Educational Innovations Beyond Technology

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Nurturing Leadership and Establishing Learning Organizations

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Foreword

Educational Innovations beyond Technology: Nurturing Leadership and Establishing Learning Organizations is an important addition to our knowledge about the effective use of learning technologies in preparing students for our twenty-first century, global, knowledge-based civilization. At present, nations face a difficult dilemma:

- On the one hand, as Law and colleagues discuss, the twenty-first century seems quite different than the 20th in the capabilities people need for work, citizenship, and self-actualization. In response, each society's educational systems must transform their objectives, curricula, pedagogies, and assessments to help all students attain the sophisticated outcomes requisite for a prosperous, attractive lifestyle based on effective contributions in work and citizenship (Dede, 2010a).
- On the other hand, for a variety of reasons delineated in this book, in every country industrial-era schools have proven incredibly resistant to innovation. Of all society's institutions, K-20 formal education has altered the least over the past century and shows few signs of dramatic shifts in practice and policy across the majority of institutions, despite massive external pressures for improvement and diminishing financial resources to support a model that is very labor-intensive (Clarke & Dede, 2009).

In contrast to the recent pundits who present visions of educational evolution unproductive because they ignore this dilemma, Law's research develops a detailed, evidence-based conceptual framework for realistically analyzing these challenges and developing effective strategies for improvement.

As its source of cross-cultural data, this book uses the Second International Study on Technology in Education (SITES) M2 study centered on cases of technology-based educational innovation in a wide spectrum of nations. The richly documented information collected in this research is unique in its range and detail, yet few scholars have examined the macro-level patterns that emerge across the countries involved. In particular, this book describes the influence of context on learning technologies in ways that inform decision making by practitioners and policy makers. The metaphorical lens of nested educational ecosystems developed by Law and her colleagues both explains the resistance to change that schooling exhibits and suggests generalizable approaches that are proven in fostering improvement and evolution.

Since SITES M2, dramatic changes have occurred in learning technologies. In particular, the emergence of Web 2.0 interactive media and of immersive interfaces for simulation and gaming are providing powerful new tools and environments for fostering student engagement and learning. In every country, the growing prevalence and affordability of wireless mobile devices is also broadening the menu of levers of educational improvement and of alternative structural models to replace industrial-era schools (Dede, 2010b). However, these improvements in technology do not undercut the fundamental insights in this book, because the findings Law describes and the strategies she articulates are independent of specific technological affordances and universally applicable across national and cultural settings.

Overall, this book is a valuable resource for stakeholders in education, whether their sphere of influence is the classroom, the school, or the larger setting of leadership and policy. We keep repeating our mistakes in technology-based education innovation, in part because "Those who cannot remember the past are condemned to repeat it" (George Santayana). This work provides an outstanding historical analysis that provides a strong foundation for future action and educational transformation.

Harvard University Chris Dede

References

Clarke, J., & Dede, C. (2009). Design for scalability: A case study of the River City curriculum. *Journal of Science Education and Technology,* 18(4), 353–365.

Dede, C. (2010a). Technological supports for acquiring twenty-first century skills. In E. Baker, B. McGaw, & P. Peterson (Eds.), *International encyclopedia of education* (3rd ed.) (pp. 158–166). Oxford: Elsevier.

Dede, C. (2010b). Commentary: Transforming schooling via the 2010 U.S. National Educational Technology Plan. *Teachers College Record*. Date Published: June 02, 2010. Retrieved 6 May 2010 from http://www.tcrecord.org ID Number: 15998

Acknowledgement

The writing of this book has been a long journey, and took much longer than we anticipated. The idea of writing a book began in 2003 when we were conducting an in-depth secondary analysis of the international case studies collected from the IEA SITES M2 study. At that time, we had just completed the APEC Education Foundation funded *Bridging the Digital Divide e-Educational Leadership in ICT* project in which we used some of the case studies as stimulus materials for the workshops in this project. We were somewhat hesitant about the value of writing a book on technology supported pedagogical innovations several years after the data were collected, as technological innovations continued to mushroom at an ever quickening pace. We are very grateful to Marie Sheldon, who was Senior Publishing Editor at Springer at the time. We would not have made the decision to embark on writing this book in 2005 without her support and encouragement, which has continued until her departure from Springer in early 2010.

Our initial intention was to complete the manuscript by spring 2007 since we had to focus our energy on analyzing the SITES 2006 survey data and were committed to publishing the international research report for that study by early 2008. We sought comments and feedback on our first draft chapters from a critical friend, Colin Latchem. As someone working in the field of technology in education but unconnected with IEA studies, he gave us many comments which made us realize that there was a lot more work that needed to be done to clarify the central ideas of the book, and to make it accessible to the general reader. Colin's criticisms caused us to rethink and rework the whole manuscript, which meant that we could only focus on it after the publication of the SITES 2006 report. Here, we would like to thank Colin for "causing" the delay in completing the text, as it has allowed us to develop the theme of this book in a more accessible and coherent manner. The delay has also allowed us to take into consideration the findings from SITES 2006, which reveals that pedagogical practices have largely remained traditional even though the adoption of ICT in classroom practices has increased. The findings have strengthened our view that the ideas and message of this book are still very relevant today.

This work would not have been possible without having access to the goldmine of the SITES M2 case reports. We want to thank the National Research teams in the IEA SITES M2 study community for the excellent work they have done in conducting the studies and writing up the case reports. We are also very grateful for the opportunity to engage in the three SITES modules and to interact with that research community, which has given us much stimulation in formulating this book.

Finally, we would like to thank two key persons who have made significant contributions to this book. Angela Chow was the project manager for the SITES M2 and SITES 2006 projects. She contributed much to the coding and analysis of the case reports as well as in helping us with our early writing efforts. Her rigorous work in this has helped to provide the empirical basis for the book. We would also like to express our sincere thanks to Paula Wagemaker, who has labored long hours, amid her winter vacation and even during the magnitude 7.1 Richter scale earthquake that hit Christchurch, New Zealand, the beautiful city she lives in, to complete the copyediting for this manuscript. Her meticulous editing has improved greatly the readability of this book, and any error that remains, is the responsibility of its authors.

September, 2010

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Chapter 1
An Ecological Metaphor for Researching Technology Use and Pedagogical Innovations

Education is organic: it involves actions of individuals, interacting with one another within different contexts and environments in homes, in urban centres and rural settings, in classrooms, schools, regions, countries, and the world. Ecology is a study of interactions between organisms and interactions of organisms with their environments. In this book, we use the ecological metaphor as a conceptual and practical framework for broad-based research in education. The advantage of this metaphor is its interdisciplinary nature and its all encompassing ability to view multiple interrelated components of entire environments and how these impact on and affect one another and the entire system. We argue that the study of technology use and pedagogical innovations in education systems demands such an approach. The main purpose of this book is to explore where and how information and communication technology (ICT) has made significant educational impact on the goals, outcomes, and processes of education in different countries, and where this impact is clearly evident. Another purpose is to examine the strategies and policies at the school and system levels that appear to be the most effective in bringing about desired learning outcomes and processes.

ICT plays a significant role in most aspects of contemporary society. It is changing the nature and key processes of many industries, services, and professional fields, and it has been introduced into schools amid much anticipated impact. It is the focus of many educational policy and research documents pointing to the advent of the knowledge economy, the associated new demands on citizenry, and the consequent need for fundamental reforms in curriculum goals and pedagogical processes (e.g., Education and Manpower Bureau HKSAR, 2001; International Society for Technology in Education, 1998, 2007; UNESCO, 2008). In response to these calls for system-wide changes in schooling, many countries have embedded ICT in education master plans setting out visions and strategies for integrating the new technologies across the curriculum (e.g., Singapore Ministry of Education, 1997, 2002; Tarragó, 2009).

An ever-increasing body of literature describes the many changes taking place as the global economy moves from the industrial era to the knowledge age (e.g., Drucker, 1994; Nonaka & Takeuchi, 1995). Kozma (2005, 2008) clearly articulates the economic rationale for educational reform and the role of ICT in education. Drawing upon economic theory and economic development data from across the globe, he highlights three factors that can contribute to increased productivity: capital deepening, higher quality labor, and technological innovation.

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Capital deepening refers to the adoption and use of more productive versions of technology. However, economies cannot achieve sustained development by relying on capital deepening alone. A better-educated population is also needed to support a more productive, technology-based economy. Societies need to be capable of using technology to solve problems and to develop new products, new services, and new knowledge. New knowledge needs not only to be shared and applied by many people, but also to be used by an appropriately prepared labor force to create further innovation. Hence, increased productivity through technology innovation has a compounding effect on productivity and results in what economists refer to as the knowledge economy.

Both higher-quality labor and technology innovation rely heavily on high-quality education. Drawing on international economic data sources, Kozma (2005, 2008) demonstrates the relationship between economic wellbeing and educational attainment at individual and national levels: an average increase of 9.7% in personal income for every additional year of schooling for individuals, and additional growth in a country's per capita GDP for each year of schooling equivalent to a return on investment of 7–12%. Kozma refers to other data showing that higher test scores of one standard deviation equate to 1% growth in per capita GDP. In short, the quality of education has an even stronger relationship to growth than has the length of schooling.

The knowledge needed for the knowledge economy differs from the requirements of the industrial age when knowledge and skills were predictable and specific and change was relatively slow and incremental rather than quick, radical, and unpredictable. Today, the need is for more generic capacities. There have been many attempts (e.g., Partnership for 21st Century Skills, 2003, 2007; Secretary's Commission on Achieving Necessary Skills, 1991) to identify the knowledge, skills, and abilities required for the successful knowledge worker of the twenty-first century. These attempts all point to the importance of information literacy skills, which include not only the ability to identify information needs and to access and evaluate information for the purpose of problem-solving, to collaborate, to conduct inquiries and solve problems, to communicate and present, but also to fully utilize ICT in acquiring and applying such skills. An important conclusion to be drawn from all of these studies is that the goals and processes of schooling must change if schooling is to prepare students for the demands of the twenty-first century (Istance, 2008).

It is therefore not surprising to observe that in many educational reform and ICT-in-education policy initiatives in an increasing number of countries (Plomp, Anderson, Law, & Quale, 2003, 2009), large expenditure on providing schools with the necessary ICT infrastructure and Internet connectivity, and significant improvements in student access to ICT. The results of the Second Information Technology in Education Study (SITES) provide examples.[1] Many developed countries have also established teacher ICT competency standards. The SITES 2006 results indicate

[1]SITES, conducted under the auspices of the International Association for the Evaluation of Educational Achievement (IEA), consists of three independent modules: Module 1, the Indicators Module (school survey, with data collected in 1998/1999); Module 2, the Innovative Practices Module (case studies, collected during 2000/2001); and Module 3, the Survey Module, also known as SITES 2006 (school, teacher, and optional student survey, conducted in 2006/2006).

that teachers in most of these countries see themselves as having enough technical competence to use ICT in their teaching practices (Law & Chow, 2008a).

In addition to these developments, a considerable amount of research and development work on ICT and schooling is also being conducted. However, as yet, many aspects of this work still require answers. Despite all of these endeavors, it is all too often the case that computers in schools are being "*oversold and underused*" (Cuban, 2001, emphasis ours), and that even when they are being used, they have no significant impact on learning outcomes (Russell, n.d., 1999). Collins and Halverson (2009) and Halverson and Collins (2006) conclude from their examinations of this apparent lack of impact of ICT use in schools that publicly funded schooling (at least in the context of the United States) are incapable of taking advantage of the educational potential of ICT because the culture of schools is intrinsically conservative. These very disconcerting findings warrant deeper and more rigorous discussion and research. This book provides one response to that call.

With change and innovation, there is always an adoption cycle (Rogers, 2003). It is certainly the case that integration of ICT in education lags behind its adoption and exploitation in business, industry, and services. Some people observe that the modern school room has changed so little that a time traveler from the eighteenth century would feel at home in it. However, as we show in this book, an increasing number of schools in both the developed and developing world are taking advantage of ICT to change the ways they manage, operate, and teach. There have also been major efforts, for example, in England, to create new physical school infrastructure to support the new educational vision that encompasses integration of state-of-the-art ICT to support teaching and learning (Department for Education and Skills, 2003).

SITES 2006, which surveyed 22 educational systems around the world (Law, Pelgrum, & Plomp, 2008), found that of the representative samples of mathematics and science teachers surveyed, 50 and 60%, respectively reported using ICT in their teaching of and learning activities for their Grade 8 students in the academic year 2005/2006. This percentage was higher in the economically more developed countries such as Singapore and Norway, with the highest percentage of reported usage reaching 80% or above.

Data such as these, the rapidly increasing accessibility of hardware and software, and the heightening technological and information literacy of the general population make us confident that ICT will eventually become widely adopted in teaching and learning, compatible with its uptake in other walks of life. The real challenge, however, centers on whether ICT adoption will actually help to realize the vision of a changed educational paradigm, best suited to the requirements of the twenty-first century.

In this book, we take as our departure point, the need for education to change its goals and processes in order to achieve the core competencies of lifelong learning and solving authentic problems collaboratively with globally distributed peers. Much research has documented successful curriculum and pedagogical innovations designed to achieve such goals through the use of ICT. The *International Handbook of Information Technology in Primary and Secondary Education* (Voogt & Knezek, 2008) provides many good examples such as Erstad (2008), Scoter (2008), and Webb (2008). However, most of the innovative and well-known exemplars arise through projects led by expert groups from outside schools such as the Kaleidoscope projects (http://www.noe-kaleidoscope.org/pub/case_studies/), the Quest Atlantis (QA) projects (http://atlantis.crlt.indiana.edu/) and the TELS projects (http://telscenter.org/).

Whether these changes will be sustainable after withdrawal of the external forces driving is questionable. An even greater challenge is scaling the few such expert-led innovations from implementation in a relatively few schools to entire educational systems. Hence, we also need to identify the critical factors, policies and strategies that are needed both at the school level and the system level to achieve scalable and sustainable educational change and development.

