that ICT should be used to support other curriculum areas and should not be seen as a separate entity."

It is good to find that teachers made significant contributions in suggesting or pointing out the absence of some essential aspects of work in the preliminary model. A parent stated that the teacher "also motivates and inspires at the same time as demonstrating, facilitating and supervising". Another teacher suggested that when being "with young children, the teacher initiates ICT activities". Despite agreements and extensions of various descriptions made, there was also a disagreement about one of the roles of the teacher mentioned in the paper. The teacher pointed out that:

"In most schools provision of hardware and software will be up to the ICT co-ordinator, not the classroom teacher."

The comment leads to a review of the definition of "teacher". With the context of using ICT for teaching literacy and numeracy, the term is restricted to "subject teacher". If the subject in which ICT was used is literacy, the IT co-ordinator could be regarded as an external developer. It would have been more appropriate if the teacher's role was described as "allocating hardware & software for the learning task". And the description of "providing hardware and software" could be added in the list in Path 3. As a form of meta-learning, this is an example illustrates how the researcher improves the model through reflection on teachers' feedback.

It might be worthwhile to note that the paper sent for teachers' comment was focused on the use of ICT for subject teaching and learning, which was narrowly defined as the teaching and learning of literacy and numeracy. This is slightly different from the proposed framework described in section 6-1, which has a wide definition of subject teaching and learning. It would mean that the framework will not only apply to the teaching and learning of literacy and numeracy, but also apply to the teaching and learning in other subjects in the primary curriculum. In other words, besides the use of ICT for literacy and literacy, the proposed framework will also consider its use for teaching and learning in IT, science, history, art, music, PE...etc. The major reason for that is the belief in the potential contributions that ICT can bring. It might be more difficult to apply the use of ICT in some subject areas. However, as mentioned in Chapter 2, it was believed that ICT could make a contribution in a certain way. The framework in this chapter has to be treated as a working framework, as it has room for improvement.

Comments and suggestions on the list of activities in path 3

In reviewing teachers' comments, it is obvious that the lack of reliable ICT equipment was their common concern. Many teachers hoped that somebody could get the equipment ready for pupils to use. This can be illustrated by the comment made by one of the teachers who stated, "All hard and software used by children should be user friendly and error free. It must be easy for children to use and this may need to be examined carefully."

Perhaps a technician is the best person to do the job above. Unfortunately, not all primary schools in the UK have a technician available. Often the responsibility goes to the IT co-ordinator in the school, as mentioned above. Other external developers may include any adult helpers who can do the job. For instance, a parent who is familiar with IT, a software designer or a research worker aiming at the use of ICT in schools. Besides being responsible for the provision and maintenance of hardware and software, some of the teachers may have very high expectations of the potential contributions external developers can made.

"Obviously path 3 would help to alleviate many of these problems (difficulties with software or the hardware) and allow the teacher to teach and assess. Only then can the influence of the pupils be managed."

"I think that all teachers would welcome an external developer who could be called on to act as a troubleshooter or to inject new ideas into the school."

"The external developer has time to prepare and research what will be the best to learn. Therefore, their influence upon the children will be great."

"More importantly, the external developer can be seen as the "expert" solving all the problems and producing new software and hardware."

It is clear that an/the external developer may take the lead to bring educational initiatives and educational innovations. The possibility for the external developer to be involved in the design of software or the design of computer-based instructions is greatly determined by the nature of software. It might be difficult for an external person to be involved in the design of a subject-specific software application because technical expertise is likely to be needed. However, the experience of transferring printed material into electronic format described in section 6-3 has demonstrated that it is possible for an external person, as well as teachers, to be involved in the design of instructional material when a generic software application is used.

Some of the teachers expected the external developer to be a teaching assistant, and to play a part in giving instructions.

"Training parents to help with ICT is one way school can achieve more one to one adult help in the classroom."

"Helpers in classroom are a great help, especially, those with ICT at home. More children are coming to school with computer knowledge but then tend to click menially and often 'too' confident. Need a lot guidance at this young age."

Comments and suggestions on the list of activities in path 5

As mentioned in the case studies above, an external developer can have indirect impacts on pupils through supporting the teacher. Helping teachers in solving technical problems not only facilitate pupil learning, but also gives emotional support to teachers. The increase in teachers' confidence in IT would likely facilitate the increase in the frequency of using ICT.

"If schools knew they had timetabled help available (even 1 day per month!), they could save all the little problems till then. It is often these little problems that affect teachers' confidence in using IT. Schools/teachers are often unwilling to ask for outside help when a problem doesn't seem major."

"Many teachers still feel frightened of ICT (cost of equipment, damage et. al.)."

Instead of offering direct service to pupil, teachers needed to be trained in how to tackle technical problems. Such a need is essential, as one of the teachers stated:

> "The most crucial influence on raising ICT standards (literacy and numeracy) is to have teachers who have been given well-planned training. Especially true of teachers not confident in using ICT."

However, training teachers with IT skills is not enough. Teachers are required to possess "knowledge and understanding of when, when not and how to use ICT effectively in teaching specific subjects in the primary curriculum" (DfEE, 1997). In other words, teachers need to be trained in how to tackle the instructional challenges associated with the use of ICT as well. This is demonstrated by the quote of a teacher with reasonable confidence in IT.

> "For myself, I am fairly computer literate on a personal level, however, lack knowledge to develop IT effectively and manage IT in classroom to support curriculum."

For practising teachers, learning by doing is also a mean for teacher development. It is important that ideas concerning the use of ICT have to be practical and feasible for the trainees. The statements below support the idea:

> "Again as with pupils are external developer brings in an expertise and knowledge that the teacher lacks and needs. If the external developer's ideas are manageable then the teacher will embrace them. If difficult to manage then, forget it!"
>
> "Hands on training - not distance learning..."

The experience of the project described in section 6-3 has demonstrated that modelling and sharing provided by the external developer have impacts on teacher development. A practical demonstration done by the external developer could be a good means of convincing the teacher about the feasibility of the idea. Besides personal talks and interactions, the dissemination of ideas and examples of good practices through newsletters, academic paper and/or the internet are alternative ways of sharing. For example, in response to the idea of getting the external developer to prepare written instructions, one of the teachers commented, "Bullet point! Excellent idea and I'm going to use it with clear steps to cut down labour intensity".

