Chapter Two

Study Design and Methodology

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A considerable body of recent literature describes the profound changes occurring as societies move from agricultural and industrial economies to a highly interconnected global knowledge economy (see, for example, Dertouzos, 1997; Tapscott & Williams, 2006). In the industrial age, the pace at which new knowledge evolved was relatively slow and a major role of schooling was to ensure that students mastered a well-defined set of knowledge and skills. However, with the advent of the 21st century, people are finding such abilities no longer sufficient when facing the everyday realities of the workplace. These realities demand making rapid decisions based on incomplete information when tackling novel situations, an aptitude for working through a plethora of information of varying levels of accuracy when tackling ill-defined problems, and the capacity to collaborate with a diverse team that may be distributed globally when endeavoring to accomplish personal and organizational goals (Peters, 1997).

Citizens in the 21st century must also be prepared for lifelong learning because learning is no longer confined to the young or to institutional contexts (Young, 1999). Hence, there are strong arguments that the educational outcomes core to wellbeing in the knowledge economy are different from those in the industrial age and should encompass higher-order cognitive, affective, and social skills (Drucker, 1988). Given such a context, it is not surprising that a number of high-profile regional, national, and supra-national projects have been

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conducted to develop descriptions and frameworks for 21st-century student success in the knowledge economy. Examples include the European Commission's proposal for a 21st century e-skills agenda (http://europa.eu/rapid/pressReleasesAction.do?reference=IP/07/1286&format=HTML&aged=1&language=EN&guiLanguage=en), the enGauge 21st Century Skills project (http://www.ncrel.org/engauge/skills/skill21.htm) of the North Central Regional Educational Laboratory, and the Partnership for 21st Century Skills project in the United States (http://www.21stcenturyskills.org/). These projects not only have identified the crucial characteristics desired of learners in the knowledge economy but also emphasized the importance of ICT-skills and information literacy in the context of 21st-century learning outcomes.

A strong theme running through these projects is that curricular and pedagogical changes need to take place if schools are to successfully help students develop these learning outcomes. The role of ICT is envisaged not simply as a technical skill or as a means of improving learning effectiveness but also as a way of transforming the goals and processes of education. In fact, there is increasing evidence that young people who have always been surrounded by and interacted continuously with ICT develop a different approach to learning and knowledge management from students who have not had this opportunity (Pedró, 2006). The OECD is conducting a study on these "new millennium learners" to examine the challenges they pose and the extent to which their emergence will contest prevailing views of interpersonal communications, knowledge management, and learning within schools.

It is within this context of change and desire for change in education that the three SITES projects have been designed and conducted. As Pelgrum and Anderson (1999, p. 3) explain, the SITES program is motivated by the desire to provide empirically based answers to the following questions:

1. To what extent have education systems adopted and implemented objectives that are considered important cornerstones of education in the Information Society?
2. To what extent is ICT facilitating implementation of objectives that schools intend to achieve?
3. What differences in ICT-related practices exist within and between systems and how can these differences be explained?

It is well documented in academic literature that use of ICT per se does not necessarily facilitate achievement of these desired learning outcomes (see, for example, Fisher, 2006; Pearson & Somekh, 2006; Watson, 2001). There is also strong research evidence that significant changes in the pedagogical process (a term that we use interchangeably with the teaching and learning process) are necessary to achieve these new curriculum goals (Law, in press; Somekh & Davis, 1997). Hence, in SITES-M1, indicators for pedagogical orientations were developed to answer the above questions.

SITES-M2 was a qualitative study that employed comparative case studies methodology. Conducted between 1999 and 2003, it provided rich data about highly innovative cases of ICT-use in classrooms considered indicative of future classrooms (and the pedagogical practices conducted in them) in countries around the world (Kozma, 2003). Analyses of the 174 case studies collected from 28 systems globally provided a rich empirical base for the development of further indicators of pedagogical orientation in the SITES 2006 study. As these indicators are core to the design of this study, a brief description of how they built on and evolved from the previous two SITES studies is provided in the next section, after which we present the details of the study design.

One very significant finding from the study was that despite the extremely wide economic and cultural differences existing among the 28 participating countries and education systems, the national selection committees established very similar selection criteria for innovativeness. Furthermore, the 174 case studies collected from primary and secondary schools around the world actually shared many common features in terms of their classroom practices. These included changes in the roles played by students and teachers and the use of technology to connect students and teachers to peers and experts outside school, even though the school curricula and levels of access to technology in the schools were very different.

At the school level, common patterns of contextual factors were also found in cases that demonstrated sustainability. SITES 2006 built on these earlier findings, and sought, through surveys of teachers, principals, and ICT coordinators, (1) to understand the extent of and the ways in which countries around the world accomplish ICT-integration in their classroom practices, and (2) to identify those factors that most contribute to the effective integration of ICT in learning and teaching.