ICTs in Learning and Teaching: Are They Sustaining or Transforming Technologies?

In his book, *The Innovator's Dilemma: When New Technologies Cause Great Firms to Fail*, Christensen (1997) introduces the concepts of sustaining and disruptive technologies. Sustaining technologies are those that foster improved performance of existing, established systems. ICT examples are digital desktop publishing and computer graphics and animation. Disruptive technologies have features that enable them to address new needs in new markets and to support the rise of totally new systems. The invention of the digital camera is a disruptive innovation. When the digital camera came onto the market, the quality of its photos was much lower than the quality of photos taken on an ordinary film-based camera. However, the digital camera enabled the user to view the photograph immediately, and then to manipulate, copy, and transmit the image in a matter of seconds.

These features have led to fundamental changes in how we use the photograph as a medium in our daily lives. They have also prompted profound changes in professions such as journalism. Further enhancement of the photographic quality and functionality of digital cameras falls under the realm of sustaining innovation, as these are simply improvements on the initial disruptive innovation. However, it is important to note that the subsequent "sustaining innovations" are important to the eventual "disruptiveness" of the initial invention because these heighten customer interest in the digital camera as a disruptive technology. Eventually, this interest reaches a "tipping point" – the moment when the demand for digital cameras supersedes that for conventional film-based cameras.

Does the introduction of ICT into educational processes signal a sustaining or disruptive innovation? Is this introduction addressing new needs in new markets and supporting the rise of totally new systems? We use the term "education market" in this book to refer to a particular target audience, such as adult learners or preschoolers, or to an education system, such as public schooling or home schooling. In these contexts, *sustaining* technologies can improve, make cheaper, or extend what is currently being provided. For example, PowerPoint can be used instead of the overhead projector, streaming video can be accessed rather than broadcast TV, stories can be read on ebooks, mobile learning can be carried out via smart phones, and lessons can be taught in conventional ways to students in remote locations by videoconferencing.

ICT can also be used to radically change the what, where, when, and how of teaching and learning. For example, children can learn by means of web-questing and collaborating online with children in other schools or even countries; open schooling systems can be established for isolated, disadvantaged, and marginalized children; and new delivery systems can be created for gifted students or those with special learning needs. Students are empowered to use the Internet and search tools to acquire and construct new knowledge and arrive at solutions to problems that they themselves have identified. They can then use web-authoring tools to publish their findings to the world.

A major paradigmatic shift in which the teacher is no longer the source of all knowledge and opinion is possible through ICT use. The processes made possible by this use bring fundamental change to the nature of the classroom, its working relationships, and the roles and expectations of teachers and the taught. Pedagogy is transformed from receiving and following instruction to productive problem-solving, knowledge creation, and other new pedagogical goals and activities hitherto absent from most educational settings. Note, however, that in this latter scenario, the transformative uses of technology come about by "disrupting" the established practices and prevalent pedagogy and hence bring tension to the educational system. The adoption of ICT in teaching and learning can thus be sustaining or disruptive, depending on the nature of the educational process that the technology is designed to support.

For Christensen (1997), the term disruptive is positive rather than negative. Disruption simply highlights the inevitable social and organizational change brought about by the innovation. Some educators may prefer to use the term "transformative" to refer to the potential that ICT use has for redesigning teaching and learning activities and serving new educational markets (e.g., Oblinger & Hawkins, 2006). In this book, we use both terms interchangeably. We use disruptive when we want to highlight changes in social relationship and work practices, and the inevitable tension that transformative uses of technology bring about.

Many commentators and researchers consider the classroom environment in which the teacher teaches in front of a class of students seated in rows as an educational solution suited only to the industrial age, where mastery, conformity, and obedience were seen as the prime goals, rather than creativity, realization of individual talents, and empowerment. Many of today's classrooms are still typically organized in ways that allow teachers to teach students so that they can master the knowledge and skills in the prescribed curriculum and have the quality of their learning assessed through standardized tests. A growing realization among many sectors of society that this approach is totally unsuited to the escalating changes associated with globalization and the knowledge economy has resulted in increasing pressure on schools and teachers to make changes to the goals and processes of education, and the roles played by and learner. Transformative uses of technology, such as those described above, can facilitate this.

Sustaining or transformative uses of technology do not depend on technology alone; they also depend on the intended use of the technology in specific educational contexts. Often, specific technologies prioritize certain uses and hence can be used more easily for sustaining or transformative purposes. However, such prioritization is not deterministic, as we explain later. Further, the characteristic that most influences the choice and deployment of ICT in school education is the pedagogical decision-making of the teacher. These, in turn, are determined by the curriculum goals and training and pedagogical competence of that teacher (Pierson, 2001; Webb & Cox, 2004).

Drawing upon the above discussion, we broadly conceptualize pedagogical practices aligning with what has been practiced and refined throughout the twentieth century as *traditionally important* and those that align with the goals and processes in curriculum reform policies designed to address the needs of the knowledge economy as *innovative* (meaning that it is not yet established and needs to be creatively developed). *Sustaining* uses of technology in education are thus those that maintain and strengthen the traditionally important pedagogical practices. *Transformative* uses of technology in education are those that are integral to the implementation of innovative pedagogical practices. The latter involves changing the roles of teachers, learners, and members of the community, and the power relationships among these three groups. The way learning outcomes are assessed and staff performance is appraised also changes, thus challenging the predominant value and reward system inherent in the educational systems of today.

These are the fundamental changes (as perceived by stakeholders) that have to take place for the innovations to become commonplace. Of course, in practice, there is a need for both sustaining and transformative uses of technology. The art – or, if you prefer, the science – of teaching depends on determining which of these is most appropriate under what circumstances. It also depends on the realization that whether technology is sustaining or transformative is determined not by the intrinsic functionalities of the technology itself but by the pedagogical design and context within which the technology is used. Many teachers first start using technology in a sustaining way – for example, using PowerPoint or spreadsheets – and then progress to more transformative approaches as their confidence and competence grows. However, in this book, our explorations focus primarily on the transformative uses of ICT in the school and the classroom. The specific questions we explore are these:

1. What evidence is there that ICT can contribute to fundamental pedagogical changes compatible with the human resource needs of the twenty-first century and what are the key identifying characteristics of these ICT-supported pedagogical practices?
2. What models of ICT-based school and classroom change and innovation are likely to contribute to sustainable and escalating "mainstream" educational change?
3. What policies and/or strategies at the school, local, national, or cross-national levels can be employed to bring about successful systemic ICT-supported pedagogical change?

We think that the best way to examine these questions is through cross-national comparisons of in-depth case studies because these give us access to the contextual details and subtle nuances of different pedagogical innovations. The case studies collected for the second module of SITES (SITES-M2) provided an excellent source for our present study. *Pedagogical practice* was defined in SITES as the totality of the specific curriculum goals and designed learning interactions and processes to achieve those goals in the context of a specific curriculum unit. All together, 28 education systems participated in the study, and 174 case studies were collected during the 2000/2001 school year. The case studies were selected by an expert panel set up locally in each country according to a common set of membership criteria. Each panel decided on the selection criteria for innovativeness as well as the final list of cases selected for its system. Kozma (2003) provides an overview of the study, a comprehensive description of the cases at the classroom and school levels, and preliminary relational analysis of the cases.

Readers may consider the SITES-M2 case studies too dated for the purpose of our study, as it is already 8 years after the case studies were collected. However, research results indicate that teaching and learning practices in schools continue to be largely unaffected by the digital revolution, even though the digital technologies used in everyday life have changed markedly since the turn of the millennium. Although many of the teachers surveyed in 2006 as part of the third module of SITES reported using ICT in their teaching, the kinds of teaching and learning activities undertaken and the roles performed were still largely traditional (Law & Chow, 2008b). The kinds of innovation featured in the 2001 SITES-M2 cases are, we believe, still rarely encountered and would be considered innovative even today.

Kozma (2003) presents comprehensive accounts of school and classroom innovations. He looks at why authorities and teachers perceived these as successful and why they expected, at that time, that these innovations would be not only sustainable but also replicable in other educational communities across the globe. Rather than perceiving the SITES 2006 results as indicating a lack of change in the surveyed educational systems, we prefer to regard these results as suggesting an ecological model of educational change – an issue we elaborate on later in this chapter. It was this thinking that led us to conduct further in-depth secondary analysis of the SITES-M2 case studies in order to address the research questions stated earlier.

Another strength of the set of SITES case studies is that they contain rich details of what was actually happening within the classrooms at the time and how technology was being used in them. The studies also detail the school and national contexts within which this development was taking place. The large number of cases collected from the wide range of national and regional contexts provided us with a rare opportunity to identify broad patterns in technology-based pedagogical change and innovation and their relationships with different contexts. Details of how we conducted this analysis are provided in Chap. 2.

Pedagogical Practices as Competing "Species" in the Ecology of School Education

Comparison of the SITES 2006 results with the findings of the earlier survey (SITES M1), conducted in 1998 (Pelgrum & Anderson, 1999), showed that the percentage of schools reporting that they used computers in their classrooms had markedly increased. However, it was also evident that this increase had made little impact on traditional ways of teaching. In other words, the adoption of ICT in classrooms was sustaining rather than transformative. As such, simply examining the factors affecting teacher adoption of ICT would not explain the conditions required for – or the actual nature of – pedagogical innovations that leverage the potential of ICT.

In a comprehensive review of the literature on factors influencing teachers' adoption of ICT, Mumtaz (2000) posited that teachers' theories about teaching are central to their decisions to adopt or reject technology. Mumtaz's emphasis on the importance of teachers' enthusiasm is echoed and strengthened by Law (2008) in her discussion on what motivates teachers to acquire the wide repertoire of knowledge and skills beyond the technical and pedagogical needed for ICT-based pedagogical innovation. Law also considers the risks that these teachers need to take when acting in this manner. She draws on Oakes, Quartz, Ryan, and Lipton's (2002) work to put forward the view that the cognitive, metacognitive, and socio-emotional energy involved in engaging in such innovations must come through the professional values and epistemological beliefs of the teachers themselves. Davis (2008) argues that the changes involved in ICT-supported innovations do not simply occur in single isolated classrooms. Teachers, she says, also need to assume leadership roles in educational renewal. She proposes an ecological model for understanding the complexities of the contexts within which teacher change occurs in technology-supported innovations and the commitments needed for this.

We consider an ecological perspective to be an appropriate framework for understanding and analyzing ICT adoption in schools and classrooms where traditional and innovative pedagogies compete for resources, time, and recognition within and beyond the school. In some settings, traditional models of teacher-centered pedagogy are still highly regarded, and teacher training is predicated upon these. In other settings, teacher training, reward, and recognition focus more on fundamentally changing the nature of the learning environments and interactions so that students can not only take greater responsibility for their learning and how they go about it but also become lifelong learners and problem-solvers and generally equip themselves for life and work in the twenty-first century.

Researchers engaged in ecological studies recognize that when two species compete, one becomes dominant, threatening the survival of the other. An example of this is the introduction of the American grey squirrel into England, which largely replaced the indigenous red squirrel (http://www.saveoursquirrels.org.uk/). The newcomers competed for the same habitat and food supply and were more successful in the *ecological niche*. A habitat of any given size can only sustain a corresponding population level of species occupying the same niche in the food web (referred to in ecology as *carrying capacity*). Such was the aggressiveness and breeding rate of the grey squirrels that they now outnumber the indigenous red squirrels by a ratio of 66:1. The outcomes of such a process also depend on broader environmental factors. For example, red squirrels survive better and outnumber the grey squirrels in coniferous forests. Changes in the environment often result in some species thriving because they have the required characteristics and/or can adapt while others fail to survive under the new conditions. Before Britain's Industrial Revolution, black moths were rarely found around London and other major English cities. However, with the advent of industrialization and the blackening of the limestone buildings due to air pollution, white moths became easy prey for birds. The dark-colored moths benefited from this environmental change; as coal-powered industry and home heating progressed, their number greatly exceeded the number of white moths.

Zhao and Frank (2003) used an ecological model as an integrative framework to investigate why technology was not being used more widely or imaginatively in primary schools in four school districts in the United States. This model, based on the idea of ecosystems and subsystems, provides a more nuanced understanding of the different levels of change (individual, classroom, school, regional) and the interactions between these. We believe that this ecological approach takes us beyond simply identifying and correlating factors and focuses attention on interactions, activities, processes, and practices. However, unlike Zhao and Frank, who, in their study, considered teachers to be the keystone species, we think it more appropriate to consider pedagogical practices, with their different pedagogical characteristics and levels of computer use, as the species competing for teachers' adoption within specific environments.

In many countries, projects and initiatives are designed to develop and introduce new learning technologies and pedagogies into the school curriculum in accordance with national goals of education reform. Examples include the Web-Based Inquiry Science Environment (WISE; see http://wise.berkeley.edu/) and Quest Atlantis (http://atlantis.crlt.indiana.edu/). These projects can be seen as analogous to laboratories that design new species and then put them out into various agricultural settings to breed and be further tested for their longer-term viability and impact. Introducing ICT-supported pedagogical innovations into "farms" (i.e., the experimental school sites), and nurturing them so that they prosper and multiply and are shown to be truly effective, presents a major challenge to change agents. Moreover, for these innovations to have lasting impact on overall educational practice, they need to have the capacity and the means to spread beyond the experimental sites and become thriving species in the wider pedagogical ecology. If we take the ecological metaphor further, we realize that whether the "farmed pedagogies" survives and thrives out in the "wild" depends on the quality of the design and the robustness of the experimental laboratory species, and on how the survival characteristics of that species match the general ecological conditions of schools and classrooms, such as the national curriculum frameworks, assessment and examination systems, and teachers' and students' general levels of technological literacy.