Comments and suggestions on the list of activities in path 2 and 4

In the comments made by teachers, there were also queries about the presence of the path. Two possible reasons are reported. Firstly, pupils at the age of primary education are rather passive in initiating ideas about teaching and learning, including the use of or not use of ICT. Secondly, some teachers do not give their pupils the opportunity to give feedback. They are listed as below:

> "Strangely, children in my experience won't tell the teacher or ask if they can use the computer. If the children see that the computer not being used they won't feedback on its lack of use to the teacher."
>
> "Not much opportunity for pupil feedback."

On the other hand, there are also teachers who encouraged pupils to give feedback. For example, one of the teachers treated pupils' feedback as a process of learning and it was found to be effective.

"Children understand more if they are encouraged to explain what they are doing in ICT and what they have done (clarification). All pupils of all abilities are able to explain what they have done. Good reinforcement."

Nevertheless, teachers can also learn from their pupils. The idea is supported by a teacher who stated, "Use pupils' ICT knowledge - often they know what to do."

Comments and suggestions on the list of activities in path 6

In the qualitative analysis of the comments that teachers made, no comment was found to be a clear indication of the independent contribution that teachers made to the external developer. However, there are statements that support the presence of path 6, which seems to be linked with the presence of path 5. In other words, the results indicated that there are interactions between the teacher and the external developer, and they affect one another.

"There must be discussions between teacher and external developer i.e. choice of software and developing IT's skills."

"Once the external developer has suggested what can be done, the teacher then provides feedback on the realism of their suggestions or the resources that they will need/use to bring about change. They will then continue to provide feedback as they implement the change asking the external developer for further clarification where necessary."

The application/modification of the proposed classroom-based learning framework to out-of-school learning context

Teachers had queries about whether parents and teachers can perform well in relation to their role in promoting out-of-school learning. Here are some of the concerns:

"Parents are often at a loss to use equipment and to direct their children learning - it's too easy to 'get the latest game'."

"(Teachers) Have little time to develop skills that will aid that out of class usage in a positive way."

On the other hand, there are comments which are highly positive. Here is a typical one:

"I think the tripartite relationship between parent teacher and pupil is important for promoting out of class usage of ICT and it is exactly along that line that I wish to pursue with our internet connection.."

It is obvious that the potential contributions that the three parties made in out-of-school learning is not restricted to cognitive outcomes, but also the quality of life of the pupil.

"The main benefits will be parents will understand what their children are doing in ICT. Parents and children can spend quality time together, talking and learning together. The community will appreciate what a school is doing in ICT and be even more supportive."

To sum up, the comments above indicate that it is worthwhile to consider and is possible to apply the framework for promoting effective use of ICT for classroom-based learning to the out-of-school learning context. The impacts could be great, as it can go beyond cognitive learning outcomes and affect the child's quality of life. As there are concerns about the feasibility of the role played by the parties being involved in the framework, further studies are needed because it is still at its preliminary stage of development. At present, no adjustment is needed for the out-of-school learning framework.

Other comments and suggestions: unnamed paths in the model and peer interactions

In the qualitative data analysis, it was found that one of the teachers commented:

"Many factors other than use of computers affect children's progress."

The research found that the above statement is a good reminder about the importance and the potential contributions that non-computer-related factors have on pupil learning. Among them are factors that affect the three parties in the model, but which are not addressed in the paths above. For example, family background is one of the factors that links with effective learning. A poor relationship with members of the family may have negative impact on the pupil's learning, whether the computer is used or not. Similarly, there are other factors that affect the performance of the teacher and the external developer. Therefore, before focusing our attention back on the tripartite relationships between the three parties in the framework again, we are reminded that these factors should not be ignored.

We should also bear in mind that each of the three parties in the framework can be represented by one or more than one person. For instance, in the project described in section 6-5, the role of external developer was taken over by two external persons. There are interactions between peers, and this can be illustrated by the statements below:

"Something that doesn't seem to have been mentioned in depth is the effect of pupils learning / knowledge or other pupils."

"Helpers in classroom are a great help. Especially, those with ICT at home."

"In our school, we also have a group of "expert" children who can be called on."

In line with this, the grouping or pairing arrangement for the computer-related work described in section 6-4 is concerned with the interactions between pupils. Similarly, there are interactions between subject-teachers and between external developers. The success or failure of the interactions will have an impact on pupil learning.

A refined model of promoting the use of ICT to support teaching and learning literacy and numeracy in primary schools

So far, this section has reported the examination of the validity of the framework proposed in section 6-1 on the basis of:

- the experience gained in the four case studies and
- the comments made by teachers.

The examination also provides the researcher with opportunities to reflect. The results of reflection can be summarised as four types below:

- a confirmation of some ideas of the original framework,
- an extension or elaboration of some ideas in the original framework,
- a modification of ideas of the original framework, and/or

- a redefinition of specific concept(s) presented in the original framework.

In other words, the examination has led to confirmation or changes to the original framework. Therefore, it might be good to present a refined framework as a summary of this section. In addition to the discussion about the unnamed paths in the model and peer interactions above, refined descriptions of the six identified paths between the three parties are presented in the paragraphs below.

Path 1

This path represents the influence of the teacher on the pupils. The teacher plays an important role in promoting and supporting pupils to learn with ICT. These may include:

- arranging the physical environment,
- allocation of hardware & software,
- making decisions concerning the use of ICT e.g. the usage focus, frequency...etc.,
- acting as a designer of instruction e.g. initiating, planning and organising learning activities and learning instructions,
- acting as a demonstrator, a facilitator, a manager, a supervisor, and a source of encouragement,
- equipping pupils with the essential ICT skills for the learning task,
- giving technical and operational support, and
- checking progress and record keeping.