2.1 Emerging pedagogies for lifelong learning and connectedness in the 21st century

In SITES Module 1, the concept of *emerging paradigm* was developed to capture those changes occurring in classrooms internationally that align with what is believed to be conducive to the development of learning outcomes important for the information society. Some of these changes include higher indices of learning, such as self-directed learning, and collaborative inquiry, for the student. They also require teachers to take on more of a facilitative role, not only in guiding students' independent learning and self-monitoring, but also in ensuring evaluation. It is conceivable that many of the teaching and learning activities that were well established in the industrial society, such as teacher-driven, lock-stepped homogeneous pacing, teacher-driven instructions, and students learning individually and being assessed via close-ended tests and examinations, still occupy an important place in classrooms. SITES Module 1 referred to these activities as belonging to the *traditionally important paradigm*.

Within this framework, traditionally important practices were not conceptualized as "bad" or "poor" practices because it is conceivable that they still contribute positively to students' learning. However, the interest was in finding out whether practices belonging to the emerging paradigm could be identified and, if yes, where the balance between these two kinds of activities lay. Based on this conceptual framework, indicators were constructed to identify principals' perceived presence and importance of traditionally important and emerging pedagogical practices in their schools. The SITES-M1 study found significant differences across countries in terms of the relative importance that principals in their own schools assigned these two kinds of practice.

By focusing on innovative pedagogical practices, the SITES-M2 case studies provided very rich descriptions of what might count as emerging characteristics of pedagogical practices that make substantial use of ICT. Kozma and McGhee (2003) reported evidence from the case studies that use of ICT often leads to changes in teachers' and students' roles and practices. They also identified two core models in these practices—the Student Collaboration Model, in which students collaborated with others in their classes to search for information, and the Product Model, in which both teachers and students created products that often involved using multimedia tools and web resources for research and problem-

solving purposes. There was also evidence that some of these practices provided students with opportunities to take responsibility for their own learning, to identify their own learning needs and strategies, and to develop collaboration, inquiry, and communication skills. These aptitudes all align with the 21st-century educational outcomes described in the previous section.

Adopting another analysis framework, Law (2003, 2004) identified, in addition to the dimension of technology use, five dimensions along which significant changes were seen to have taken place in the SITES-M2 case studies. These were curriculum goals, the roles of the teacher, the roles of the learner, the multidimensional ways in which students' learning outcomes can be manifested, and connectedness with peers and experts outside the classroom walls. The connectedness dimension highlights a prominent feature found in the Outside Collaboration Model—one of the student models evident in Kozma and McGhee's (2003) analysis. In this model, students collaborated with outside peers and experts to create products and publish results. Law's (2004) analysis also found that the Asian case studies showed much less evidence of connectedness compared to those cases collected from other regions of the world, a finding that suggests connectedness is a more culturally dependent dimension than are the other five dimensions.

In designing the pedagogical orientation indicators for the SITES 2006 study, the research team considered it desirable to replace the indicator for the emerging paradigm with a more refined set of indicators. At the time SITES-M1 was designed, there was little certainty over the extent to which the activities considered within the emerging paradigm would be present within schools generally. Moreover, because SITES-M1 was a study of schools that involved surveying only principals and technical coordinators, the questions on the pedagogical paradigm were given to principals only; the research team considered that it would be inappropriate to ask principals questions involving details of classroom practices. However, because SITES 2006 focused on what happens in classrooms, data were collected through teacher questionnaires, making it possible—and, in fact, desirable—to probe into classroom practices in greater detail.

The rich descriptions and associated analyses of the innovative practices collected through SITES-M2 provided a good empirical basis for the development of more refined indicators of the emerging paradigm. Given that the *connectedness orientation* appeared to be a more

culturally bound characteristic of the innovative practices, the research team decided that separate indicators should be developed to capture this aspect of the changing pedagogy in schools. Other descriptors of the innovative practices related to the use not only of more collaborative-, inquiry-, and production-oriented activities but also of strategies designed to take greater account of individual differences, such as the provision of remedial instructions. After completing several rounds of explorations, the research team developed another set of indicators, labeled the *lifelong learning orientation* and designed to capture these aspects of the innovative practices.

Lifelong learning is a term that often appears in the literature related to education in the 21st century. This term is often used to refer to post-compulsory education or to continuing education, offered to people who are in the workforce (Field, 2006). However, various commentators strongly argue that lifelong learning should be an important agenda for schools (see, for example, Young, 1999). The "curriculum of the future," according to Young, should prepare students not just to pass examinations but also to be lifelong learners in contexts where there may not be teachers. School curricula should "move from being heavily 'designed' in timetables, syllabuses, and lesson plans to relationships between learning at school and learning in non-school contexts" (Young, 1999, p. 474). This sense is the one ascribed to the term lifelong learning used in this study. Because both lifelong learning and connectedness are features of 21st-century learning outcomes, the term 21st-century pedagogical orientation is sometimes used in this book to refer generally to both lifelong-learning and connectedness orientations.