But then, as we showed above, the ecosystems change, slowly and organically, through interactions with the species residing in them. Educational systems are complex adaptive systems. The laboratory-designed species inhabiting these ecosystems contribute to the interactions and changes within the wider system – even when they do not succeed and survive as sustainable species in the longer term. Thus, for example, in the evolution of educational technology, we can see, through hindsight, how programmed learning (as an algorithmic approach to teaching and testing), the early mechanical teaching machines, and the experiments with analog multimedia of 40 years ago fed into the development of computer-based learning while fading from the scene themselves. Environmental changes result in population changes: those species that are better suited to the new conditions become more numerous while those less suited to the change decrease in number. These phenomena are why conservationists study the habitats, lifecycles, feeding, and breeding habits of different species: they do so in order to understand population changes in the natural environment and in turn develop ecologically sound conservation strategies.

In writing this book, we see ourselves as playing the role of ecologists, examining case reports of ICT-supported pedagogical practices identified as innovative and as providing evidence of sustainability and transferability by nationally established expert teams in the countries participating in SITES-M2. Nearly all of the cases collected in SITES-M2 were *emergent* in that they were initiated by teachers and/or school heads rather than as interventions by authorities or agencies outside the school. We have already mentioned the value of these case reports to our study. However, we emphasize here the particular value they offer with respect to providing us with a reliable and illuminating data source on which to base our investigations into the features and characteristics of ICT-supported innovations that emerge under very different contextual milieus. We hope that this more organic, ecological approach to the selection and analysis of case studies of ICT-using pedagogical innovations will provide insight on how we can nurture, sustain, and scale pedagogical innovations under different national, regional, and school contexts.

As we suggested earlier, different pedagogies and learning technologies compete for the same niche – physical resources as well as the attention and regard of teachers, students, parents, and members of the wider community. Thus, at the classroom level, we need to establish the following:

- The characteristics of successful ICT-supported pedagogical innovations that grow out of actual everyday classroom situations
- How these innovations relate to, or differ from, laboratory-designed, externally introduced innovations
- How the features of these innovations vary across the various subjects of the curriculum and across different countries and cultures
- How these innovations link to the contextual characteristics of the various ecosystems within which they become or need to become embedded

And at the school level, we need to establish:

- The conditions that provide opportunities for new ICT-based pedagogical practices to emerge and take root
- The environmental impact that the new practices have on the educational ecology
- The bases upon which the researchers who conducted and reported on the case studies believed that these cases would have a competitive edge in continuing to attract resources and even become dominant practices

- The conditions under which these practices emerged, developed, became sustainable, and were mainstreamed
- The patterns of similarity and difference across countries and cultures
- The critical environmental factors influencing the sustainability and scalability of innovative pedagogical practices
- How the case characteristics and environmental factors might interact

In addition to using the SITES-M2 case reports as research data to inform our understanding of ICT-supported pedagogical innovation, we used the cases and our analyses as leadership and professional development resources to stimulate further innovation and change within an ecological framework.

Outline of This Book

This book comprises four sections: an introduction; an examination of ICT-using pedagogical innovations at the classroom level; a look at the contextual conditions at the school level and beyond; consideration of matters relating to nurturing leadership and establishing learning organizations, and a conclusion. Brief descriptions of these sections and the individual chapters follow.

1. *Introduction*: This section has two chapters. The first describes the ecological metaphor underpinning the research framework and methodology used in this book. The second chapter describes the contextual background and research methodology used in SITES-M2, which provided the case studies that informed our data analyses and reports.
2. *Examining ICT-using pedagogical innovations at the classroom level*: In this section, we argue that an innovation is, by its nature, an emergent phenomenon, and that each innovation should be considered unique. We therefore needed to establish the characteristics or features that distinguish these innovations from "normal practice." We also needed to identify the different levels of innovation emerging from the distinctive school ecologies around the world. We accordingly decided to use two different analytical approaches to help us understand the changes from an ecological perspective.

   Chapter 3 describes the six dimensions used to analyze and compare the innovations. It also reports on similarities and differences in terms of the extent of change along the different dimensions for the case studies collected. While the innovations can be characterized according to these six dimensions, such an analysis cannot present holistically the roles and activities of the teachers and students within these case studies. Chapter 4 therefore reports on the typologies, constructed through a cluster analysis, of the students' and teachers' roles and activities described in the case studies. These typologies reveal the extent to which these roles and activities differ from the traditional roles and activities played by students and teachers in teaching and learning situations. This analysis thus provides more concrete and holistic descriptions of the qualitatively different activities that students and teachers might engage in if an innovation were rated at a specific level of innovativeness. This approach is analogous to describing the different varieties of a species that evolved during the process of adaptation to environmental changes.

Chapter 5 "zooms out" to provide a characterization of the entire pedagogical practice – a depiction of how teaching and learning is organized in the complex everyday milieu of the school in the different case studies. Characterizing "methods of organizing learning" is helpful for teachers and others interested in introducing transformative classroom applications of ICT because it provides them with typologies of activities and an understanding of how to organize them. A special focus of this chapter is on the knowledge and skills that teachers and students require in order to implement each "method" and on the ICT infrastructure necessary to enable that implementation. This chapter therefore serves to inform initiatives directed at the professional development of teachers as well as the decisions that teachers and school managers make in regard to integrating ICT into the curriculum.

3. *Contextual conditions for innovation at the school level*: Classroom practices are embedded within schools. This third section of the book comprises three chapters that extend the ecological study of ICT-using pedagogical innovations at the classroom level by examining the contextual conditions at the school level. The overarching question in this section is how can pedagogical innovative practices be supported, sustained, and scaled up?

   Chapter 6 begins with a review of literature on innovation implementation and educational change, and it is followed by an examination of contextual conditions of pedagogical innovations in the 82 SITES-M2 cases at the school level. We identified 64 school-level conditions, which we grouped under five themes: school background, school strategies, principal leadership, school ICT infrastructure, and government and community support. We also explored the interactions between the school-level conditions and classroom innovations.

   Pedagogical innovations bring about changes in schools – changes that are viewed as stimuli to learning. In Chap. 7, we attempt to address the question of how schools nurture innovative practices by examining the organizational learning in different innovation schools. Taking innovation schools as learning organizations, we explore variations of organizational learning pertaining to different types of pedagogical practices implemented in schools. We also consider how these forms of organizational learning relate to school conditions. This chapter provides, in order to examine variations of organizational learning among innovation schools, an in-depth analysis of four SITES-M2 cases, representing different types of pedagogical practices and innovations.

   Our examination in the previous two chapters of the ecological features of innovation schools and changes brought about by different types of pedagogical innovative practices in four schools points to the complexity of educational change and the challenge of how to sustain and scale up innovations. In Chap. 8, we argue that much of the effort involved in systemic educational change relates only to systematic changes. Complex systems are characterized by the high degree of interconnectedness among different components. Sustaining and transferring innovations should not be viewed as stages to be considered after establishment of a good innovation prototype: sustainability and transferability can only be achieved if mechanisms for the opportunistic set-up of social infrastructures for innovation-centered networking are built in as an integral part of the innovation, even at the initiation stage. We draw, in Chap. 8, on 83 case studies to support and illustrate this claim.

4. *Nurturing leadership and establishing learning organizations*: The final section of this book contains three chapters. Here, we focus on leadership and change mechanisms beyond the school. We describe initiatives to build networks of learning organizations for multilevel-change leadership, taking the SITES M2 case studies as the stimulus resource to foster leadership development and cross-institutional as well as international collaboration. We include, as an example, the Education Leadership initiative, which focuses on bridging the digital divide among countries in the Asia-Pacific region.

   In Chap. 9, we explore how the SITES-M2 cases can be used to support the professional development of teachers. Our proposal here is to help teachers develop an ecological understanding of change, and an evolutionary model of adoption to suit their unique environments. The model for the use of these studies is thus not one of "farming" innovations, i.e. replicating them in different regions, countries, schools, and classrooms; rather, it is one that allows practitioners to observe, analyze, and, where appropriate, adapt ideas from the case studies. More specifically, the chapter examines the use of SITES-M2 studies to stimulate change in thinking about innovations and the role that technology can play in different contexts. We suggest that such thinking can be initially stimulated and facilitated through workshops for teachers and educational administrators that focus on in-depth exploration of selected case studies.

   We consider, in Chap. 10, ways of scaling up and transferring innovative practices in varied environments. We take the concept of leadership and examine its extension beyond the roles and responsibilities of the principal and the senior management team. This examination involves consideration of distributed and multi-level conceptions of leadership. Drawing on three initiatives, we discuss the networks within these multi-level initiatives and their impact on scaling up innovations and change.

   In Chap. 11, the final chapter, we revisit the two key ideas underpinning the studies reported in this book: the role of technology as disruptive when used in transformative pedagogical practices; and innovation as emergent phenomena in nested and connected educational ecologies. We conclude the chapter with a summary of the findings reported in this book, and how these shed further light on the theoretical framework that we adopted in this book.

Chapter 2
Research Design and Methods

In recent years, various educational researchers and theorists have promoted the study of educational institutions or systems as ecosystems (e.g., Bransford, Slowinski, Vye, & Mosborg, 2008; Davis, 2008; Lemke & Sabelli, 2008). The ecosystem provides a framework for studying educational change because it highlights the hierarchical relationship between components in a nested structure, for example, classrooms are nested in schools, and schools are nested in regional districts and educational systems. All are interdependent and interconnected elements in the educational ecosystem. However, empirical studies in education adopting such a framework are still rare. A notable example is Zhao and Frank's (2003) study of computer use in four school districts in the United States. They explicitly designed their study according to a framework in which computer use is seen as one invasive species in the education ecosystem. Using a survey to collect their data, Zhao and Frank explored the adoption of ICT in the four school districts at classroom, school, and district levels, and found significant relationships between different statistical parameters based on a theoretical model of the interrelationships among various elements in the educational ecosystem.

In the present study, we are not interested in hypothesis testing, but rather in gaining a deeper understanding of the interdependencies between factors and features that are located at different levels of the educational system. In particular, we are interested in studying technology-supported pedagogical innovations (which we refer to as innovations for short) as emerging varieties of the pedagogical practices species in the educational ecosystem. New varieties of a species naturally emerge through the processes of evolution and adaptation or mutation. However, whether specific emerging varieties will prosper and survive in significant numbers depends on the local ecological environment – on whether the environmental conditions match the specific ecological niches[1] of the varieties.

[1]In ecology, niche is a term that describes the relational position of a species or population in its ecosystem. The total resources and physical conditions required by a species are referred to as its ecological niche and determine where it can live and how abundant it can be in a particular location or environment. The notion of ecological niche also involves consideration of how an organism or a population responds to the distribution of resources (e.g., food supply), competitors, and enemies (e.g., predators, parasites, and pathogens) and how it, in turn, alters those same factors.

N. Law et al., *Educational Innovations Beyond Technology: Nurturing Leadership and Establishing Learning Organizations*, DOI 10.1007/978-0-387-71148-5_2,

The sociocultural, economic, and technological changes taking place in our increasingly globalized world suggest potential for new emerging varieties of pedagogical practices to become dominant, replacing varieties that were successful relative to earlier environmental conditions. Our purpose, in our “ecological study,” is to examine the varieties of technology-supported pedagogical practices that have emerged against the changing social and educational contexts at the turn of the twenty-first century, and to identify which features at the individual classroom, school, and system levels may be associated with different varieties of innovations. We are particularly mindful that an ecological perspective does not mean seeing the sustainability or scalability of an innovation as an intrinsic property of the innovation per se; that property depends on the extent to which the match between the contextual conditions and the environmental niches allow the innovation species to prosper.

From the outset, we were aware that our study needed to capture the diversity in characteristics of the innovations at the classroom level. We knew that we also needed to explore possible links between differences in pedagogy and classroom-level characteristics with contextual factors at the school level, such as leadership and school culture, as well as at the system level (e.g., related government policies and strategic initiatives). We considered comparative case study method the most appropriate method for this purpose because it allows the researcher to collect rich contextual information and to uncover the complex relationships among the various contextual factors involved in the situation or phenomena under study.

In this chapter, we describe and explain the methodological design (i.e., comparative case study at classroom and school levels, using the SITES-M2 case reports) we adopted when conducting our ecological study. We begin by briefly describing case study method and explaining why it is appropriate for ecological studies of this kind. We then describe the sampling and data-collection design used in SITES-M2. This is followed by a description of how we selected, for our study, the cases from the collection of SITES-M2 case reports. In the final part of the chapter, we briefly describe the analytical approaches that we adopted to analyze the case study reports, and how the ecological framework revealed new insights into ways of sustaining and transforming innovations.

Case Study Design in SITES-M2

Case studies are intensive descriptions and analysis of bounded systems or units (Smith, 1978). They are conducted in order to provide in-depth understanding of the situation and meaning for those involved in these systems and units. Research interest is generally focused on studying the process rather than the outcome, on describing and analyzing the context rather than specific variables, and on discovery rather than confirmation (Merriam, 1998). Case studies are particularly suited to uncovering the interaction of significant factors characteristic of situations or phenomena where it is impossible to delineate the variables involved from their context (Yin, 1994). They are useful in providing heuristic insight into the problems or situations studied, as the knowledge resulting from them is concrete and contextual, as opposed to the generally abstract and formal knowledge derived from other research designs (Stake, 1981). The SITES-M2 case studies were designed and analyzed using an *instrumental* approach, which means that the analysis focused on generalizing beyond specific case-bound issues, relationships, and causes in order to address targeted research questions (Kozma, 2003).

The key methodological decisions in case study design are the definition of a case (i.e., specifying the case boundary), case selection method, the kinds of data to be collected and how, the nature, structure and content of the case report, quality assurance, and data analysis. All of these decisions have to be made in relation to the central research questions to be addressed.

Having a clearly identifiable boundary for the object of study is arguably the single most definitive characteristic of case study research (Merriam, 1998). Such boundaries often have a commonsense obviousness (Adelman, Jenkins, & Kemmis, 1983). Miles and Huberman (1994) suggest that a case can be represented graphically as a circle with a heart in the center, with the circle defining the edge of the case (i.e., that which will not be studied) and the heart representing the focus of the study.