Path 3

This path shows the direct influence of the education developer on pupils. Perhaps the term "instructional facilitator" might be accurate if the role includes providing a direct service for the pupil(s). There are things that they can do to promote and support pupil learning with the use of ICT, which may include:

- providing and maintaining equipment e.g. ensuring an error-free hardware and software environment,
- acting as a designer of instruction e.g. initiating, planning and organising learning activities and learning instructions,
- improving the learning environment associated with computers e.g. preparing a user-friendly computer interface, providing written instructions...etc.
- acting as a teaching assistant and/or a learning facilitator,
- acting as an participant observer, and
- when necessary, taking up the role of a teacher.

Path 5

This path shows the influence of the external developer on the teacher. In fact, the term "staff supporter/developer" could be more accurate when the role involves working with teachers. Examples of these activities may include:

- supporting teachers with extra resources e.g. technical support, preparation of teaching and learning material, human resources, emotional support...etc.

- working as a co-ordinator between teachers e.g. facilitate sharing between teachers, promoting effective practice and collaborative problem solving, and
- acting as a staff developer e.g. act as an observer, provider of feedback, promote teachers' self-reflection and meta-learning.
- So far, the paragraphs above have provided some descriptions and examples of major activities. The text below will also provide some descriptions and examples of the feedback of these activities.

Path 2 and path 4

The two paths are feedback given by pupils to the teacher or to the education developer.

- personal characteristics e.g. age, sex, ability, attitudes, experience in ICT, learning style/approaches,
- positive and negative feedback during the learning process e.g. problems or difficulties encountered, motivation, satisfaction; and
- feedback concerning learning outcomes e.g. learning attainment, gains, change in attitudes.

Path 6

This path represents the influence of teachers on the education developer. This would certainly include the feedback provided by the teacher to the external developer concerning the instructional support. In fact, the teacher and the education developer may work closely together. Often, there are communications and inter-exchanges of ideas which could have taken place before the classroom actions are administered by the teacher or the education developer. Examples of the activities may include:

- teacher's expression of needs and intentions,
- personal relationship between the teacher and the educational developer, and
- feedback by the teacher.

Summary of chapter 6

- The four classroom-based research and development projects in this chapter covered a range of curriculum areas, features of ICT, methods and focuses of study. They illustrate various aspects of success in teaching and learning literacy and numeracy supported by the use of ICT and the impact on teacher learning and development through participation in the projects.
- In the first project, portable computers and generic software were used to support the development of mental calculation skills in addition, subtraction, multiplication and division. With the intention to give support to both subject teaching and IT capability, the hardware and software choice was found to be appropriate for the pupils and the classroom setting. Significant learning gain in maths was made by the pupils in the project.
- Another project demonstrated success in using text-to-speech support facility to support the development of reading. Its effects on writing and spelling were not clear. An in-depth analysis of the learning process of several pupils was also reported. Various difficulties concerning the use of ICT for subject teaching and learning were also identified, such as the increase in the teacher's workload, technical and operational difficulties, the limitation of time and resources, the limitation of technology e.g. words mis-pronounced by the text-to-speech support facility. Extra time and effort are needed to establish the link and the relationship between the teacher and the external developer, however, their interaction contributed to the change in the teacher's confidence and inclination towards using computers.
- Various features of two software applications were associated with learning attainment and learning gains in another project. This means that features of

software applications have significant impact on pupil learning. The intervention strategy used in this study for helping socially neglected pupils to work in pairs on the computer seemed to be successful. It is recommended that attention be paid to the interest and the satisfaction of all the pupils in the group or pair, dealing cautiously with the gender issue in grouping.

- Pupils are encouraged to use palmtop computers for in-school and out-of-school learning. There was an increase in the pupils' confidence toward using computers, however, there was a decrease in their confidence in using the mouse. Parents' comments about the benefits and pitfalls of using palmtop computers for out-of-school learning were reported. A typical pupil in the class who had a computer at home received significantly less help from members of the family in using palmtop computers than the help received by other pupils.
- The results support the framework for supporting primary teachers and pupils for effective classroom-based learning through the use of ICT proposed above. Various aspects of weaknesses are identified. The chapter ends up with a refined framework. To some extent, the framework is also valid in supporting out-of-school learning. The major parties to be involved will include the pupil, family member(s) and external developer.

Chapter 7

Thesis summary, conclusions, implications and suggestions

The aims of this chapter are to:

- provide a summary of the major contributions of this thesis supported by the results of data analysis, and
- identify some implications and give suggestions for classroom practice and future research.

- A list of the sections in Chapter 7 -

- End of the list -

(7-1) Conclusions and major contributions of this thesis

To address pedagogy supported by computers or ICT from the perspective of pupil learning as well as from the perspective of teacher learning and development, this thesis started with a review of some factors that could make learning and teaching with ICT effective on the basis of contemporary theories or models of learning and teaching. A model of effective curricular learning and teaching supported by computers or ICT is proposed (refer to Illustration I2-10 in Chapter 2). It is proposed as the framework of investigation throughout the thesis.

The measurement of effectiveness includes learning progress (i.e. value-added or learning gains) and learning attainment. Attention is also paid to learners' developed abilities (i.e. verbal and non-verbal), attitude towards learning as well as towards themselves and school learning.

The results show that the model helps to illuminate the inter-relationships between different types of measure of learning and teaching. It is recommended as a framework for other investigations concerning the effective use of ICT or the development of pedagogy supported by the use of ICT.

In the model, the effectiveness of using computers to support the learning and teaching of literacy and numeracy in primary education depends on:

- the characteristics of the pupil,
- the teacher's pedagogy, including theory (or views) and practice, and
- the interaction between the two components of learning and teaching above.

Further comments about these factors and the model can be found in the text below.

(7-1-1) Pupil characteristics and learning supported by the use of computers

This thesis addresses some key components of learning and their links to the use of computers from the perspective of human-computer interaction. Some other factors affecting the effectiveness of learning with ICT are addressed, including:

- in-school and out-of-school usage of ICT,
- subject preference,
- grouping, and
- gender difference.

There are two types of pupil characteristics: computer-specific characteristics and some other learning-related characteristics. The former type includes:

- pupils' attitude towards using computers,
- self-rated competence in using computers, and
- appreciation of software interactivity.