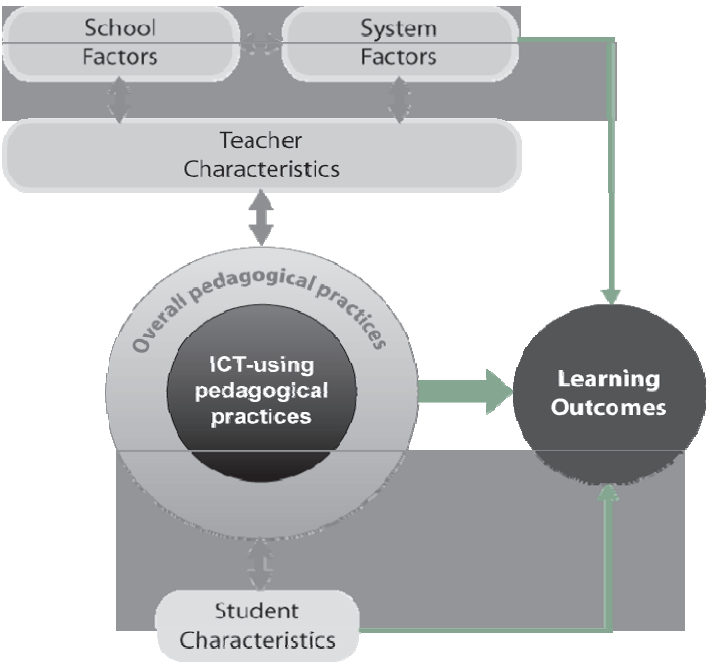
2.2 Conceptual framework and research questions

2.2.1 Conceptual framework

While SITES 2006 studied both classrooms and schools, the focus of the study has been on what happens in the classroom and how ICT is used in it. Consistent with the conceptual frameworks adopted in the previous two SITES studies (see Kozma 2003; Pelgrum & Anderson, 1999), SITES 2006 took the view that ICT-using pedagogical practices are part of the overall pedagogical practices of the teacher. For teachers, the reasons for and the ways of using ICT in the classroom are underpinned by their overall pedagogical vision and competence. Also, pedagogical practices

are not determined solely by the characteristics of the teachers, such as their academic qualifications and ICT-competence, but also by school- and system-level factors. While we expect students' learning outcomes to be influenced by the pedagogical practices they experience, we need to acknowledge that the outcomes (whether perceived or actual) influence the subsequent pedagogical decisions of the teacher. This is because teacher-, school-, and system-level factors often have to change or be changed to accommodate the expected or actual impact of pedagogical practices on students. Figure 2.1 presents the overall conceptual framework for the study.

Figure 2.1 Overall conceptual framework for SITES 2006



2.2.2 Research questions

SITES 2006 set out to tackle four research questions:

- *Research Question 1: What are the pedagogical practices adopted in schools and how is ICT used in them?* This question aimed to identify the key pedagogical approaches and practices adopted by teachers

in their teaching, to assess the importance assigned to using ICT when implementing these different approaches and practices, and to document the perceived impacts of ICT-use on students. This, the main research question to be answered through the teacher questionnaire, included carefully designed quantitative indicators.

- *Research Question 2: What ICT is used and how is it used in specific situations where ICT has been employed relatively extensively within a pedagogical practice?* This question endeavored to gather descriptions from teachers of the satisfying experiences they had encountered when using ICT in their teaching. Teachers who had used ICT extensively in their teaching of the target class were asked to identify one example of practice from their own past experience in which they or others had used ICT to support learning and teaching. They were also asked to report on the contributions they thought ICT had made to their teaching practice and to student outcomes. Hence, while some qualitative data were collected from the questionnaire, the information was used primarily quantitatively to provide a more holistic picture of how ICT was actually being used in specific contexts. Also, this part of the teacher questionnaire was an international option, which meant that the participating systems could decide whether to include it.
- *Research Question 3: What teacher, school, community, and system factors are associated with different pedagogical approaches and ICT-use, and can an explanatory model be identified?* SITES-M2 (Kozma, 2003) as well as other research studies (Becker & Ravitz, 2001; Fullan, 1993; Jones, 2004; Owston, 2003; Scrimshaw, 2004) identified certain contextual factors as important conditions for ICT-use and innovative pedagogy. Research Question 3 explored the status of such factors, how these might relate to different characteristics of pedagogical practices and ICT-use, and whether any systematic differences could be observed across countries in relation to the explanatory models identified.
- *Research Question 4: What system factors are associated with different pedagogical approaches and ICT use?* Four clusters or spheres of system-level factors were explored in the study: demographics, education system, pedagogical trends, and ICT-related policies. All of the data for these spheres came from the national coordinator questionnaire (NCQ), except for the demographics cluster, which included demographic and technology indicators from the *Human*

Development Report, 2006 (United Nations Development Program [UNDP], 2006).

2.3 Design of the survey instruments

Unlike SITES-M2, which compared in-depth case studies, SITES 2006 aimed to provide an overall picture of the status of pedagogical practice and ICT-use in the participating countries and systems. Therefore, survey methodology was considered appropriate. The main data collection was done using three questionnaires: a teacher questionnaire, a principal questionnaire, and a technical questionnaire. In addition, a national context questionnaire was distributed to the study's national research coordinators (NRCs) in order to gather relevant contextual information at the system level from each country or system in the study. The design of each instrument is described below.