Case "Boundaries" in SITES-M2

The focus of the SITES-M2 study was *pedagogical practice*, which includes the organized or patterned set of activities or interactions used by teacher(s) and students to support and promote learning. Hence, it was the classroom and its associated context that defined each case. Here, "classroom" was interpreted loosely as a group of students learning together, organized as part of the school curriculum. Class activities may go beyond the physical classroom, for example, to situations involving interactions with individuals and groups outside school.

While the key focus of the SITES-M2 cases was pedagogical practice, a complete case study included studying the contextual factors at the school level. The concept used in the definition of a case was that of "zooming out": in order to really understand the conditions for emergence, sustainability, and transferability for pedagogical practices, one needs to find out about important aspects of the school context – the goals and vision of the school and the ICT implementation history and strategy, including infrastructure, funding, staffing provisions, staff development and other related initiatives in the school.

Case Selection

The researchers involved in SITES-M2 were concerned with studying innovations that represented the aspirations of each participating country and not just what happens in a typical classroom that was using technology. Case selection therefore required identification of the kinds of ICT-enabled practices that each country valued and wanted to showcase nationally and internationally. Because of the number of educational systems (28) participating in the study, the study design had to meet the dual requirements of providing a standardized methodology necessary for an international comparative study and of accommodating national contexts, goals, values, and national policy needs. To achieve this, the designers of SITES-M2 devised a common set of study procedures, instruments, and guidelines, the key elements of which were these:

- Establishment of an expert panel by the national research coordinator (NRC) of each system. The panel's task was to review and select the cases for study according to a set of common international criteria. The panel membership covered a range of backgrounds. It included professors or researchers at universities or research institutes who were experts in the use of educational technology, officials from education ministries with an excellent overview of the current status of and trends in educational provision, and practitioners from schools (principals and other administrators, computer coordinators, and teachers). This diversity ensured that the selected cases represented the aspiration of a wide range of educational stakeholders familiar with innovative pedagogical practices related to ICT.
- Adherence to a common set of international criteria. All selected cases had to demonstrate evidence of (1) technology playing a substantial role, (2) significant changes in the roles of teachers and students, the goals of the curriculum, assessment practices, and/or the educational materials or infrastructure, (3) measurable positive student outcomes, and (4) sustainability and transferability.
- Opportunity for each educational system to determine (define), albeit within a common frame of reference, what constituted an innovative pedagogical practice. One aspect of the common frame of reference was that the practice should prepare students for lifelong learning in the information society. This flexibility for each system to define its own criteria for innovation made it possible to accommodate the circumstances and cultural differences in each country.

In total, 174 cases were selected by the 28 participating systems.

Data Collection

The multiple types of qualitative data collected from multiple respondents on pedagogical practices at the classroom level and on contextual details at the school level allowed triangulation of the features or characteristics identified from the various sources. The following were the main types of data collected for each of the case studies:

- Interviews with administrators, technology coordinators and innovation teachers

- Focus group discussions with students, teachers not directly involved in the innovation, and, where relevant, parents, community members and other people involved with the innovation
- Classroom observations describing teacher and student behaviors, physical and technological settings, resource allocations, and the like
- Documents or archival or historical data, such as school plans, policy documents, curriculum guidelines, project proposals, assessment instruments, lesson plans, curriculum resources/instructional materials, and students' products (e.g., assignments)

Case Report Format

In case study research, much of the analysis takes place during writing of the case report (Miles & Huberman, 1994). In SITES-M2, the case reports formed the sole basis for the international cross-case analyses, as it was not possible, for reasons of language and resources, to refer back to the original data. Each case report was submitted in two formats – narrative and data matrix. The narrative format is the most common in case study research, and usually comprises a combination of description and analyses. In the SITES-M2 design, the main emphasis of the narrative report was on description. The data matrix component of the report involved a "slot-filling" approach, which meant that the report comprised short answers to a series of structured questions organised around the conceptual framework and presenting evidence of classroom practice.

All NRCs received a set of case report guidelines, and the recommendation that the report writing should be a two-step process. The data matrix was to be used during the first step, which involved reducing and organising the various data sources collected. The second step involved converting the matrix to a case narrative. This process necessitated following a standardised, highly structured format, comprising sections on curricular goals, teachers' and students' practices and outcomes, context, sustainability, and transferability (Kozma, 2003). All of the 174 case reports can be found at the SITES-M2 website, http://sitesm2.org/sitesm2_search/.

Selection of Cases for the Ecological Study

The international nature of the SITES-M2 case studies, and the fact that these were selected by national panels comprising individuals of diverse backgrounds rather than according to a particular pedagogical paradigm, gave the cases the diversity and the emergent nature that made them particularly suitable for use in an ecological

Table 2.1 Number of cases from each educational system included in the 83 cases analyzed in this study

Country/region	Abbreviation	Cases analyzed
Australia	AU	4
Canada	CA	1
Chile	CL	5
China Hong Kong	CN	9
Czech Republic	CZ	1
Denmark	DK	3
England	UK	2
Germany	DE	6
Finland	FI	5
France	FR	1
Israel	IL	2
Italy	IT	1
Korea	KR	1
Latvia	LT	2
Netherlands	NL	6
Norway	NO	6
Philippines	PH	5
Portugal	PT	2
Singapore	SG	4
Slovak Republic	SK	3
Spain (Catalonia)	ES	4
Thailand	TH	4
Taiwan	TW	2
USA	US	2
South Africa	SA	2
Total		*83*

study of innovations. However, when we began analyzing the case reports, we found that the level of detail in their description of pedagogical practice differed widely across cases. While all the case reports were sufficiently detailed to meet the analysis requirements of SITES-M2, some did not have the amount of detail in their classroom-level descriptions that would allow us to reliably conduct the coding necessary for our ecological study. In the end, we were able to code only 83 of the cases on all aspects required for our study. These 83 cases came from 25 of the 28 educational systems participating in SITES-M2 (see Table 2.1).

Analysis Design for Revealing Features of Technology-Supported Pedagogical Innovations and Their Relationship with Other Elements in the Classroom Ecology

Because the purpose of our study centered on analyzing and understanding technology-supported innovations from an ecological perspective, we needed to understand the environmental niche associated with the different case studies. In particular, we needed to "test" the assumption that the innovations were emerging in response to the changing needs of society in the twenty-first century. If that was the case, we then needed to understand the environmental niche associated with the innovations because the sustainability of those innovations depended on the "success" of that "habitat" niche in gaining dominance over the niche associated with traditional practices.

We use the term "ecology" as the study of networked relationships among individuals and communities and of the hierarchies, connections, and interrelationships among all components within an environment. Ecology, therefore, is the conceptual framework we use here for understanding and researching human, social, economic, and contextual issues, interactions, and interrelationships. The educational ecology includes all of the above components. These components, in turn, all need to be considered when researching the potential sustainability and transferability of innovative uses of technology in pedagogical practices.

In order to make the different analysis methods more understandable, we will begin with an ecological metaphor. We take the butterfly as an analogy for the species of pedagogical practices. Caterpillars, as the young phase of the butterfly, feed on the leaves of plants. As the caterpillars mature and metamorphose into the fully-grown butterfly, they help plants to propagate by pollinating their flowers. Should climate change bring about changes in temperature and amount of precipitation, these changed conditions might favor some species of plants to prosper more than others, or even the growth of plant varieties not previously seen in the area.

However, other aspects of the local conditions may not be sufficient for the new plant varieties to survive and compete successfully with the existing dominant varieties over the long term. The propagation of the new plant varieties would depend on their flowers being pollinated by the butterfly population living in that ecology. The predominant species of butterflies that have traditionally lived in the local ecology may not be able to pollinate the flowers of this "improved" plant species (improved in the sense of being more suited to the new climatic and environmental conditions) because its flowering season is earlier than the breeding season of the commonly found species of butterflies in the area. There may be some rather rare species of butterflies in that locality that breed earlier, but these will need to find plants that start growing new leaves earlier after the winter in order to provide sufficient food for the caterpillars. In essence, the mutual interdependence between the plants and the butterflies means that both need to co-evolve to ensure the long-term survival of the plant species under the changed environmental conditions. The interdependence includes not only the leaves and flowers but also whether the seeds of the new variety can germinate more easily under the new conditions.

If a form of pedagogical practice is a butterfly variety, then what constitutes the interdependent niches of its corresponding educational/social ecology? We propose that the role of the teacher is similar to the leaves that feed (or support) the pedagogical practice. The students' role is like the flower, which, through engaging in the activities of the pedagogical practice, will be "pollinated" and develop knowledge, skills, and capacities as learning outcomes, just as pollinated flowers will lead to seed-bearing fruits. The learning outcomes (seeds) need to be able to germinate to ensure the continued development of the society (the equivalent of the wellbeing of the plant species). Certain nutrients in the soil may be important for plant growth, just as the availability of certain technology infrastructure may be important for the development of particular skills.

Another important ecological concept we draw on in our study is that of "carrying capacity." Predation[2] or feeding is a key ecological dependence. While the number of plants and animals that can be found in any given habitat may fluctuate, there is a limit on the average number of species that can be supported because the amount of food produced is bounded by the photosynthesis process (the process that converts carbon-dioxide and water into glucose and oxygen). The mean number of a species that can be supported by a given habitat is referred to as its carrying capacity for that species; capacity is limited by factors such as food availability, weather, space, competition, predation, diseases, and accumulation of toxic wastes.

While the carrying capacity is always a positive number, the actual number of species "carried" varies due to random fluctuations. When the magnitude of the random fluctuation is larger or comparable to the carrying capacity for a species, the species becomes "endangered," as there is a possibility that the species will become extinct during the random fluctuation process. Urbanization is often a cause of extinction for some species because it breaks up a habitat into a number of small, isolated habitats. The carrying capacity of each isolated habitat may become lower than the magnitude of natural fluctuations. Hence, one conservation strategy is to build "ecological corridors" that allow animal species to move between habitats, effectively increasing the carrying capacity through reconnection of the isolated ecologies.

In our study of pedagogical innovations, one dimension we examine is the "connectedness" of the case study classroom – the extent to which the teachers and students in the case study interact with peers, experts, and/or community members during the teaching and learning process. In an earlier analysis of the SITES-M2 case studies, Law, Kankaanranta, and Chow (2005) found that the case studies from Finland had much higher levels of sustainability and transferability than did the case studies collected in Hong Kong. The reason was that all of the former case studies had, from the initiation stage, built-in connectedness, such that all of the case studies involved the collaboration of many partners and multiple classrooms.

What all of this meant with respect to our ecological study of pedagogical innovations was that we needed to study the interdependent environmental niches associated with the newly emerging practices, which is why we devote Chaps. 3–5 to analyses of the innovations at the classroom level (i.e., as classroom ecologies). We begin Chap. 3 by comparing the types and degree of innovativeness evident across the case studies. This comparison required us to determine how different the niches of these innovations were from those associated with traditional pedagogical practices. We identified six dimensions for comparison: the role of the teacher, the

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[2]Predation is a term used in ecology to describe "a biological interaction where a *predator* (an organism that is hunting) feeds on its *prey* (the organism that is attacked)." The act of predation is always not to the benefit of the prey (*Wikipedia*).

role of the student, the kinds of learning outcome observed, the curriculum goals, the ICT used, and the connectedness of the classrooms with the outside world. While habitats can differ from one another on any of the ecological dimensions[3] involved at any given point in time, we can categorize them into a number of typical profiles, such as equatorial rainforest, marshland, temperate savannah, and so on. Each habitat thus has its own profile of plants and butterflies, "acting" in combination with the other ecological dimensions of these habitats. In the second part of Chap. 3, we also describe a few typical classroom ecologies as frequently found profiles of the innovation dimensions in the case studies analyzed.

In Chap. 4, we examine two key interdependent species associated with pedagogical practices – teachers' roles and students' roles. While we analyze, in Chap. 3, the extent to which the characteristics of these two sets of roles align with or differ from the characteristics associated with traditional pedagogical practices, we take, in Chap. 4, a more holistic approach. Again using the butterfly ecology as an analogy, we endeavor in this chapter to describe the major observable forms of leaves and flowers in the newly emerging varieties of plants, and to examine the co-occurrence of these varieties in the case studies. The analytical method that we used at this point was an application of *K*-means cluster analysis (Milligan, 1980, 1981; Morey, Blashfield, & Skinner, 1983) on the coding of role-related teacher behavior and role-related student behavior we did on the case reports. From there, we were able to identify the major patterns of role-related teacher activity and role-related student activity reported in the case studies.

The focus in Chap. 5 is on holistic descriptions of the innovations as they would appear to someone observing them as classroom interactions and activities. Using the butterfly analogy, we describe what these varieties of butterfly look like – the wing patterns and color, size, shape, and so on. These descriptions are very helpful because they allow us to recognize the emergence of new varieties of butterfly. Moving the analogy over to the classroom, we identify, in this chapter, patterns of observed classroom activities, which we refer to as types of pedagogical practice. Teacher education programs tend to refer to types of pedagogical practice as "teaching methods." One example of a pedagogical practice gaining popularity in many parts of the world is project work. The kinds of pedagogical practice found within the 83 case studies analyzed inform much of the fifth chapter.

Analysis Design for Revealing the Interactions Between Features of School Ecologies and the Classroom Ecologies that Foster the Different Varieties of Pedagogical Innovations

Classrooms are embedded inside schools. We thus extend the ecological study of innovations to examine the contextual conditions at the school level. Chapters 6–8 report our analyses of the innovations at a higher level of ecological scale – the

[3] Environmental conditions constituting the ecological niches of the species.

school (i.e., school ecologies). A school is an institution designed for students to learn under the guidance of teachers. To extend the metaphor of classroom ecologies, we take the garden as an analogy for a school. A garden is a piece of land with different kinds of plants under the care of a gardener. But a garden is more than a collection of plants; we also find, for example, butterflies, earthworms, and the like. The presence of some of these may have been planned or accounted for; the presence of others may not have been considered.