The latter type includes:

- concrete experience orientation of learning,
- reflective observation orientation of learning,
- abstract conceptualisation orientation of learning,
- active experimentation orientation of learning,
- 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,
- time management,
- teacher-pupil relations (perception of), and
- social self-concept.

The investigation began by finding the possible links between these personal characteristics, especially the computer-specific characteristics, and learning outcomes. The results suggested that self-rated competence in using computers was positively linked to learning outcome (i.e. maths attainment, average attainment in maths and reading, non-verbal ability, maths gain, average gain in maths and reading, attitude towards maths). The generalisation remained valid when pupils' verbal and non-verbal abilities were and were not taken into account.

There were other significant links between some computer-specific characteristics and some other learning-related characteristics. For instance, pupils who highly depend on a concrete experience learning orientation or reflective observation learning orientation would favor the use of computers, and they tended to value interaction with the computer. Active learners tended to have high competence in using computers and valued the interaction with computers. Pupils who had high surface learning motivation (i.e. aiming to achieve the minimum requirement) tended to appreciate software interactivity and had a positive attitude towards computers. Pupils who had good IT skills also had high concentration in learning with the use of computers, and vice versa.

The results suggested that pupils who rated themselves as competent users of computers had better learning outcomes than pupils who did not rate themselves as competent users of computers, and vice versa. The difference in learning outcome between the two types of pupil was dependent on their:

- surface learning motivation,
- academic self-concept, and
- concentration in learning.

This implies that pupils who want to use the computers not only for fulfilling minimum learning requirements but also for other intrinsic reasons had higher maths or average attainment (i.e. average of maths attainment and reading attainment) than pupils who were not interested in studying or in using computers. Pupils who think that they are competent in using computers but low in academic self-concept can make higher learning gain in maths or in average learning (i.e. maths and reading) than pupils who think that they are not competent in using computers and low in academic self-concept. Pupils who had high concentration in learning and thought that they had good computer skills had higher non-verbal ability than pupils who had high concentration in learning but did not think that they have good computer skills.

For teachers and educational developers, pupils who are not interested in studying or in using computers can be the most difficult group to teach or to help. Simply helping them to improve competence and skills in using computer may not have an effective impact on their learning outcome (e.g. maths attainment and average attainment) if they were still in lack of learning motivation. To enable them for effective learning with the use of computers, help in building up their learning motivation has to be offered together with teaching or training in improving their competence in using computers.

In contrast, there are pupils who will benefit from teaching and training in improving their competence in using computers. These include the group of pupils who think that they are not competent in using computers and low in academic self-concept and the group of pupils who have high concentration in learning but do not have good computer skills. The expected learning outcome is an increase in maths learning gains or/and in average learning gains and an improvement in non-verbal ability, respectively.

The results also indicated that high competence in using computers did not (or was not sufficient to) bring further advantage in learning outcome for pupils who had high surface learning motivation, high academic self-concept or low concentration in learning.

To maximize the effectiveness of learning with the support of computers, teachers and educational developers also need to encourage pupils with high surface learning motivation to improve their competence in using computers and to set their learning goals beyond the fulfillment of the minimum requirements and develop their intrinsic interest in learning. Pupils with high academic self-concept tended to have high competence in using computers. Further improvement in IT skills and competence will not bring much improvement in their learning gains in maths. Teachers and educational developers need to encourage them to transfer and to integrate the learning experience gained from computer-based activities and the learning experience from non-computer-based activities. In other words, the focus of work has to be shifted from the maximization of learning effectiveness in the computer activities to the maximization of learning effectiveness as a whole by integrating the advantage gained from the computer and not from the computer. Teachers need to have an integrated pedagogy that includes instructions supported by computers. To pupils who have low concentration in learning, teachers and educational developers can keep their interest in working on the computer by choosing software programs that are interesting to them and keep them on-task. This kind of computer activity will enhance their improvement in concentration in learning, their competence in using computers and their non-verbal ability.

Results of data analysis showed that the pupils spent about 1.42 hours per week on the computer at school, while they spent about 2.42 hours on the computer(s) outside school. There was a significant difference between the two means. No gender difference was found between the amount of time spent on the computer at school or the amount of time spent outside school. There was a positive association between pupils' attitude toward different subjects (i.e. English and maths) when the computer was used to support their learning, but the association became insignificant when the computer was not used. There was a difference between pupils' attitude toward different subjects of the primary curriculum, but the difference became insignificant when the computer was used to support their learning.

There was a gender difference in the number of significant links (i.e. positive and negative links) between pupils' relative preference towards learning with computers and learning outcome. To the boys in the study, it was obvious that there were 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. However, it was inappropriate to rule out the possibility of the presence of links between girls' relative preference toward learning English with computers (i.e. as opposed to learning English without computers) and learning outcome (e.g. average academic attainment in maths and reading). As the sample size of the study was small, further research evidence is needed before a decision on the issue can be made.

In English lessons and maths lessons with the use of computers, pupils consistently thought that they learned best when working in pairs, when compared with learning alone, or in groups of 3-4 or 5-6. More pupils felt that they were happier when working in uni-gender pairs than in mixed-gender pairs, and more pupils thought that they learned better in uni-gender pairs than in mixed-gender pairs. Pupils were more willing to work in mixed-gender pairs when their judgements about learning were based on learning effectiveness than when their judgements about learning were based on enjoyment of the learning process. The implication is 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. The pattern of relationship applied to boys and girls.

The number of choices received by pupils for working as partners in reading and writing tasks on the computer was significantly related to their reading attainment and their reading gains. Similarly, the number of choices received by pupils for working as partners in number work on the computer was positively related to their maths attainment. The results of further analyses showed that popularity as partners in reading and writing tasks with the use of computers was associated with their popularity for:

- working as partners in number work on the computer,

- working as partners in e-mail discussion,
- being the best in using the computer, and
- being the best friend in the class.

Pupil popularity as partners in number work with the use of computers was associated with their popularity as:

- partners in number work,
- partners in reading and writing work on the computer,
- the best in using the computer,
- the best in writing and spelling, and
- the best leader in the class.