2.3.1 Teacher questionnaire (core component)

The core component of the teacher questionnaire was designed to address Research Question 1 as well as contribute to answering Research Question 3 (above). As described earlier, the pedagogical approach of the teacher is an important concept in this study. The SITES-M2 findings indicated that the curriculum goals and the roles played by teachers and by students in the learning process were the three aspects most indicative of the pedagogical approach of the teacher. Hence, three sets of *core indicators* of pedagogical orientation were developed, namely the curriculum goal orientation, the teacher's role orientation, and the student's role orientation. These indicators were constructed on the basis of teachers' responses to questions on the relative importance of a range of curriculum goals and the relative frequency of occurrence of a range of teacher activities and student activities. Each set contains three indicators, reflecting the relative strengths of the traditionally important, lifelong learning, and connectedness orientations respectively. In addition, for each item on the list of teacher and student activities, teachers were asked to indicate whether or not ICT had been used in those activities. This latter set of responses was used to compute two further sets of *core indicators* of the pedagogical orientations relating to ICT-using teacher and student practices respectively.

To ensure that comprehensive answers could be obtained to

Research Question 1, and to provide indicators additional to the core ones, the SITES researchers produced further questions in the teacher questionnaire that were designed to provide indicators of the following: methods of organizing teaching and learning; the location of and time when teaching and learning occurred; the learning resources (including ICT) used; the assessment practices they used and whether these employed ICT; and the perceived impact of pedagogical ICT-use on students. These indicators were called *supplementary indicators*.

Data on a number of contextual factors that might influence teachers' pedagogical ICT use were also collected through the teacher questionnaire. This information included the teachers' self-reported ICT-competence, the obstacles teachers thought hindered use of ICT in their teaching, the availability of ICT-related professional development courses, the extent of teachers' participation in that development, and the presence of a community of practice in the school (Dexter & Anderson, 2002; Dexter, Seashore, & Anderson, 2002; Geijsel, Sleegers, van den Berg, & Kelchtermans, 2001). Teachers were also asked about the priority they had accorded ICT-use in their teaching during the next academic year. These indicators provided *explanatory indicators* for the study because we could use them to help us develop an explanatory model of teachers' pedagogical ICT-use. Table 2.1 lists the set of indicators targeted in the teacher questionnaire.

The 2006 study sampled two populations of teachers: the Grade 8 mathematics and the Grade 8 science teachers from the participating education systems. One important assumption in the design of the study, as indicated in the description of the conceptual framework, was that teachers' decisions on whether and how to make use of ICT in their teaching depend not only on the nature of the school subject taught, but also on the characteristics of the students taught. The research team took great care while designing the questionnaire to ensure that when teachers answered questions related to the core and supplementary indicators, their answers referred to a specific class they were teaching in the school year the survey was conducted. This process meant random selection of a target class for each of the teachers sampled in the study.

The teacher questionnaire began with questions about the target class so that, in addition to providing information about the class their answers referred to, teachers would have a clear focus on that class when answering the later questions. However, although the teacher questionnaire asked teachers to provide information on their target class,

no attempt is made to analyze these data in this report, as they are not a core component in the conceptual design of the study. These data were primarily collected to focus teachers on a specific class when responding to questions about their classroom practices. Nonetheless, secondary analyses that include target-class information may add useful insights to our understanding of teachers' ICT-use in different class settings.

Table 2.1 Indicators included in the teacher questionnaire and the corresponding question number

Indicator type	Nature of indicators	Q. no.
Target class information	• Class size	T1–T7
	• Gender mix	
	• Curriculum track	
	• Extent of student absenteeism	
	• Proportion of students whose native language was the same as the language of instruction	
	• Hours of scheduled class time on the sampled subject	
	• Students' ICT-competence	
Core indicators	• Curriculum goal orientation	T8
	• Overall teacher-practice orientation	T14
	• ICT-using teacher-practice orientation	
	• Overall student-practice orientation	T16
	• ICT-using student-practice orientation	
Supplementary indicators	• Frequency of occurrence of different teaching and learning activities	T9
	• Whether ICT was being used in different teaching and learning activities	
	• Location of time and space for teaching and learning activities	T10–T13
	• Assessment practices	T15
	• ICT and learning resources used	
	• Perceived impact of ICT on teachers and students	T17
Explanatory indicators	• Teachers' self-reported ICT-competence	T19–T20
	• Teachers' vision for ICT-use in teaching in the coming school year	T21
	• Obstacles to pedagogical use of ICT	T22
	• Availability of and participation in professional development courses in ICT	T23
	• Perceived presence of community of practice in the school	T24

2.3.2 Teacher questionnaire (optional component)

The international option in the teacher survey aimed to gather descriptions from teachers of what they considered to be satisfying experiences when using ICT in their teaching. For this reason, teachers

were asked to indicate "whether they used ICT once a week or more in the target class" or whether they "used ICT extensively in the target class during a limited period during the year (e.g., in a project)." Teachers whose responses satisfied at least one of these two criteria were asked to provide a brief description of one pedagogical practice involving ICT that they had found particularly satisfying. The teachers were also asked to respond to three multiple-choice questions that sought their views on these matters:

- Whether the use of ICT in this pedagogical practice contributed to changes on a list of students' outcomes in the target class;
- Whether the use of ICT in this pedagogical practice contributed to changes in the teaching of the target class as listed in the question; and
- Who was the main actor (person) in initiating specified aspects of teaching and learning in this pedagogical practice.