What can be grown also depends on the natural conditions, such as the specific location, the local climate, and soil conditions, although, with appropriate gardening practice, these conditions can be changed to various extents over time. There are different kinds of gardens. Some are like parks, with different trees, flowers, grass, and ponds that people can visit and walk around. Some produce fruits and vegetables. Others are just for ornamental purposes. Gardening is the activity of managing and maintaining a garden, and can be done by an amateur or a professional gardener. Gardens located close to one another share similar climatic and other environmental characteristics, although there can still be large local variations. Gardeners may work in isolation, but also share experience or even collaborate with others to achieve their gardening goals.

Many established gardens adopt an eco-friendly approach to gardening, which takes account of the interactions among various environmental conditions in order to bring the garden to a state where it remains sustainable with the minimal amount of intervention in the longer term. Soil and water are among the most important conditions in gardening. Fertilizers, either organic or inorganic, added to the soil provide additional nutrients to support plant growth. Water is also necessary for plants to stay alive and to grow. However, the quantity and type of fertilizer matters for viability, and many gardening problems arise from incorrect watering.

Other conditions, such as wind, temperature, sun and shade, can also be manipulated to create a microclimate suitable for certain kinds of plants in specific parts of the garden. For example, pruning can be used to improve light levels around the bases of the plant; greenhouses are useful in cool climates because they allow sunlight to enter and prevent heat from escaping; leafy ground cover under certain plants, such as clematis, keeps roots cool and moist; and wind-breaks from hedges or other infrastructure can be created or modified to provide shelter from strong winds.

Different plants attract different species of bees and butterflies. Some plants may attract birds and other creatures to prey on pests and are thus beneficial. Birds can, in turn, be encouraged to visit if there are plants offering perches, shelter, and food (fruits and berries). Most gardeners know that it is important to plan and choose plants that have additional properties and functions beyond simply being ornamental or a food supply. Strategic use of different plants in combination with one another in order to repel harmful insects, attract birds and other creatures, and support desired insect populations such as bees and butterflies is the major role of a gardener, in addition to giving each plant the right type of soil, fertilizer, shelter, aspect, and treatment.

If a garden is a school, then what constitutes the interdependent factors of the corresponding school ecology? Gardens are situated in different geography and soil conditions, making them more suitable for certain plants than others. Likewise, schools have different histories, demographic backgrounds, and culture. We take school background as the soil, which cannot achieve high productivity without cultivation. School infrastructure, such as digital-resources and ICT infrastructure, are like fertilizers, hedges, and greenhouses, which can be applied to modify the local microclimate. Government and community support is like the irrigation system that supplies water so that plants grow and thrive. Some plants may need more of certain fertilizers, or more water, or less sun. Gardeners (and their teams) must plan and provide water, needed nutrients, and other environmental conditions to make the plants and animals in the garden flourish as a holistic whole. Thus, we take the school principal and his or her leadership team as the gardener who cultivates, manages, and looks after the wellbeing and development of the garden. In Chaps. 6–8, we use the lens of gardens and gardening to "view" (report on) studies of school-level factors associated with the technology-supported pedagogical innovations.

We begin Chap. 6 with a review of literature on innovation implementation and educational change. Drawing on this review, we propose five themes to frame analysis of school contextual conditions, namely, school background, school strategies, principal leadership, school ICT infrastructure, and government and community support. These themes represent the types of environmental conditions in schools that are contextually related and which strongly influence the pedagogical practices present in the school.

The 83 case reports that we analyze in Chaps. 3–5 came from 82 different schools. In these chapters, we analyze the sections on school conditions in order to understand the features of innovation schools. In Chap. 6, we report on the thematic coding and grounded approach (Miles & Huberman, 1994) that we used to analyze the 82 schools described in the case reports. This analysis led to the generation of 64 contextual categories characterizing the innovation schools. We also used one-way ANOVA (analysis of variance) to explore the interactions between school-level factors and classroom practices. The descriptions of various school-level categories arising out of these analyses provide us not only with an understanding of the contextual conditions but also with a possible conceptualization that allows us to unpack the ecological features of innovation schools as well as the complexity of school ecologies and their connections to the innovations in the classroom ecologies.

Chapter 7 examines the opportunities for organizational learning provided by different types of innovations. The innovations collected in the SITES-M2 study, although differing in their levels of innovativeness, are emerging practices that reflect the changing ecological conditions in their local education contexts. These innovations were, by virtue of their being identified as such, rare practices within their own educational systems, and often uncommon even within the schools in which they took place. While these innovations are in the minority, they do influence the education ecology within their schools and beyond through the many interactions between the classroom ecologies associated with these innovations and the broader ecological environment.

The schools hosting these innovations did not have the option of standing still: they either had to move "forward" by developing environmental conditions more suited to the innovations, or they had to go "backwards" by restricting or preventing environmental changes, such that the innovations became non-sustainable. Bringing about change in school ecological conditions, such as assessment methods, teacher appraisal, and curriculum goals, requires changing the beliefs and practices of the people involved, which can only be effectively achieved through organizational learning of the schools concerned. How was organizational learning taking place in the innovation schools? Were the differences in the organizational learning taking place in the innovation schools associated with different innovation profiles? We attempt, in Chap. 7, to provide answers to these questions. We provide, through our in-depth study of four SITES-M2 case studies, portraits of the four school ecologies associated with the four profiles of teacher-role and student-role combinations. We also explore the contextual differences associated with those innovations relating to aspects of organizational learning.

It is generally recognized that scaling up innovations is even more difficult than developing the first working prototype. It was evident from the SITES-M2 cases that many promising reform prototypes failed during efforts to transfer or to maintain these prototypes over extended periods of time in a manner that continued to create productive changes while retaining the initial values of the reform. A major challenge in education is thus how to sustain and scale up innovations. In Chap. 8, we consider the process of emergence and development of the SITES-M2 innovations collected in Hong Kong and Finland, which differed greatly in terms of their reported sustainability and scalability. We examine and compare these two sets of innovations in an effort to identify crucial factors that may account for such difference.

Given that the education sector worldwide is facing major challenges and rising expectations for schools and schooling in an environment characterized by rapid and constant change, we explore, in the final section of this book, holistic ways of using the SITES-M2 case studies to nurture and scale up change in the educational ecology. In Chaps. 9 and 10, we consider how the case studies can be used to help education gardeners develop their understandings of complex systems and the interrelationships of various parts within the changing environment. Our particular aim is to stimulate thought among these gardeners on what could thrive in their own gardens. We adopt Yin's (2009) emphasis on the value of comparing rich datasets from multiple case studies organized in similar ways. The SITES M-2 database of cases[4] hosted by the Centre for Information Technology in Education of the University of Hong Kong (CITE) contains case summaries and coding information for each of the cases listed. This material is designed to facilitate exchange of ideas and exploration of possible pathways for sustaining and scaling up ongoing change among education gardeners.

Our focus in Chap. 9 is on how the case studies can act as a catalyst to advance and change educational practices. The methodology of using the case studies is not one of "farming" or trying to replicate innovations, but one of observation,

[4]The URL for this database is http://sitesdatabase.cite.hku.hk/online/index.asp.

interpretation, and analysis. It is furthermore, where appropriate, one of adapting (through an evolving, developmental process) the ideas taken from the case studies so that they suit varied environments. In Chap. 10, leaders as head gardeners are recognized as key players in effecting change in the educational environment, at classroom, school, system, and cross-system levels. In addition, multilevel perspectives on leadership are viewed as an essential component of successful innovation adoption that is both scalable and transferable (Spillane, 2006; Yuen, Fox, & Law, 2004). Leadership is also seen as the key role in establishing networks among practitioners (Hargreaves, 2003). This chapter also outlines examples of trial networks within and across schools and systems to sustain the agenda of ongoing transformation.

To summarize, we use, in this book, a range of quantitative and qualitative methods to systematically study and compare the SITES-M2 case studies at classroom, school, and system levels. Our aim, in this regard, is to identify the characteristics of the emergent varieties of innovative pedagogical practices and how these relate to the vision for education to equip students with twenty-first century skills. We also consider how these practices intersect with the roles of teachers and students and what conditions are needed for their emergence, sustainability, and scalability. We pilot a multilevel network model, constructed on the basis of our findings from the SITES-M2 case studies and designed to foster, sustain, and scale ICT-supported pedagogical innovations.

Chapter 3
Examining Innovativeness at the Classroom Level

This is the first of three chapters that analyze and describe, from an ecological perspective, ICT-using pedagogical innovations at the classroom level. Using the metaphorical analogy for pedagogical practice as a species, we position pedagogical innovations as new varieties of species that have emerged through a process of "mutation." The extent of innovativeness of a pedagogical practice can be compared to the extent to which a mutated species is different from the prevalent, established species. There are different ways of comparing different varieties of the same species. The comparison can be made on the basis of observable, physical characteristics or on the basis of the ecological niches that different species occupy. For example, to return to our butterfly example from Chap. 2, we can recognize different varieties of butterfly by their physical appearance, such as size, wing patterns, and color. We can also differentiate them according to their genetic composition. From an ecological perspective, the most important differences are those denoted by the *niche* the variety occupies within the wider environment.

In ecology, niche describes the key environmental dependencies of a species – how it relates to other elements in its ecosystem, and specifically what the organisms of the species feed on and their foraging methods. Different niches hence represent different interactions of a species with other elements in its ecological environment. If the ecological niche of a new variety was very different from the niches of the existing species, the survival of the new variety would be challenged and it could face possible extinction. In short, mutated varieties often do not survive. However, if changes in the environmental conditions take place and become favorable to the niches of the new species, the new species would thrive, and the survival of the pre-existing species might be threatened. Hence, ecological niches important for the survival of the new species are those dependencies that differ between the new species and the pre-existing ones.

Most of the published research on pedagogical innovations focuses on descriptions of the innovations. Comparisons of pedagogy are rare, as these demand "kinds and levels of expertise over and above knowledge of the countries compared, their cultures, systems and policies" (Alexander, 2000, p. 510). The dimensions and methods used in comparing pedagogy depend on the purpose of

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the comparison. In his “five cultures” study, Alexander compared pedagogical practices in terms of the following:

- Lesson structure and form.
- Classroom organisation, tasks, and activities.
- Differentiation and assessment of students.
- Routines, rules, and rituals.
- The organisation of interactions, including whole class, group or individual, interaction mode, and direct instruction, discussion, and monitoring.
- Timing and pacing.
- The learning discourse, which reveals how learning is scaffolded as well as the nature of power and control in the classroom.

Alexander did this in order to reveal the pedagogical diversity and commonality across different country contexts – history, policy, legislation, governance, control, curriculum, assessment, and inspection. As a comparison to Alexander’s work, the Third International Mathematics and Science Study (TIMSS) video study of mathematics teaching (Hiebert et al., 2003; Stigler & Hiebert, 1999; Stigler, Gonzales, Kawanaka, Knoll, & Serrano, 1999) used, in order to arrive at normative descriptions of pedagogical practice at a national level, a “survey” model of collecting and analyzing classroom interactions. This yielded a very fine-grained analysis of the content and organization of the lessons and instructional practices

Methodologies that aim to provide descriptive comparisons, whether they use case studies or survey methods such as the two examples described above, aim to capture the characteristic features of the predominant – and hence relatively stable – characteristics of the pedagogical approaches adopted by teachers in each of the countries studied. The aim of the present study, however, is to capture the salient, emerging characteristics of pedagogical practices that are most likely to foster learners’ development of twenty-first-century skills. While pedagogical implementations can be described and compared in terms of lesson structure and form, classroom organization, tasks, and activities, and the kinds of learning discourse taking place, these tend to focus on the surface features of pedagogical activities and do not capture the essence of the changes or emergence in the context of the educational changes desired.

Our aim here is to examine, from the ecological niches perspective, how the SITES-M2 innovations differ from prevalent pedagogical practices. Hence we are interested in the characteristics of the innovations that represent key dependencies within the classroom-level learning context and that differ from the characteristics of traditional practices. We label these key ecological niche characteristics as dimensions of innovation, because these are the key changes that matter for the sustainability (survival) of these innovations. And because the pedagogical change we wish to capture is one that connects with and reflects curriculum innovation directed at preparing learners for the twenty first century, we find the curriculum framework generally adopted in IEA studies (e.g., Robitaille & Garden, 1996) to be an appropriate basis for identifying the dimensions for comparing pedagogical innovations.

This curriculum framework contains three key concepts: the *intended*, the *implemented*, and the *achieved* curriculum. The intended curriculum is the learning goals or objectives to be achieved. The implemented curriculum refers to the educational processes happening at the school and classroom levels. These processes include student practices, teacher practices, and the ways different types of ICT tools are used in the learning and teaching process. The achieved curriculum is what students actually learn. Using the IEA curriculum framework as our reference, we identified six dimensions for comparing the extent of pedagogical innovativeness—dimensions that align with the ecological framework we have adopted. We describe these dimensions in the following sections, and illustrate these with SITES-M2 case examples. We end the chapter with a description of the key ecological niche profiles of the analyzed innovations, each of which demonstrates the key typologies of the classroom contextual settings from which the analyzed innovations emerged.

Dimensions of Pedagogical Innovation

As we pointed out in Chap. 2, each case study in SITES-M2 is centered at the classroom level around a pedagogical unit. The unit is the totality of all organized learning and teaching activities established to address a specific set of content and/or other learning goals, and it cannot be further reduced into smaller units during the planning process. A pedagogical unit is not defined according to the length of instructional (or organized learning) time. It can be just one lesson designed to address a specific topic in the curriculum, or it may take place over a period of months in the context of an inquiry project requiring students to move from exploring and defining their inquiry problem to data collection, data analysis, and reporting.

Of the six dimensions that we identified for comparing pedagogical innovations, the first concerns the specific intended learning objectives of the pedagogical unit. The particular consideration here is the extent to which the specific curriculum goals align with the traditional content and skills focus or with the twenty-first-century skills focus described in Chap. 1. The next four dimensions (Dimensions 2 to 5) relate to the teaching and learning process. The two most important of these (Dimensions 2 and 3) are the respective roles that teachers and learners play in relation to decisions on what to learn and how to achieve the learning goals. The characteristics of these roles are identified in the literature (e.g., Voogt & Odenthal, 1998) as the crucial features differentiating emerging pedagogy from traditional pedagogy. Dimension 4 relates to the level of sophistication of the technology used. This dimension is included because ICT has an important role in the learning and/or teaching process of the selected cases.