(7-1-2) Some pedagogical and instructional factors affecting the effectiveness of using computers

On average there were two computers being 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 functionality of 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 difference in hardware and software add-ons (i.e. 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. It implies that the increase in provision of computer equipment only increased the opportunity and the amount of time for pupils to use the computer. At that time, no significant change was brought to teacher's pedagogy concerning its use for pupil learning. The only exception was an increase in the use of computers to demonstrate something to the whole class. Older children in primary education spent longer time on the computer, but they had less chance to get a turn than pupils in lower primary education had.

The size of the class, the number of children with special educational needs (SEN) and the pupils' experience with or access to computers outside the school are also factors affecting the effective use of ICT. In large classes, teacher's workload resulting from the use of computers is increased and the opportunity for pupils to have a turn on the computer is reduced, and vice versa. Teachers of classes that have a lot of SEN children also tend to avoid the use ICT in their weekly plan. An average of 28% of the pupils used a computer at home. That means, more than a quarter of the pupils had experience with or access to computers outside the school. A higher percentage of upper primary pupils used a computer at home than that of lower primary pupils.

Teachers' inclination toward the use of ICT in the classroom was an important factor that was positively associated with pupil academic attainment and academic learning gains. The inclination was negatively related to the 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 when the pupil finished their formal class work. This could be a possible explanation for the finding that teachers in upper primary had a higher perceived workload resulting from the use of computers.

A path model showing the impact of some ICT-related factors on learning outcome was formulated. The validity of the model was verified by applying it to predict learning attainments of pupils at lower primary and upper primary levels, respectively. A revised model was proposed.

(7-1-3) The inter-relationships between pedagogy, teacher reflection, teacher learning and development concerning the use of ICT

In this thesis, the author argues for a better understanding of pedagogy concerning the use of computers and other types of ICT and its development through learning and practice. Special attention is paid to teacher's reflective thinking and action because reflection is believed to have an impact on the theoretical (or conceptual) and practical aspects of pedagogy. The results of covariance structure modelling (or structural equation modelling) confirmed the four-factor structure of an instrument for assessing teacher reflection. That means, reflection can be classified as four categories (or levels) below:

- Level 0: Habitual action
- Level 1: Thoughtful application
- Level 2: Critical reflection
- Level 3: Premise self-reflection

Investigation was made into the potential links between measures of reflection grounded in Mezirow's (1991) transformative learning theory and on Kolb's (1984) experiential learning theory. It was concluded that the two theories had different definitions of "reflection" and "transformation".

The results of exploratory factor analysis identified five aspects of pedagogical preference, each composed of two contrasting dimensions as below:

- pro-ICT preference (as opposed to anti-ICT preference),
- pupil control preference (as opposed to teacher control preference),
- open activities preference (as opposed to closed activities preference),
- collaborative work preference (as opposed to individual preference), and
- language teaching preference (as opposed to Maths teaching preference).

Pro-ICT preference was positively related to pupil control preference, open activities preference and collaborative work preference, respectively. Teachers who perform their job as a routine or habit tended to prefer individual work in their teaching. In contrast, reflective teachers and critically reflective teachers tend to prefer open activities and pupil-controlled activities. Teacher reflection measures (i.e. excluding habitual action here) were positively related to picture vocabulary, reading attainment or reading attitude. The results imply that teachers' intentional mental efforts in applying their pedagogical content knowledge and in reviewing their own thinking and practice can facilitate children's development in reading and language skills and help their development in verbal ability. Alternatively, pupils' improvement in reading, language skills and verbal ability can also foster teacher reflection. The two alternatives may be complementary to each other.

Pro-ICT pedagogical preference was negatively related to teachers' judgement about the complexity of challenges concerning the use of ICT. In other words, teachers who regard challenges concerning the use of ICT as a sophisticated problem tended to have an anti-ICT pedagogical preference. Their personal judgement about the complexity was negatively related to pupil academic learning outcome (i.e. maths attainment, reading attainments, average maths and reading attainment, reading gains, average maths and reading gains) and positively related to pupils' attitude toward themselves and school learning. The results imply that pedagogical judgement, although it might be personal and subjective, has significant impact on pupil learning outcomes. This provides support to the investigation into the conceptual (or theoretical) aspects of pedagogy, as presented in the model.

The results clearly showed that pro-ICT preference was negatively related to pupil learning attainment and learning gains in maths and in reading. This is a warning sign for those teachers who might be over-enthusiastic in using ICT. A positive attitude towards ICT alone, without careful consideration and without sufficient teacher effort, might have negative impact on pupil learning outcomes. The use of ICT adds additional complexity to an already complex pedagogy and may become a burden for teachers.

This thesis also demonstrated the underlying structure of factors affecting the use of computers for teaching and learning in terms of the challenges perceived by teachers. The results of hierarchical cluster analysis suggested that there were four groups of factors. These include:

- personal challenges,
- psychological challenges,
- institutional and work-related challenges, and
- practical and resource-related challenges.

Teachers' personal challenges appeared to be the fundamental issue affecting their pedagogical decisions concerning the use of ICT. They refer to teachers' knowledge and skills about hardware, software and their pedagogical knowledge about the use of ICT. Psychological challenges refer to teachers' interest, expectation concerning the use of ICT and their concerns about pupil ability. Institutional and work-related challenges include teachers' duties, workload and their time and effort in regard to planning, preparation, classroom organisation and supervision and the carrying out of the policy that the school or education authority has assigned to teachers. Practical and resource-related challenges refer to a mixture of practical challenges for various types of resources, including reliable equipment, technical support and additional supports in human resources. The results imply that primary teachers tend to put their priority according to the order of presentation of the challenges listed above.