The specific items included in these three questions were designed on the basis of descriptions of how pedagogical practices emerging in the information society might differ from those commonly found in the industrial society (Voogt, 2003).

2.3.3 School questionnaires

Because the concepts addressed at the school level concerned policy-related and school-contextual as well as technical ICT-related issues, the SITES 2006 researchers decided to create two school-level questionnaires. The first contained questions appropriate for school principals and so was called the *principal questionnaire*. The second focused on technical issues and was called the *technical questionnaire*. The final version of the questionnaire for school principals contained 34 questions covering 222 variables and was estimated (on the basis of the pilot tests) to take roughly 20 minutes to answer. The final version of the technical questionnaire contained 19 questions addressing 115 variables, and was estimated to take 15 minutes to complete.

So that answers would reflect the information sought, Question 3 required the inclusion of indicators of school-level conditions. One of the main questions addressed in SITES-M2 (Kozma, 2003) and other studies regarding pedagogy and ICT was, "Which conditions are likely to lead to sustainable development?" The information obtained from SITES-M2 and these other studies (e.g., Jones, 2004; Scrimshaw, 2004) indicated

that, next to conditions at the teacher level (such as confidence, level of access, lack of time, resistance to change), conditions at the school (and even the supra-school) level are crucial for initiating and implementing sustainable developments (Owston, 2003).

In general, it is fair to state that the school climate should be one that stimulates and supports teachers to make changes in their pedagogical approaches. More specifically, after an initial stage of orientation at the start of school-wide reforms, a common vision should be established among the main players (e.g., teachers and school management) about desired pedagogical approaches and the role of ICT in the school. The development of such a vision requires serious efforts from the school leadership—effort that, for instance, involves teachers in decision-making about future directions, stimulates staff development, facilitates well-organized technical and pedagogical support, and so on.

Just as it is often argued that individual teachers cannot bring about a sustainable school-wide change, it is increasingly believed that individual schools cannot bring about system-wide change. The vision held by schools therefore needs to be consistent with external policy, which includes ensuring that policy visions are operationalized through the intended curriculum, examination regulations, and the like (Owston, 2003). If teachers need to change their behavioral repertoire (for instance, by adjusting their roles or by adopting new didactical approaches), they need to be trained, which means the school leadership (with the backing of school external forces, such as the ministry of education) needs to facilitate teachers' participation in professional development courses (be they inside or outside the school).

When change concerns the use of ICT, it is important that teachers receive technical support as needed. It is particularly important that this support is immediately available during the lessons in which ICT is used. If it is not, teachers quickly turn away from using ICT. Schools therefore need to organize support in such a way that immediate help is available. The same holds for pedagogical support. Although the immediacy of pedagogical support is not so pressing as it is for technical support, teachers often confront new problems when deviating from the traditional whole-class model of teaching and learning. For instance, the assessment of group processes and products brings challenges to the traditional practice of assessing individual achievement. Another obvious condition for ICT-use is the availability and accessibility of necessary equipment and connectivity. This condition is therefore also

an important one to examine.

Table 2.2 summarizes the school-level conditions mentioned above (vision, infrastructure, staff development, support, management, and organization) and operationalized in the two school-level questionnaires.

2.3.4 The national context questionnaire

The cultural and national policy contexts within which ICT is embedded in education vary widely, a consideration that is well documented in the many national reports of previous IEA studies and itemized in the anthology by Plomp, Anderson, Law, and Quale (2003). These studies found that education-system characteristics help us understand trends in school ICT-policy and teaching pedagogy. While the aggregation of school and teacher reports gives us summary glimpses of cultural and policy differences across education systems, systematic collection of key descriptors at the country level provides us with a more comprehensive characterization of the policy context within which to interpret the survey findings from the school and teacher questionnaires.

It was for this reason that the SITES 2006 research team conducted a questionnaire survey of the study's national research coordinators (NRCs). The survey instrument used was called the *national context questionnaire* (NCQ), and it was administered online by the IEA Data Processing and Research Center in the last quarter of 2006. The NRCs were asked to consult with policymakers in their respective ministries of education and with other experts when answering the questions. The questionnaire included both open-ended and close-ended questions on topics related to centralization of educational decision-making, teacher development and certification requirements, and recent trends in policies for ICT in education.

2.3.5 The instrument design process

The design of the SITES 2006 study was a collaborative process that involved valuable input from the NRCs from all the participating systems. Draft field-trial and main-study instruments were reviewed during the NRC meetings with the aim of improving the quality of the instruments. The NCQ was also constructed in conjunction with several rounds of suggestions from the NRCs. The contributions of the NRCs to the research design are gratefully acknowledged.