Classroom connectedness (Dimension 5) refers to the extent to which outsiders, such as students and teachers from other schools, or people from the community (experts, parents, alumni), are involved in the teaching and learning process. The sixth dimension of comparison is the multiplicity (or otherwise) of learning outcomes revealed through the learning process. This last dimension is not about the level of achievement gained by the students. In fact, the SITES-M2 study did not collect systematic data on students' learning outcomes. The point of interest is the extent to which different kinds of learning outcomes (or inadequacies), such as communication skills, collaboration skills, information literacy, and the like, can be revealed through observing the students' learning process.

Innovations that bring change to these six dimensions (change in the sense of a move away from traditional practice) create tension within classrooms and schools. These tensions arise out of the differences in organizational routines, values, established social relationships, and other aspects of the educational ecology.

Developing a Scale of Innovativeness

In their consideration of future teaching and learning practices, Plomp, ten Brummelhuis, and Rapmund (1996) discuss the concept of emergent pedagogical practices arising out of the implementation of ICT in classroom programs. They also consider issues related to the management of change associated with integrating ICT into teaching and learning. During their discussion of these matters, the authors introduce two important concepts, which they term "care for the old" and "courage for the new." Their basic idea is that those who implement ICT in educational settings must be fully aware that the process is not just about the adoption of new technologies. The process also produces new learning outcomes and new modes of learning. We kept the notions of care for the old and courage for the new in mind when developing a scale of innovativeness to reflect the magnitude of change along each of the six dimensions of innovation identified above.

Plomp et al. (1996) also suggest that schools and schooling cannot be changed overnight; the process of innovation has to be a gradual one. Thus, people involved in the early stages of the implementation process anticipated that ICT would most likely be used to deliver traditional classroom practices directed at achievement of long-extant goals. The authors argue that this kind of implementation should be supported so that the stakeholders involved can ease into the change, and this is where they bring in their notion of care for the old. However, those practices designed to bring about new learning goals and new modes of learning are the practices likely to exhibit innovative features and lead to new learning outcomes. Educational institutions wanting to implement new practices such as these need to have courage and determination to persevere, as these practices are the ones that will define and shape the future of schooling. They need courage for the new.

Table 3.1 presents features for each of the six dimensions along a continuum of innovativeness, from the most "traditional" through "emergent" to "most innovative." In defining the levels, we took the *traditional* classroom to be one where the pedagogical practice is traditional across all six dimensions. This classroom typically focuses on pre-defined activities and learning outcomes. It is teacher-centered – students follow instructions and learn from the teacher. It does not use ICT, it is

Table 3.1 Levels of innovativeness for the six dimensions of innovation

Innovation dimension	Level: Traditional	Some new elements	Emergent	Innovative	Most innovative
Learning objectives	Conceptual learning Solving well-defined problems Motivate learning	Information skills ICT-based productivity skills Self-accessed learning	Critical thinking Catering for individual differences	Inquiry skills Communication skills	Collaborative and organizational skills Provide authentic learning contexts
Teacher's role(s)	Present and explain Set instructional tasks Monitor and assess	Provide feedback Develop teaching materials Design curriculum and learning activities	Select ICT tools Co-teaching	Support/model inquiry process Liaise with parties outside school	Support team building and collaborative process Mediate communications between students and experts
Students' role(s)	Listen and follow instructions	Data-gathering and data-processing Search for information	Presentation of own learning Analyzing and drawing conclusions from data	Collaborate with local/remote peer learners Engage in inquiry Provide technical support to teachers/others	Peer tutoring Engage in peer evaluation Provide (computer-related) instructions to adults (incl. teachers) Determine own learning goals and strategies Reflect on own learning
ICT used	No ICT used	ICT in course administration Tutorials/drill and practice applications Web browser and search engines	Email Asynchronous and synchronous communication tools Web/multimedia production tools ICT as productivity tool (Word, PowerPoint, webpage/media production etc.)	Asynchronous and synchronous tools for collaboration Data-analysis software Network and computer-mediated collaborative tools	Simulation/modeling software Data-logging tools Purpose-designed software as mindtools for specific purposes

(continued)

Table 3.1 (continued)

Innovation dimension	Level: Traditional	Some new elements	Emergent	Innovative	Most innovative
Connectedness	*Parties involved*				
	Isolated classroom	Teacher collaborating with teachers in the same school Students collaborating with students from different classes of the same grade in the same school	Teacher collaborating locally/nationally Collaboration of multi-grade students from the same school	Involvement of various communities groups (parents, alumni, community groups, private sector, etc.) in the curriculum process	Collaborate with teachers and/or students in other countries
	Roles of parties involved				
	As observers	Support course administration Provide technical support	Assess students Provide feedback to students Provide additional information to teachers/students	Develop teaching materials/curriculum Source of authentic learning tasks	As classroom instructor/teacher Monitor students' task progression
Multiplicity of learning outcomes exhibited	Written test/exam Close-ended written tasks	Individual open-ended written/presentation tasks	Group products: presentation/discussion log, etc. Creative learning product involving variety of media	Inquiry plan/method/instrument for problem solving in authentic contexts Portfolio/learning log	Evaluation of peers Inquiry report Authentic products for learning context

isolated from the outside world, and assessment focuses entirely on cognitive learning outcomes.

The classroom that we consider *most innovative* across all six dimensions is one with the following attributes:

- Targets the development of collaborative inquiry abilities through the provision of authentic learning contexts.
- Has self-directed students, who take responsibility for defining their own learning goals and pathways in collaborative inquiry, while the teacher guides the exploratory process.
- Facilitates team building and reflection.
- Mediates communication between and among students and various outside parties, such as experts and co-learners.
- Allows both teacher and students to use appropriate technology to support their teaching and learning activities as well as their communications with the outside world.
- Bases assessment primarily on authentic evidence generated during the learning process, such that the assessment reflects not only the cognitive outcomes but also the targeted process outcomes.

Emergent classrooms are those with practices mid-way between the most traditional and the most innovative. The characteristics of emergent classrooms, such as targeting deep understanding and catering for individual differences, are features considered good educational practice long before the advent of the contemporary focus on preparing students for the knowledge society.

In the remainder of this chapter, we provide case examples to illustrate pedagogical practices associated with the different levels of innovativeness on the six innovation dimensions.

Dimension 1: Learning Objectives

This dimension is concerned with the learning goals or objectives that a specific pedagogical practice targets. The full spectrum of innovativeness on this dimension evident in the SITES-M2 case reports ranged from well-defined knowledge acquisition goals to the development of twenty-first-century skills, such as inquiry, collaboration, and communication. Table 3.1 (above) provides descriptions of learning objectives that demonstrate the five levels of innovativeness, namely "traditional," "some new elements," "emergent," "innovative," and "most innovative."

Some cases had goals that were entirely *traditional*. Their underlying aims were to help students learn specified concepts, solve well-defined problems, and develop stronger motivation to learn. One example of this is the case PH011,[1] involving a Secondary 1 (first year of secondary school) science and technology class. The key learning goal was to master targeted science concepts in the curriculum.

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[1]This example and the others given in relation to Dimension 1 are described in more detail in Fig. 3.1.

Traditional	Some new elements	Emergent	Innovative	Most innovative
PH011: Net Learning in Science and Technology Computer-assisted instruction (CAI) was integrated in the teaching and learning of science and technology. The class of students was divided into three groups to work on a given set of questions in the computer room, learning resource center, and library. The teacher designed the learning tasks, prepared the information resources, and monitored the groups in the three learning stations. The groups prepared and presented their reports to the whole class, and the teacher clarified some concepts when necessary.	**TW003: Integrating ICT into Teaching through Teacher-Created Software** The focus of this innovation was to develop students' understanding of science concepts via a computer-based simulation software developed by the teacher. The teacher used his own notebook and two TVs in order to demonstrate and explain the scientific phenomena in the classroom. Students then worked with the simulation software in groups in the lab to complete the activity sheet. All related materials were prepared and stored in a server. ICT was also used for storing and grading the students' learning products.	**DK004: Differentiated Learning Incorporating ICT** This was an intensive reading course for third grade students in which an educational computer program, Work with Danish, developed by two teachers working in the remedial centre of the school, played a central role. Sometimes the class was divided into two groups, working alternatively in the computer room under the supervision of the ICT-supervisor, reading in the classroom, and sometimes working on collaborative activities. Students could choose and work with the assignments at their own pace and level.	**ZA001: The HIV/AIDS and Population Project** Four teachers designed a seven-week-long curriculum in which students engaged in research on HIV/AIDS issues, with the aim of developing students' computer literacy, problem-solving, collaborative, and presentation skills. Students worked in small groups, each on one sub-topic they had identified earlier as a class. They gathered information from a variety of electronic and other sources, including email and live interaction with experts. Various software applications were used as tools to organize findings and to make presentations.	**CN008: Computer-Assisted Scientific Investigations** This innovation took place as a joint collaborative innovation effort among teachers of biology, chemistry and physics at senior secondary level (grades 10 to 12). Instead of carrying out normal laboratory experiments listed in the textbook, students were given the opportunity to identify their own inquiry problems and to design and carry out the investigations using computer-based data-logging systems and graphing and statistical tools. The goal was to develop students' investigative skills and scientific thinking as well as their use of ICT for conducting scientific experiments.

Fig. 3.1 Brief summaries of case-study examples of different levels of innovativeness in learning objectives

Cases at the next level of innovativeness – those *with some new elements* – include new learning objectives, such as information skills, empowering student learning with ICT skills, and self-accessed learning. An example of this is the case TW003. Here, a science class at the lower secondary level used simulation tools to visualize biological concepts and developed the ICT-related skills needed to access, retrieve, and present information.

Cases with *emergent* learning objectives go beyond the learning of specific knowledge and skills to include goals such as developing critical thinking and catering for individual differences. For example, in case DK004, pupils from a primary school class were given the opportunity to work on different tasks in an intensive reading program according to their individual needs and pace.

Cases with *innovative* learning objectives address twenty-first-century learning goals, such as inquiry and communication skills. ZA001 is an example of such a case. In this example, a class of Grade 7 students worked on an open-ended school-based project titled "The Imminent Over-Population of the World and the Influence of HIV/AIDs on the Human Race." In addition to information search and retrieval skills, students developed problem-solving and inquiry skills as well as the ability to communicate and learn from experts outside of the school.

At the *most innovative* end of the spectrum are practices such as described in case CN008, in which students, provided with authentic learning contexts, had to develop collaborative and organizational skills in order to accomplish complex problem-solving tasks. Students had to consider authentic problem situations from everyday life. One such problem required the students to answer this question: "Why does pineapple juice soften beef?" The students also had to formulate hypotheses based on their reading of related scientific principles. They then had to design and carry out specific investigations directed at addressing the problem.

Dimension 2: Teachers' Roles

The roles of the teacher are arguably the most important of the six classroom dimensions, as it is the teacher who orchestrates the activities and interactions within a classroom (Law, Yuen, & Chow, 2003). Teachers play multiple roles to support student learning before, during, and after the designed learning activities. These roles typically include instructional, facilitative, pastoral, administrative, and liaison roles. The SITES-M2 case reports revealed a wide variety of teacher roles, ranging from the traditional instructor to the most innovative. Highly innovative teachers act as coaches and co-learners in situations where students work as members of a learning community. Table 3.1 (above) provides descriptions of teacher roles across the five levels of innovativeness.

At the *traditional* end, teachers play the roles of presenting and explaining information, setting instructional tasks, and monitoring and assessing student learning. All of these roles can be enhanced through the use of the computer, as in case TW006 (see Fig. 3.2, which provides brief case summaries of the illustrative

TW006: ICT-based Geography Lab In this lower secondary geography class, all teaching and learning activities took place in an Internet-connected and multimedia-enriched geography teaching lab.The teacher collected related teaching materials from the Internet, and posted them onto her own website. During the lesson, she presented the teaching materials with a LCD projector, and controlled the students' display monitors through a broadcasting system. Students were asked to finish their group or individual activity sheets during class-time by searching for online information.	**US020: Online High School Classrooms without Walls** The Online High School is a consortium of high schools located in different states in the United States. At the time of the case study, network-based courses were being taught by consortium teachers for students within the consortium schools. Course materials were developed by teachers with assistance from experts, and were posted on an Internet server for students to access at any time. Teachers interacted with their students, and students interacted, via a proprietary course platform, with one another asynchronously to collaborateon projects, discuss topics, and debate issues.	**SG003: An IT-Enabled Standards-Based Approach to Project Work** Teacher collaboration for interdisciplinary project work using a suite of web-based tools is a special feature of this innovation involving six Grade 8 classes. Project expectations are communicated to the students through the Instructional Planner. Teachers and students used a collaborative module for threaded discussions and project management. Teachers used the Authentic Assessment Tool module to check and calibrate, via established rubrics and benchmarks, their assessment of students' project work.	**UK005. Writing for a Real Purpose** This was an E-pals project in which 10-year-olds and employees at a mobile phone factory communicated by email. Students were allocated time, about twice a week during the school day, to write and send emails to their mentors in the business sector. Teachers were responsible for liaising with the coordinators in the business sector and coordinating the students' activities for the project.They also screened all the incoming emails before passing them on to the children.	**DE014. Developing Team Potential and Acquiring Job-related Qualifications** "The Economy and Schools" was the name of a project in which teams of students analyzed a large-scale enterprise, examined a smaller company, and finally developed their own business ideas. A business consultancy supported the teachers with information, attended the student presentations, and provided feedback. In addition to liaising with the business sector, coordinating activities, and observing project progress, teachers assumed the role of co-learners, as the subject matter was relatively new to them. ICT was used to support information search and presentations.
Traditional	**Some new elements**	**Emergent**	**Innovative**	**Most innovative**

Fig. 3.2 Brief summaries of case-study examples of different levels of innovativeness in teachers' roles

examples on different levels of innovativeness in teacher's roles given in this section). The teacher's role can also take on *some new elements*, as in case US020, in which teachers design online course materials, make presentations, and assign individual tasks to students through an asynchronous online platform within the context of a consortium of high schools from different states in the United States.