The results also showed that teachers' perceived personal challenges concerning the use of ICT were negatively related to the pro-ICT pedagogical preference. Each of the four types of perceived challenge concerning the use of ICT was positively related to teachers' personal judgement about the complexity of challenges concerning the use. Each of the perceived challenges was also negatively related to pupils' attitude toward themselves and the school. The higher the extent of the overall challenge and the specific type of challenge perceived by a teacher, the lower their pupils' attitude toward themselves and the school. This imply that schools might be able to improve their pupils' attitude towards themselves and towards the school through strategies to support the use of ICT for teaching and learning purposes or strategies to reduce the perceived challenges concerning its use. Given that no significant correlation between perceived challenges and any other academic outcomes (i.e. maths attainment, reading attainment, average attainment, maths learning gains, reading learning gains, average learning gains), two questions were raised for debate:

- Should teachers and other school personnel work against perceived challenges concerning the use of ICT for teaching and learning, aiming for a side effect - promoting pupils' confidence about themselves and the schools?
- Is it appropriate or ethical to help pupils build their confidence on the basis of their experience on expensive or attractive teaching equipment available in school, rather than on their own academic performance?

Generally speaking, each of the challenges was also negatively related to the extent of actual usage of ICT in primary classrooms. The generalisation was made on the basis of correlation tests between the challenges and:

- the frequency of class usage of computers,

- the opportunity for a typical pupil in class to have a turn on the computer, and
- the amount of time that a pupil spends on the computer in a week.

None of the three aspects of computer use was related to teachers' personal judgement about the complexity of challenges concerning the use of ICT to support teaching and learning. The results implied a failure to demonstrate the significance of links between the specific conceptual (or theoretical) aspect of pedagogy and the above practical aspects of pedagogy. In contrast, the results of data analysis indicated the significance of links between another conceptual aspect of pedagogy and the pedagogy in practice. The amount of time that a pupil spends on the computer in a week was positively related to:

- pro-ICT pedagogical preference,
- pedagogical preference for pupil control, and
- pedagogical preference for open activities, respectively.

The other two measures of computer use, the frequency of class usage of computers & the opportunity for a typical pupil in class to have a turn on the computer, were not related to pedagogical preference. To sum up, the results demonstrated the links and discrepancies between the conceptual (or theoretical) aspect of pedagogy and the practical aspect of pedagogy, as presented in the model.

Premise self-reflection measure was found to be a significant factor affecting the theoretical and practical aspects of pedagogy. It was positively related to some measures of computer use (i.e. the opportunity for a typical pupil in class to have a turn on the computer in 1997/98 & the amount of time that a pupil spends on the computer in a week in 1998/99) and was positively related to pedagogical preference (i.e. preference towards open activity as an opposition to closed activity and preference towards pupil control as an opposition to teacher control). This implies that teachers' redefinition of the pedagogical problem concerning the use of ICT will lead to a new direction of actions toward their practice concerning the use of ICT.

The results of correlational studies were linked together to form as a path model explaining the development of pedagogy supported by the use of ICT. The validity of the model was supported by the results of series of multiple regression analyses. Special attention was paid to the direction of the cause-effect relationship between some variables in the model, which were supported by the results of some two-wave two-variable analyses (2W2V). The reported findings give support to the inter-relationships between pedagogy, practical knowledge and instructional practice, as proposed in the model of effective curricular teaching and learning supported by computers or other types of ICT.

(7-1-4) Conclusions, major contributions and implications of case studies in this thesis and a framework for supporting (and promoting) primary teachers and pupils for effective classroom-based learning through the use of ICT

A preliminary framework for promoting/supporting primary teachers and pupils in teaching and learning literacy and numeracy with the use of ICT was devised to support the classroom-based development work in this thesis. The focus of work was expressed in terms of the tripartite relationships between teacher, pupils and external developer. The validity and the applicability of the model was investigated through the implementation of the theoretical framework as four classroom-based research and development projects and from the written comments provided by teachers.

The results of the projects and qualitative evaluations showed that the preliminary framework had its strengths as well as weaknesses. A refined model was proposed. It aimed at promoting/supporting primary teachers and pupils for learning and teaching in various subjects in the primary curriculum with the use of ICT. Nevertheless, the results of a case study suggested that the (preliminary) framework had great potential to be used to promote and support subject learning and teaching in the primary curriculum. With adaptations and refinements, the framework can be used as a framework for promoting the use of ICT for out-of-school learning.

Four case studies are reported about effective use of ICT in teaching and learning of literacy and numeracy through classroom-based research and development projects. There are similarities and differences between them. The results and experience gained demonstrated the effective use of ICT in a range of curriculum areas, using various features of computers. Attention is paid to the combination of various variables addressed in the previous chapters of the thesis, including the learner's characteristics, pedagogy, teacher reflection, teacher learning and development as well as the classroom practices of teachers, pupils and external developer (i.e. an external person who wants to promote the use of computers for subject-based learning).

In the first case study, spreadsheets were used on portable computers to develop mental calculation skills through prediction of number patterns in Year 4. It described insights about how to make use of various features of a portable computer to support the teaching and learning of a topic in Maths and the development of IT skills. It also revealed that even an enthusiastic teacher with excellent IT skills still required a lot of work to use ICT effectively. The results showed an increase in the pupils' score on a standardised maths test and a retest in the first phase of the project and the pupils made an average of 5 months gain in their number age within a period of 2 months in the second phase of the project. Through participation in the project for two academic years, the teacher made a change in the way he considered using ICT for subject teaching. Instead of thinking about it from the perspective of technology, his attention was shifted to the pedagogy of subject teaching.

The second case study demonstrated success in improving reading and spelling for low achievers and children with special educational needs in Year 4 to 6 using a text-to-speech support facility on the computer. In the first phase of the project, the project aimed at supporting the existing teaching material being used in the class with text-to-speech facilities on the computer. No significant improvement in reading was detected. It reported various difficulties met in integrating and promoting the use of ICT into the subject curriculum, including the link between the external developer and the teacher and the actual challenge of implementing ideas into the classroom. These included technical problems, limitation of technology, pupils' lack of basic IT skills for the task and the increase of teacher's workload as a result of the time pressure.

The focus of work became clear in the second phase of the project, which aimed at developing phonemic awareness skills through a series of dictation tasks with the use of electronic worksheets on the computers and with the use of paper and pencil. Ideas in tackling technical and operational difficulties were put into effect. The results of a standardised reading test and a retest showed an increase in 12 months of reading age within 3 months. The results of a standardised spelling test and a retest did not show a higher than expected gain in spelling. An in-depth study of individual pupils was carried out. The results seemed to indicate that the extent of special educational needs had a negative impact on academic performance. This generalisation was made with the support of analyses of recording of computer screens when pupils were working on the computer. A range of technical and operational errors were detected, including uncertainty of the requirement of the task, lack of the ability to concentrate or the required IT skills, lack of ability to read and understand the instruction on the computer screen.