Table 2.2 Summary of the contents of the school questionnaires

Concepts addressed in the school questionnaires	Description
Infrastructure	• Availability of ICT-hardware (types of computers, local area network, internet connections, electronic whiteboards, etc.) • Availability of software (general and subject-specific software, learning management systems, assessment tools, etc.) • Infrastructure needs and problems
Pedagogical practice	• Extent to which lifelong-learning practices present in the school
Vision	• Vision of the school management with regard to pedagogy and ICT, covering three dimensions: traditional, lifelong learning, and connectedness
Staff development	• Encouragement or requirements for teachers to acquire knowledge and skills with regard to pedagogical practices and the use of ICT • Priorities for school staff to acquire ICT-competencies • Ways that teachers in the school had acquired knowledge and skills for using ICT in teaching and learning • Availability (school-based and/or externally) of ICT-related courses
Support	• Persons involved in providing support and the amount of support time they provide • Extent to which pedagogical support is available for teachers • Extent to which technical support is available for teachers
Organization and management	• Role of principals in initiating changes • Decision-making responsibilities • Management of change • Stimulation of cooperation among teachers • Promotion of alternative assessment practices

2.4 Sampling

A major design issue in an international comparative study such as SITES 2006 is the selection of quality samples. Only properly selected samples yield unbiased, accurate, and internationally comparable survey estimates. Answering the first and third general research questions described above required collection of data at two levels:

1. *The school level*, involving (i) a principal questionnaire and (ii) a technical questionnaire (to be answered by the ICT coordinator)
2. *The classroom level*, involving a teacher questionnaire to be completed by mathematics teachers and science teachers in the sampled schools.

The research questions addressed by SITES 2006 required data and results reported at the school level and at the teacher level, each in their own right. Two target populations therefore were defined: *the school*

population and *the teacher population*.

The internationally desired school population was defined as all schools with students enrolled in the target grade, that is, schools with students studying in the grade that represents eight years of schooling, counting from the first year of ISCED Level 1 (OECD, 1999). SITES 2006 targeted two teacher populations: the population of all teachers of mathematics teaching in the target grade, and the population of all teachers of science (or, depending on the education system, biology, physics, chemistry, and/or earth science, if appropriate) teaching in the target grade in the school year in which the survey was conducted.

The sampling design also had to optimize the accuracy of the survey estimates at both levels. A sampling design that would sacrifice the accuracy of the estimates of one level for the accuracy of the estimates of the other level would have been incompatible with the project's purposes. For instance, selecting schools with probabilities proportional to their size and then selecting, per sampled school, a fixed number of teachers would have provided an accurate estimate at the teacher level but generated a large variability that would have decreased the accuracy of the population estimate at the school level. Conversely, selecting schools with equal probabilities would have generated a large variability of the teacher weights.

To overcome these conflicting requirements, size strata were created within each explicit stratum. The formula used to compute the number of schools per explicit stratum constituted a good compromise between an allocation representative of schools and an allocation representative of students (and thus probably of teachers).

The school sample size per country was fixed at a minimum of 400 schools. An effective sample size of 400 schools resulted in the following approximate 95% confidence limits for sample estimates of population means and percentages:

Means:	m ± 0.1s (where "m" is a school mean estimate and "s" is its estimated standard deviation);
Percentages:	p ± 5% (where "p" is a school-level percentage estimate).

Within the sampled schools, mathematics teachers and science teachers were independently and randomly selected[1]. Because the study was mainly interested in ICT-users, the number of teachers to be sampled within each school had to be, in some sense, inversely proportional to the percentage of ICT-users in the school. More precisely, the research team decided to increase the number of teachers to be sampled as the estimated percentage of ICT-users decreased, unless none of the teachers was an ICT-user. The within-school sample size was thus equal to:

- Two teachers per subject for any school in which 76 to 100% of teachers were estimated to have used ICT for teaching over the past year
- Three teachers per subject for any school in which 51 to 75% of teachers were estimated to have used ICT for teaching over the past year
- Four teachers per subject for any school in which 1 to 50% of teachers were estimated to have used ICT for teaching over the past year, and
- Two teachers per subject for any school in which 0% of teachers were estimated to have used ICT for teaching over the past year.

Finally, the design of the teacher questionnaire required the sampled teachers, when answering some of the questions, to refer to a particular class in the target grade that they were teaching during the school year. Hence, for each of the sampled teachers, one of the classes in the target grade taught by that teacher had to be randomly selected *as* the *target class* and this target-class information had to be given to the teacher before he or she began answering the questionnaire.

In summary, the SITES sample design can be described as a stratified two-stage sample, with schools constituting the first level and teachers the second level.

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[1] Italy was an exception in that, in schools, both mathematics and science are taught by the same teacher at Grade 8. Therefore, a random sample of teachers teaching both mathematics and science was selected from the sampled schools. These sampled teachers were then systematically assigned to respond to the questionnaire with respect to whether they were teaching mathematics or science in their target classes.

2.5 The field trial

IEA requires, as part of its quality standard, that a field trial is carried out to test and prepare for the main data collection in all studies it conducts. The survey instruments and the sampling routines and procedures as well as the survey operation procedures, the software, the data-processing, and the data-analysis routines are trialed before the main data collection using a sample from the target population (see Martin, Rust, & Adams, 1999, pp. 45ff.). The results of the field trial are then used to make informed decisions about the main study design and implementation, especially with regard to which questions will be used during the main data collection.

One of the major challenges in large-scale international surveys is to gather data that are comparable between different countries and/or education systems. During the field trial, the survey operation procedures, the software provided to education systems for entering the data, and the survey administration information were tested for suitability in the light of the different contexts and cultural backgrounds of the participating education systems.