At the *emergent* level, teachers engage in more complex collaborations in pedagogical experimentation. An example is case SG003, which was an inter-disciplinary project in mathematics, science, and English, involving six Grade 8 classes in a neighborhood school that used a suite of web-based communication tools to facilitate the planning and conduct of learning activities. The teachers at this school engaged in many instances of co-teaching, presenting information, and monitoring task progression.

More *innovative* teacher roles include supporting and modeling the inquiry process and liaising with parties outside school, as in case UK005. In this example, the teachers liaised with identified volunteers from Business in the Community (BITC), a national organization that encourages businesses to become involved in the activities of the local community. The volunteers acted, via email, as mentors for 25 Grade 5 students in a small industrial town. The aim of this innovation was to boost the students' social skills, self-esteem, motivation, and attainment levels, and to improve their ICT and writing skills.

The *most innovative* teacher roles evident among all the case studies collected included those focused on providing support for team building and the collaborative process and on mediating communications between students and experts. An example is case DE014, in which six teachers from the same school collaborated to support a class of Grade 12 students in a 10-month project that required the students to analyze one big enterprise and a smaller local company, and to develop their own business proposal. The teachers not only were facilitators of the learning process but also co-learners with their students, as the subject matter involved was also new to them.

Dimension 3: Students' Roles

This dimension encapsulates the roles played by students in various learning activities as well as in interactions with one another and with other people outside of the school involved in some way in the learning process. The students' roles differed widely across the SITES-M2 case studies. The roles ranged from students simply following instructions to taking on different levels of responsibility towards their own learning goals and strategies. Table 3.1 (above) provides descriptions of students' roles across the five levels of innovativeness.

At the *traditional* end of the spectrum, students learn by listening and following instructions, such as in the case of ES006 (Fig. 3.3), in which a class of physics students at the upper secondary level learned by listening to teachers' presentations and working on drill and practice exercises in the technology lab. *Some new*

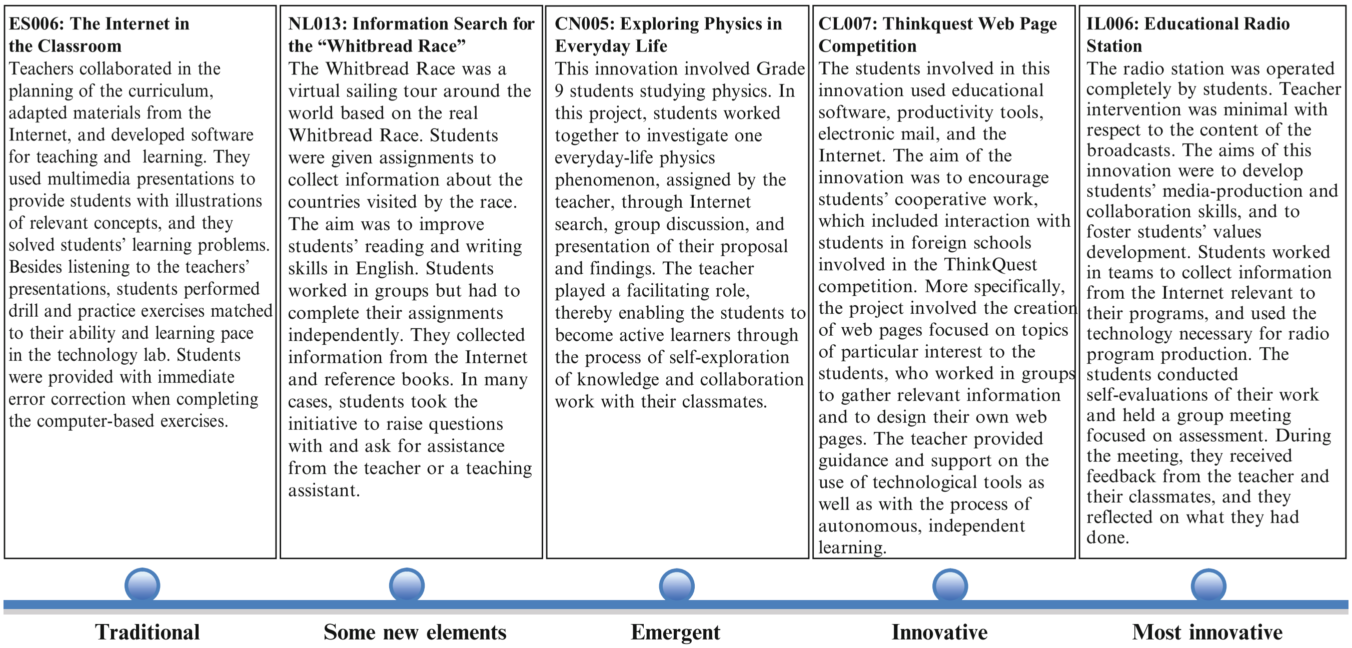


Fig. 3.3 Brief summaries of case-study examples of different levels of innovativeness in students' roles

elements were evident in students' roles in case studies where students participated actively in data-gathering, data-processing, and/or information searching. For example, the key roles of the Grade 8 students in NL013 involved searching for information on Internet in order to answer questions and completing tasks related to a virtual sailing race around the world, which was designed to improve students' English proficiency.

At the *emergent* level, students play a more active role in the learning process. They analyze information, draw conclusions, and present their own learning to peers. An example is CN005, in which two classes of Grade 9 students worked in groups for 4 months on physics topics related to everyday life. During this time, the students looked up information on an assigned topic from the Internet and other sources, analyzed the collected materials, drew conclusions, and finally presented their findings.

Students' roles become more *innovative* when they include collaboration with local/remote peer learners, inquiry-based activity, and providing technical support to teachers. For example, in CL007, the upper secondary school students participating in a ThinkQuest webpage development competition as part of their computer-based English course worked on topics according to their own interests. They also regularly communicated through email with English-speaking participants from other countries.

The *most innovative* students' roles involve students taking up wider responsibilities, such as tutoring and evaluating peers and determining learning goals and strategies – tasks traditionally carried out by teachers. For example, the 40 Grade 10 to 12 students in IL006 took key responsibilities in all the operations of their school radio station from program planning and decision-making through to information collection and on to production, recording, and broadcasting. The students also had to liaise and collaborate with other organizations, such as the community police. In this instance, the students produced a program on youth issues.

Dimension 4: ICT Use

We defined innovativeness with respect to ICT use according to the levels of technological sophistication of the ICT tools used in the practices. We use the term "sophistication" as a means of identifying the extent to which tools specifically designed to support teaching and learning extend beyond traditional modes of instruction, and the extent to which these designs are based on sound pedagogical principles grounded in educational research. A classroom with *no ICT used* falls into the *traditional* category on this dimension, while the second level (*some new elements*) includes the use of basic tools such as web browser and search engines as well as tutorials/drill and practice-type instruction-oriented applications.

Because the focus of SITES-M2 was on technology-supported pedagogical innovations, we were not surprised to find that none of the 83 SITES cases we analyzed featured ICT use at these two lowest levels. Some examples of the ICT tools used at the *emergent* level included email, asynchronous and synchronous communication tools, web/multimedia production tools, and ICT productivity tools such as the Office suite.

ICT tools at the *innovative* level included the use of more advanced tools such as network and collaboration tools, data-analysis software, and asynchronous and synchronous tools for collaboration. An example of innovative use related to WorkMates (F1001), an online platform specifically designed at the University of Turku, Finland, to support collaboration among students. Lower secondary students used this platform in their science projects to document and report on learning progress, share information, view and comment on one another's online notes, and conduct online discussions.

ICT tools at the *most innovative* end of the spectrum are advanced tools developed for specific pedagogical purposes, such as simulation/modeling software, mindtools, and data-logging tools. For example, the students in CN008 used data-loggers and graphing software to conduct scientific investigations. Table 3.1 (above) provides descriptions of ICT tools across the five levels of innovativeness.

Dimension 5: Connectedness

ICT opens up a whole new frontier in learning because it connects students and teachers to people beyond the classroom walls. The connectedness dimension describes the extent to which a practice reaches beyond the traditional model of the isolated classroom. This dimension has two aspects. The first is the nature of the external parties involved, and the second relates to the roles played by the external parties in the students' learning processes. Table 3.1 (above) provides descriptions of the different levels of innovativeness relating to these two aspects.

When we considered the case studies with respect to the *nature of the external parties* involved, it was evident that the most *traditional* classrooms were those with no outside parties involved. Classrooms with *some new elements* were those that involved collaborations of teachers in the same school and/or collaborations of students within the same grade level in the same school.

At the *emergent* level, the practices involved collaborations across different local schools or across different grade levels in the same school. Connectedness at the *innovative* level saw classrooms opened up to various community groups such as parents, alumni, and members of private sectors. Classrooms that had established international collaborations were those connected at the *most innovative* level.

The *roles that external parties* other than the classroom teachers play in influencing the teaching and learning process are also important in determining the level of connectedness of the innovations. In *traditional* practices, outsiders participate as observers only. They have no direct involvement in classroom practices, as was the case with the parents of the lower secondary students in TH005 (Fig. 3.4). They did not participate, even though they were well informed of the innovation. Outsiders' roles take on *some new elements* when they provide peripheral support

TH005: ICT, Light Bulbs, Lamps and Electric Wires
In this innovation, the teacher developed web-based materials that provided both science content and tests. Students engaged in experimentation, online search, report writing, presentation, and publishing on a webpage. Students displayed their work on the web so that other students, teachers, and parents were aware of what was being done and could offer comment.

PH006: Filipino Literature in Motion
In this innovation, students used technology to express their understanding of Filipino literature through poster design, slogan-making, writing a poem, painting, and slide presentation. Students cooperated in groups, and the teacher acted as "adviser," giving comments and suggestions when necessary. The school's ICT coordinator stayed in the classroom throughout the period when the innovation took place, providing technical assistance to the students.

NL024: Computers as a Measurement Tool
Pairs of students chose a topic related to physical phenomena, formulated research questions, and set up an experiment. They had to monitor their schedule of task completion. Computers with appropriate hardware and software were used for taking measurements and recording data and for graphical visualization of results. The teacher and the technical assistant supported the students, helping them address problems associated with technical issues and experimental design.

CN001: My Pocket Money
This four-month interdisciplinary project involved a class of Grade 6 students. They conducted research on the amount of pocket money their fellow students received and how they used that money. The students also surveyed their fellow students', parents', and teachers' attitudes towards pocket money. As part of this project the students raised funds that enabled them to hold a service day in a neighborhood home for the elderly. The students received feedback from the community on the fundraising and the service day. Throughout the project, the students used ICT to collect and analyze data, and for documentation, presentation, and publicity purposes.

FI004: Web Course in Sipoo Upper Secondary School
This web course aimed to develop students' advanced technical skills (production of web-pages and interactive applications, building and maintaining servers and web-based environments, and basic maintenance of PC-equipment), as well as their ability to work with groups, in customer service, and to understand business activities. Students attended lectures (face to face and video-conferencing), completed exercises and independent work, and undertook small-scale projects for companies. Many of the teachers in the course were professionals and experts employed from outside the school.

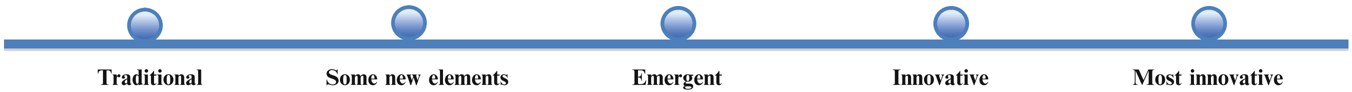


Fig. 3.4 Brief summaries of case-study examples of different levels of innovativeness in roles of external parties for the connectedness dimension

in areas such as course administration or technical help for the innovations. For example, in PH006, the school ICT coordinator came into the classroom to provide technical support to students engaged in producing digital products in the context of a language course.

Outsiders play an *emergent* role when they take up more significant roles in the pedagogical process, such as assessing students and providing feedback or additional information to teachers or students. For example, the technical assistant in NL024 played an important supporting role by providing the necessary materials and equipment to the upper secondary students who designed and conducted their own scientific investigations. Outsiders play *innovative* roles if their involvement contributes directly to the curriculum itself. An example of this related to the project work undertaken in CN001. This project included a fund-raising activity and a service day for the aged, work that the Grade 4 students involved conducted in collaboration with a center for the elderly in the neighborhood. The center provided an authentic context and meaningful learning tasks for the students.

At the *most innovative* end, outsiders are invited into the core of the classroom interactions, becoming involved as classroom instructors and monitoring students' task progression. We found one such example in FI004. Here, the school engaged ICT experts from outside the school to teach students the different kinds of technical skills they needed to achieve the intended learning outcomes in a web course. The teachers acted as facilitators, guiding and supporting the students as needed.

Dimension 6: Multiplicity of Learning Outcomes Exhibited

Although SITES-M2 did not collect systematic data on students' learning outcomes, the case reports describing students' performance or the products that students created provided illustrations of students' learning outcomes. The SITES researchers found large variations across the case studies in how students' learning outcomes (and learning difficulties) were assessed as well as in the kinds of learning outcomes (e.g., cognitive, affective, metacognitive) observed.

Traditionally, only well-defined cognitive outcomes are measured through the use of close-ended written tests. However, as more authentic and varied learning tasks are employed, a more diverse range of outcomes (or inadequacies), such as critical thinking, inquiry, collaboration, and communication skills are observed. This dimension focuses on the multiplicity (i.e., diversity of means) of learning outcomes evident (not necessarily through formal assessment) in the case study descriptions of students' learning processes and activities. Table 3.1 (above) provides descriptions of the different levels of multiplicity of students' learning outcomes across the five levels of innovativeness.