Through participation in the project for two academic years, the teacher developed her confidence and skills in using computers to support pupil learning. Before participating in the project, her inclination towards using computers to support subject teaching and learning was below average. By the end of the project, her inclination was among the top

10% of all the respondents in a teacher survey. The results of analyses of classroom observations indicated that, before participating in the project, pupils who worked on the computers were sitting in a corner of the classroom where the teacher could hardly see their work. Throughout the second phase of the project, pupils who worked on the computers were sitting at the back of the classroom with the screen facing the teacher. The teacher played an active role in managing and offering assistance to the pupils who were on the computer. The ideas for the arrangement were initiated by the teacher, not by the external developer. The results of qualitative analysis identified two major sources of input that were associated with her development, including:

- the support that the teacher gained from the external developer, and
- the encouragement and satisfaction that the teacher received from the pupils and from her own practice.

So, the interactions between the teacher, the external developer and the pupils appear to have been a key factor affecting the effectiveness of instruction.

The third case study focused on the use of and the effectiveness of two multimedia software applications to promote reading development and understanding of science topics in Year 6. Attention was also paid to gender preference for group work on computer-related tasks. The same topics were introduced using the passages presented by the two multimedia software applications, with a similar level of difficulty in reading and clarity of the presented information. The first software application made use of its text-to-speech support facility, while the second software application made us of its hyperlink and animation features. The computer was used as a presentation tool to demonstrate the operational steps of the two software applications, in terms of playback of video clips.

The results indicated that pupils with low reading attainment found the first software application interesting and were happy when working on it, and vice versa. They also found the first software application helped them remember the presented facts, to read more and develop further inquiry about the topic, and vice versa. In contrast, pupils with high reading attainment noticed that the second software gave quick responses, gave them a lot of chances to take part in learning, did not require a lot of teacher's attention when it was being used, and gave them the confidence to use it again on their own, and vice versa.

Pupils who paid a lot of attention to the visual element presented by the first software application had high learning gains, while pupils who thought that software W was the type of software they liked had low learning gains. The results of chi-square tests further demonstrated that, with the use of the two software applications, pupils with low reading attainment had high reading gains, while pupils with high reading attainment had low reading gains, and vice versa. This case study demonstrated that various features of software applications had significant associations with learning attainment and learning gains, respectively. This implies the importance of software selection. Teachers are advised to evaluate the features of software applications before choices concerning software selection are made.

The Year 6 boys and girls in the study found difficulties in working with pupils in the opposite gender group. Such a problem could be common in mixed gender groups when working on activities supported by the computer as well as activities without the computer. Having said that, it seemed to be easy for boys with good IT skills to dominate the control of the computer when they worked together with a partner from the opposite gender group. The strategy of grouping/pairing socially neglected pupils with the most preferred working partner seemed to be effective in bringing a positive group learning environment for the target pupils, however, not all the named partners enjoyed the group/pair working experience with the target pupils. It leads to the implication that extra care is needed when considering grouping a socially neglected pupil with a working partner from the opposite gender group. During the process, the results of a standardised reading test and a retest showed that pupils had made 13 months progress in reading age in about 3 calendar months.

The last case study investigated the use of computers for in-class and out-of class learning in Year 3. Each pupil was provided with a plamtop computer to complete a writing task on the computer for a week and to complete another writing task on paper in another week. The topic was to "describe an event that interests you most in this week".

During these two weeks, pupils were asked to fill in two logbooks. This indicated that a typical pupil in this class spent an average of 0.49 hours on the computer at school in a normal week and a typical pupil in this class spent an average of 1.26 hours on the palmtop computer in the week when it was available to the pupil. As the amount of time pupils spent on palmtop computers during the project development period was significantly higher than the amount of time that they normally spent on school computers; when compared with the usage of school computers, the "in-class" usage of palmtop computers was relatively intensive. In contrast, pupils did not spend more time on palmtop computers than they normally spent on school computers during their "out-of-class school time" (i.e. break time and lunch time). This implies that when pupils were at school, the palmtop computers did not seem to be more attractive than the computers at school.

There was no significant difference between the amount of time spent on palmtop computers during the five weekdays (i.e. Monday to Friday) and the amount of time spent on the computer in a normal week. The former was 2.24 hours and the latter was 1.16 hours. Similarly, there was no significant difference between the amount of time spent on palmtop computers during the weekend (i.e. Saturday and Sunday) and the amount of time spent on the computer in a normal weekend. The former was 1.3 hours and the latter was 1.04 hours. There was no significant association between pupil reading attainment/gains and the amount of:

- in class computer time at school,
- out-of-class computer time at school, and
- out-of-school computer time.

The exception was a positive correlation between reading gains and the number of hours spent on palmtop computers during weekends. The Pearson correlation statistic was 0.43. Two possible explanations are suggested. Firstly, some pupils were really keen on using palmtop computers. As the computer activity was targeted for learning, the extent of motivation (or positive attitude) to learn was linked with the extent of learning gains. Secondly, the adult(s) at home was more likely to be available to help or to attend to the child in doing the homework on the palmtop computers during weekends than during weekdays. Their expectation, motivation and positive attitude could have positive impacts on pupils' academic performance and behaviour.

Pupils generally had common sense about computer-related equipment by the end of the project, while they generally felt not sure or did not have that at the beginning of the development project. Such an increase was also noticed by some parents who responded to the questionnaire administered immediately after the development project. There was also an increase in pupils' confidence towards using spreadsheets and a decrease in their confidence or skills in using the mouse. The findings were consistent with the features of palmtop computers, which have spreadsheet facility but do not have a mouse.

Some parents reported that the experience that their children gained from using PSION increased their responsibility or their patience. This was questionable because it had nothing to do with the functionality of the equipment, but the context of learning. The implication is that educators should not only pay attention to the provision of hardware and the quality of software, but also to the instructional environment in which the computer activity takes place. Similarly, educators need the pedagogy associated with the use of ICT. Pupils need effective instruction about the computer activity to be achieved and to understand that the computer is only a tool for the activity.