The field trial for SITES 2006 was carried out in autumn 2005. Eighteen education systems participated in the trial. They were Catalonia-Spain, Chile, Chinese Taipei, Denmark, Estonia, Finland, France, Hong Kong SAR, Israel, Italy, Japan, Lithuania, Norway, the Russian Federation, Singapore, the Slovak Republic, Slovenia, and Thailand. The full set of instruments was administered to a sample of (usually) 25 schools per education system. The school principal, the ICT coordinator, two to four mathematics and two to four science teachers from each school were asked to participate (the exact number differed, as prescribed by the sampling design described above). Overall, data were received from 370 school principals, 377 ICT coordinators, 779 mathematics teachers, and 729 science teachers in the 18 systems participating in the field trial.

The field trial data were processed at the IEA Data Processing and Research Center (DPC). The procedures for data cleaning intended for use in the main data collection were trialed. This process included, but was not limited to, checking and recoding of inconsistencies between tracking information and information given in the questionnaire, recoding nationally adapted variables according to the information provided by the national research centers to ensure international

comparability of the data, and checking for data-entry errors.

The option of online data collection (ODC) was offered to education systems as an additional data-collection mode. To investigate the comparability of data collected using the traditional paper-and-pencil mode and the online mode, a split-half design was implemented in the SITES field trial. Because the comparison between the two data-collection modes showed no significant differences, the ICC decided to offer ODC as an international option to the education systems participating in the main data collection. (The following section provides more information on the ODC option.)

In December 2005, the ICC finalized the main study design. Item statistics provided by the IEA DPC were used to make informed decisions on the final selection and wording for the questions to be included in the main data collection. These proposals and decisions were also discussed with NRCs during the second NRC meeting, and their feedback was taken into account during shaping of the final instruments and survey operation procedures. In general, the field-trial results showed the feasibility of the study's main features, including the instruments.

2.6 Online data collection

The advantages of collecting large amounts of data in international surveys over the internet are evident and substantial in terms of costs and time. However, these factors do not provide grounds in their own right for implementing online questionnaires. What must be proven is that quality, in terms of high participation rates and comparable data irrespective of the data-collection channel, is maintained.

The thematic background of SITES 2006 made it a good candidate for IEA to explore the feasibility of collecting data over the internet in addition to collecting data through the traditional paper-and-pencil response channel. Consequently, the ICC carefully planned the ODC component in SITES and then gradually launched it in a series of well-monitored steps in close cooperation with the participating education systems and experts from late 2004 onwards as a component of the field trial. The findings were than used to determine if ODC could be offered as a non-mandatory international option for the main study.

Methodologically, the main challenges were to ensure isomorphic

versions of the instrumentation in both modes, so that the resulting mixed-mode survey could be reliability administered within the existing survey framework and procedures, and the two sets of data subsequently integrated and processed. After a technical try-out designed to identify obstacles connected to the software itself (the IEA *SurveySystem*), including those relating to its implementation in the different browsers and languages that would be used in the survey, a feature-complete software was used for the field trial.

A split-sample design was employed to identify, investigate, and statistically control for possible measurement problems in relation to the data-collection mode, such as response bias and non-response at variable or questionnaire level. The aim here was to determine if the two modes—online and paper-and-pencil—would yield comparable data, thus allowing implementation of both modes in and across countries. Accordingly, one half of the field-trial schools were randomly assigned to the online mode; the other half received paper questionnaires. The major conclusion drawn, based on various statistical and qualitative approaches, was that there were no substantial differences between the data derived from the paper mode and those from the online mode of the kind that would reduce the research team's ability to combine these sets of data and to make joint analyses.

On the basis of the satisfactory field trial results, ODC was offered to the education systems participating in the IEA SITES 2006 main data collection, making it the first study in the history of international comparative educational assessments to apply such a methodology. The study's national centers had to accurately document the required survey mode at the school and individual levels, and it was mandatory for them to check that the schools accepted this mode before sending out materials. The centers were also required to provide fall-back questionnaires to those individuals without internet access and/or required equipment, or who simply refused. The majority of the participating systems (17 out of 22) opted to implement ODC, usually as the default data-collection mode.

2.7 Methodological issues

This section describes some of the more technical considerations relating to the design, analysis, and reporting of the study. Readers interested only in the substantive findings from the study can skip this section, whereas readers wanting more details about the research design, analysis, and associated methodological details should, after reading this chapter, refer to the SITES 2006 technical report (Carstens & Pelgrum, 2008).

2.7.1 Development and reliability of scale indicators

In quantitative studies, scales are often constructed from responses to a number of items in order to provide better indicators for conceptual constructs. Different methods can be used to construct scales. Confirmatory factor analysis (CFA) is widely recognized as a rigorous statistical technique for constructing measurement models designed to confirm or disprove hypothesized underlying latent variable structures (Byrne, 1989). CFA is also used extensively in studies across different fields, such as psychology, marketing, and career counseling (see, for example, Byrne, 1989; Harvey, Billings & Nilan, 1985; Kumar & Sashi, 1989; Marsh, 1985; Thacker, Fields, & Tetrick, 1989). However, a Cronbach's alpha reliability score of 0.5 or above is often considered acceptable for a set of items set as a scale. SITES 2006 used both methods.