The results indicated that pupils who did not have a computer at home received help from members of the family in using PSION for an average of 2.13 hours during the week when the equipment was available to them, but pupils who had a computer at home received such a help for an average of 0.78 hours during that week. It means that a typical pupil in this class who had a computer at home received significantly less help from members of the family than the help received by other pupils during that week. It was suggested that the interaction effect between the ownership of a computer at home and the impact of using portable computers for out-of-school learning could be investigated by future research with ANOVA design.

(7-2) Some implications and suggestions of this thesis

In relation to the findings of this thesis, the author has come up with a list of implications and suggestions. They are listed as below:

- Pupil competence in using computers seems to be a necessary, but insufficient condition, for achievement and improvement in learning supported by computers. Therefore, teachers and educators need to consider pupils' competence in using computers for all pedagogical and instructional arrangements supported by the use of 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 to learn 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. Multimedia features of the computer could give support to this learning orientation by providing multi-sensory information through demonstrations and presentations.
- 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 is linked to pupil motivation. Having said that, attention needs to be paid to the nature of the relationships. The links between computer s 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.

- It was found that the effect of self-rated competence in using computers interacts with the effect of surface learning motivation, academic self-concept and concentration in learning, respectively. To maximize the effectiveness of pupil learning supported by computers, attention to both computer-specific characteristics and other learning-related characteristics the target pupils are needed. For examples, pupils with high surface learning motivation can be sub-divided into two groups according to their self-rated competence in using computers. These include pupils who want to use the computers not only for fulfilling minimum learning requirements, but also for other intrinsic reasons as well as pupils who are not interested in studying or in using computers. In the study, the former group was doing well in learning with the computers, while the latter group were in need of helps in building up their learning motivation to be offered together with teaching or training in improving their competence in using computers. The expected outcome is an improvement in maths attainment and the average attainment (i.e. the average of maths and reading attainment). To the group of pupils who think that they are not competent in using computers and low in academic self-concept and the group of pupils who have high concentration in learning but do not have good computer skills, teaching and training in improving competence in using computers will make contributions to their learning. The expected outcomes are an increase in maths/average learning gains and an improvement in non-verbal ability, respectively. Nevertheless, the presence of various interaction effects demonstrates the need to regard effective learning and teaching supported by computers and/or ICT as a complex system. This justified the use of multiple regression technique to search for effective pedagogy concerning the use of computers or ICT.

- Pupil attitude toward learning with (and without) ICT was also affected by their subject preference, grouping and gender difference. There are complex links and/or interactions between them. Therefore, in the planning or decision-making concerning the use of ICT, it would be more appropriate to consider the three factors together than to consider one of them.
- Pupils spent longer time on the computer(s) outside school than on the computer at school. It is important for teachers, parents and other related persons to consider promoting the use of computers for out-of-school learning. The last case study has demonstrated the great potential in this dimension of work. Further examination, refinement and testing of the framework for promoting out-of-school learning supported by ICT, as addressed in Chapter 6, is recommended.
- The results imply that there was a mismatch between the pace of the recent increase in provision of computers and the pace of teacher training and support concerning the use of ICT. The increase in opportunities for pupils in class to have a turn on the computer seems to be an indicator of the success of the former. Extra efforts will be needed on the latter, with the aim of increasing the teachers' or the classroom use of ICT and the development of pedagogy concerning the use of ICT.
- It was found that teachers in upper primary had a higher perceived workload resulting from the use of computers than teachers in lower primary. However, it was still

uncertain whether this was related to the differences in the curriculum usage of ICT. Similarly, it was also uncertain whether the use of ICT in large classes or classes that had higher number of SEN would increase teacher's workload. Further research on these areas is recommended.

- The results suggest that pupils in upper primary classes spent more time on the computer than pupils in lower primary classes. Further investigations to determine the optimal amount of time for pupils in different levels of primary education to spend on the computer is needed.
- This study had a pioneered work in linking quantitative assessment of teacher reflection with pedagogy and practice concerning the use of computers. The results indicated that reflection played a role in teacher learning, practice and development, which could go beyond the use of computers or ICT. Having said that, the author is looking forward to seeing an revised version of the instrument for assessing teacher reflection in the coming future.
- No significant links were found between the measures of reflection and/or the concept of transformation between Kolb's experiential learning theory and Mezironw's transformative learning theory. Confirmation of these results is needed. At this stage, readers are advised not to rule out possible links between the two theories. It is hoped that the experience gained from this study will influence research in this area.
- The underlying structure of challenges (i.e. or factors) concerning the use of computers for teaching and learning found in this study provides useful information to support teachers' use of ICT. The results suggested the order of stages or urgency of work starting from the teachers' knowledge and skill about hardware, software and

their pedagogical knowledge about the use of ICT. This is followed by their interest, expectation concerning the use of ICT and their concerns about pupil ability as well as their duties, workload and their time and effort in regard to planning, preparation, classroom organisation and supervision and the carrying out of the policy that the school or educational authority has assigned to teachers. Finally, there is a need for support for equipping and maintaining reliable equipment, for technical support and for additional support in the form of human resources.

- The results of the study raise a warning signal for those teachers who might be over-enthusiastic in using ICT. To be effective, a positive attitude towards ICT has to go with careful consideration and sufficient teacher effort. Similarly, the schools should not only work on strategies to support the use of ICT and to reduce the number and level of perceived challenges concerning its use, but also should pay attention to various factors affecting the effectiveness of its use.
- The case studies in the thesis exemplified the successful experience in using computers or ICT in a range of learning and teaching contexts. The model of "effective curricular learning and teaching supported by the use of computers or ICT" and the model of "promoting and/or supporting primary teachers and pupils in teaching and learning literacy and numeracy with the use of ICT" were found to be useful in describing the inter-relationships between the data. They are recommended as the frameworks for future studies concerning educational use of ICT. At this stage, they are treated as working models, further examination, refinement and testing will be needed for further validation and improvement.

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