Because the three sets of indicators for the overall pedagogical orientations designed for the teacher questionnaire, namely the curriculum goal orientations, teacher-practice orientations, and student-practice orientations, were central to the design of SITES 2006, CFA was used in the pilot and field-trial stages to ensure the questionnaire items designed would deliver indicators that had prima facie construct validity and met the requisite statistical standards.

The factor analysis results for both the pilot and the field-trial studies yielded four factors with acceptable CFA goodness-of-fit statistics for each of the pedagogical-orientation constructs. The four factors were labeled "traditionally important," "collaborative inquiry," "student-centered," and "connectedness." The analysis also revealed a high degree of correlation between the collaborative inquiry and the student-centered-orientation indicators, which allowed the two to be collapsed into one factor, labeled "lifelong learning," in line with the constructs in the conceptual framework presented earlier.

Because the statistical reliability of the indicators for the pedagogical-orientation constructs could depend on context factors at the system level, reliability scores needed to be computed for each participating system to ensure that each met the quality requirements for scale construction. Unfortunately, this procedure could not be satisfactorily performed systematically for each system in the field trial because the sample sizes were small (typically around 40 teachers per system from around 25 schools). All explorations on scale construction therefore were conducted on the entire set of teacher-questionnaire returns from the field trial.

During the final analysis of the main study data, the reliability for each scale indicator was computed for each participating system to ensure that the indicators reported were statistically acceptable for all participating systems. The only instance in which this degree of acceptability was not the case concerned the scales pertaining to the traditionally important orientation, particularly the traditionally important student-practice scale. (We report on this in greater detail in Chapter 5.)

Another limitation encountered in the development of scale indicators was the small number of items that could be used to form a scale. This small number was a consequence of the need to constrain the length of the questionnaire in order to minimize respondent dropout.

For the other indicators in this study, items comprising a scale were either determined a priori or through exploratory factor analysis. Cronbach's alpha reliability was then used to determine the acceptability of the indicator for reporting purposes. It is important to point out that the small number of items comprising each scale meant all indicators were computed using listwise deletion whenever data were missing from among the scale variables. Listwise deletion reduces the probability of bias due to missing data.

2.7.2 Reporting standards for IEA studies

Statistics derived from analyses of survey responses are used to provide estimates of the respective measures of the population sampled. Non-response may introduce a bias in survey outcomes, and the potential bias increases with lower participation rates. IEA requires a participation rate of at least 70% after replacement for the respective statistics to be included in international comparisons. As described in the earlier section on sampling, the research questions that SITES 2006

addressed required that data and results be reported at the school level and at the teacher level, each in its own right. As such, the school and teacher samples were drawn with a two-stage design, which meant that participation rates for results derived from the school questionnaires and from the teacher questionnaire needed to be computed separately.

Non-adherence to survey administration procedures can be another potential source of bias. Teachers may make different pedagogical decisions for classes on the same subject and at the same grade level because of different student characteristics in these classes. Thus, as described in Section 2.2.1, a target class was identified for each of the teachers sampled in the study and indicated clearly on the questionnaire. Unfortunately, the procedure for target-class selection and subsequent indication on the distributed questionnaire was not strictly followed in all schools in some participating systems during the main data collection stage, although this problem was not encountered during the field trial.

IEA guidelines for reporting survey findings require that clear demarcations be made between statistics deemed to be unbiased from those where the bias may not be negligible by presenting these in two distinct lists. This guideline is evident in the presentation of the survey findings in Chapters 4 to 7. Furthermore, whenever the "international mean" is reported in this publication, it is important to note that the mean was computed on the basis of responses collected from systems where the respective statistic was deemed to be unbiased.

2.8 Summary

SITES 2006 was developed as an international comparative study that sought answers to the following issues:

1. How and to what extent ICT was being used in the context of the overall pedagogical practices of representative samples of Grade 8 mathematics teachers and Grade 8 science teachers?
2. The extent to which the preconditions for different pedagogical practices and ICT use were present in a representative sample of schools, and
3. The extent to which these preconditions, the pedagogical practices, and ICT-use were related.

The main instruments used in this study were a survey of mathematics teachers and science teachers and surveys of principals and ICT-coordinators in schools, supplemented by a national-context questionnaire designed to provide pertinent information at the system level. The research questions primarily addressed, through analysis of quantitative indicators supplemented by qualitative analysis, teachers' descriptions of their satisfying experiences when using ICT in their teaching.

Consistent with our view that pedagogical practice and ICT-use should be understood within the school- and system-level contexts, the findings from this study at the system level are reported first, followed by reports of the findings from the school-level questionnaires. Findings from the teacher questionnaire are reported in three separate chapters, the first of which addresses the first research question by describing the mathematics teachers' and the science teachers' pedagogical practices and ICT-use. The second chapter focuses on the teachers' characteristics and how these affected their pedagogical use of ICT, and the third, which addresses the second research question, covers the teachers' reports of satisfying pedagogical practices that involved use of ICT. The eighth chapter in this book pulls the findings together in the form of explanatory models that seek to link the findings from the different levels.