From our review of the case studies, it was evident that, at the most *traditional* end, students' learning outcomes were only revealed through written tests or close-ended written tasks and examinations, as evidenced in SG006 (see Fig. 3.6). *Some new elements* in student learning-outcomes became apparent when we examined students' individual responses to open-ended tasks, such as in DE012, where primary students were free to select writing tasks from a range of choices, such as story writing or an account of the history of their hometown. At the *emergent* level, we observed a more diverse range of learning outcomes. These encompassed creative learning products produced by individual students or groups of students. The Grades 4 to 6 students in CN003, for example, used drawing tools on portable computers to create digital artworks.

Students involved in producing artifacts such as inquiry plans/methods/instruments for problem-solving in authentic contexts provided evidence of *more innovative* student learning outcomes. So, too, did, students using portfolios and learning logs. Examples such as these illuminate the students' learning process instead of simply being a snapshot of student performance at the end of a learning process. For instance, in case NO007, the project-learning processes and the activities of the lower secondary students were logged by the platform they were using (in this instance, it was WISE; refer http://wise.berkeley.edu/). Using the learning log as her reference point, the teacher checked and provided formative feedback to the students throughout the project.

At the *most innovative* end of the spectrum, innovations incorporating peer evaluations and inquiry reports containing self-appraisal and self-reflection provided opportunities for students to demonstrate their ability to critique others' work as well as to learn through self-reflection. We also considered authentic products arising from the learning context, such as the radio station in case IL006 (described earlier under students' roles), as belonging to the most innovative category of multiplicity of learning outcomes exhibited (Fig. 3.5).

Case Study Comparisons of Innovativeness "Profiles"

Scoring the 83 selected SITES-M2 cases on their extent of innovativeness, using the six-dimension scale just described provided us with a set of innovation scores that enabled us to further explore and compare the features of the pedagogical innovations at a meaningful level of abstraction. An examination of the innovation scores showed that case studies that were innovative across all six dimensions were relatively rare. Instead, imbalances in the extent of innovativeness were often observed, and there were many instances in which a practice was innovative in some dimensions but relatively traditional in others. Thus, a comparison of the level of innovativeness of the cases could not be made on a single dimension, nor simply on an "average" innovation score. Rather, comparisons within and across case studies had to relate to each study's "profile of innovation" across the six dimensions.

We developed a diagrammatic format (see Fig. 3.6) to provide a visual representation of the innovation profile. A score furthest away from the center in the lower-left quadrant of this representation denotes a highly traditional practice while a score furthest away from the center in the upper-right quadrant denotes a highly innovative practice. The example given in Fig. 3.6 shows a practice in which the

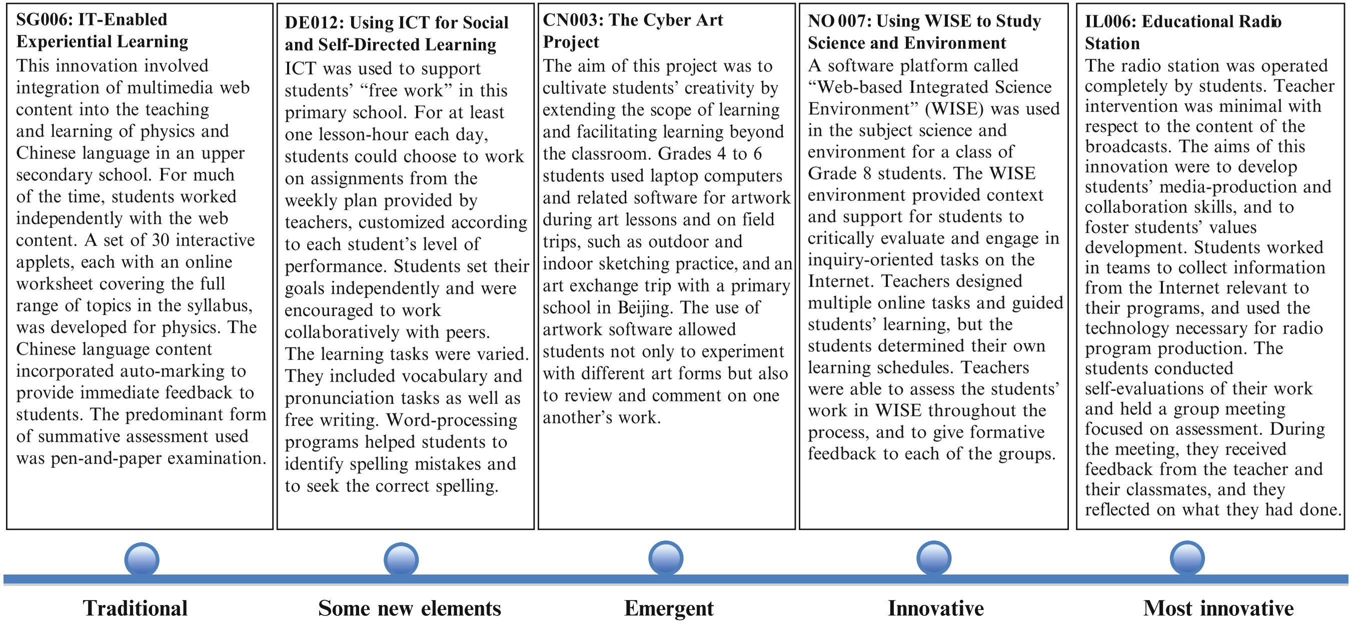


Fig. 3.5 Brief summaries of case-study examples of different levels of innovativeness in multiplicity of learning outcomes exhibited

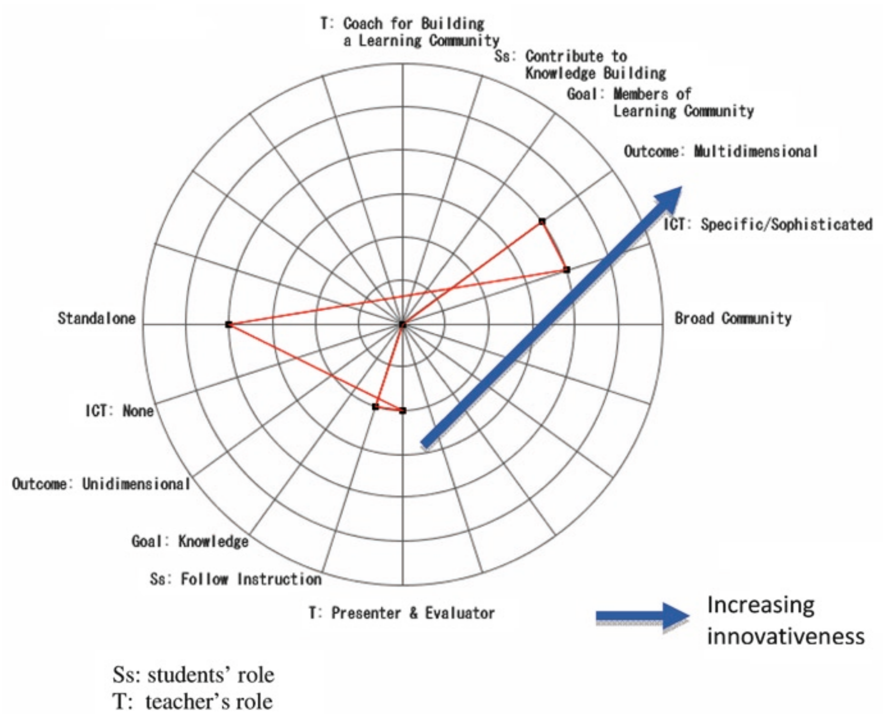


Fig. 3.6 Example of a case-study innovation profile

ICT tools used and the multiplicity of learning outcomes exhibited were relatively innovative, while the curriculum goals were emergent (halfway between the most traditional and the most innovative). The teacher's and the students' roles were relatively traditional, and the classroom was essentially isolated.

In the remainder of this chapter, we discuss a few examples of innovative practices that were highly innovative across all six dimensions. We also provide a description of three other noteworthy profiles of innovation emerging from the analyzed cases. These reflected imbalances indicative of the diverse foci commonly found in innovation efforts.

Balanced, Highly Innovative Cases

As just indicated, we did find a few cases that were highly innovative across all six innovation dimensions. One example was the innovation "Economy and Schools" in which Grade 12 students took part in a business education program in Germany. During the 10 months of this program, the students, with the support of a business consulting company, learned about large and small enterprises and how to develop

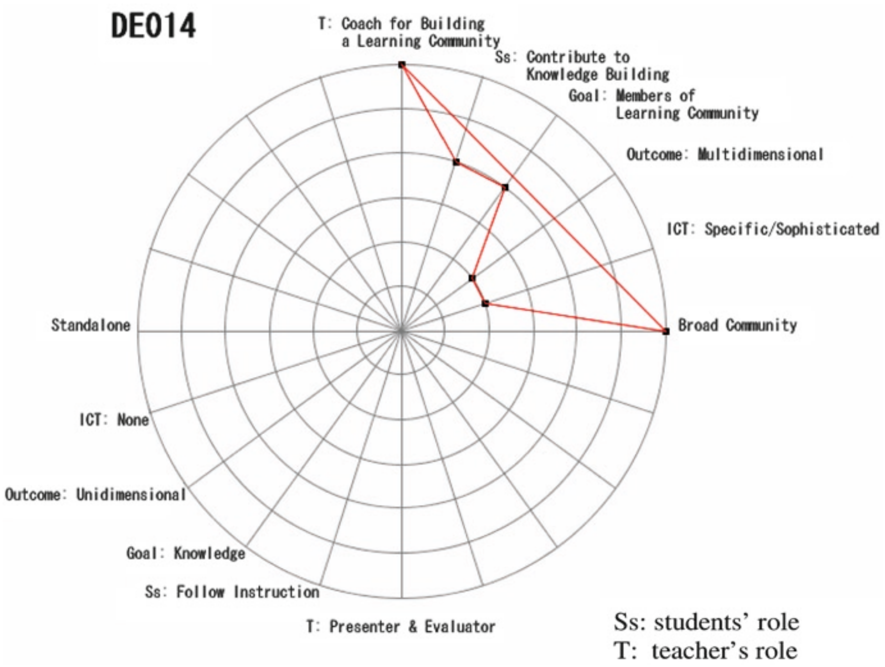


Fig. 3.7 Innovation profile for Case DE014: promoting team potential in the project, "economy and schools," and acquiring key qualifications for obtaining jobs

their own business ideas (DE014; see Fig. 3.7). The subject content for this project was relatively new not only for the students but also for the teachers involved. The teachers assumed the role of co-learners, facilitated group-dynamic processes, and monitored the project progress.

The project helped students gain a better understanding of economic concepts and their connections to authentic business contexts. It also helped them acquire skills associated with self-organization, teamwork, and ICT use. ICT played a substantial role in supporting the students' efforts to search out information on the big enterprises in Phase 1 and to conduct research on markets and locations during Phases 2 and 3 of the project, respectively. The use of PowerPoint enhanced the quality of the students' presentations and provided students with a structure for division of labor within the groups. Volunteers from the business sector attended the student presentations and provided the students with feedback.

Another example involved the use of telecommunication tools to study climate and weather. Students from four primary schools in Catalonia, Spain worked in virtual cooperative groups to understand meteorological concepts, to collect and analyze data, and to compare weather variables (ES001; see Fig. 3.8). The innovation covered a wide range of curriculum goals, ranging from conceptual learning

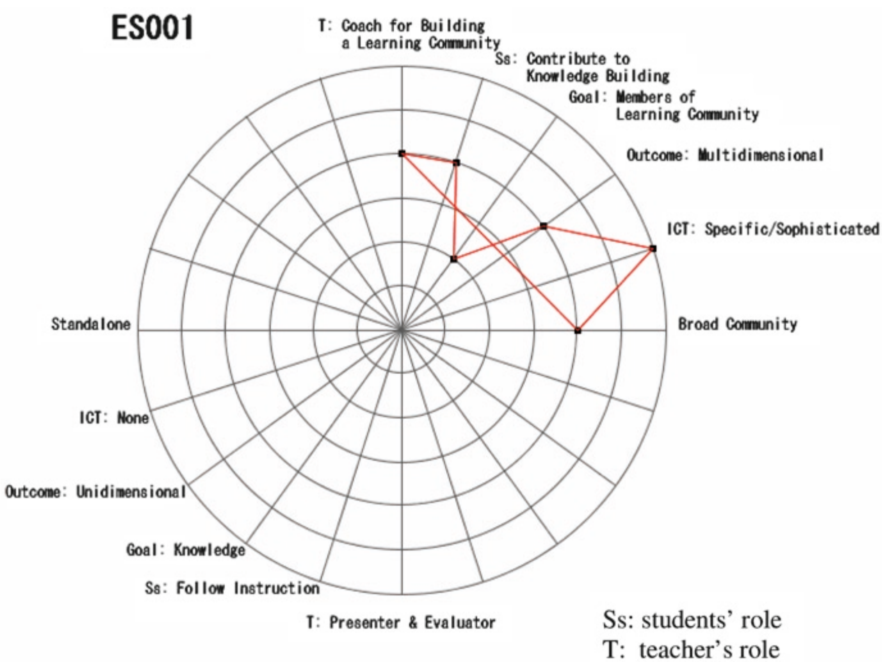


Fig. 3.8 Innovation profile for Case ES001: cooperative project using telecommunication tools to study climate and weather

about meteorology, acquiring the skills needed to operate weather-measurement tools, and data-handling and analysis, to working cooperatively with remote peers.

In addition to working in groups and experiencing all of the stages involved in conducting research (determining the project focus, collecting data, conducting analyses, drawing conclusions, and final reporting), the students had to collaborate with remote peers from other schools and to share data with them via online means. The two teachers involved worked closely together in co-planning and co-teaching. Instead of providing direct instructions to the students regarding their projects, they facilitated and monitored project progression by asking students probing questions and engaging them in discussions.

The students used various meteorological instruments to collect the weather data. They also used online technology extensively in order to share this information. The teachers reported that ICT had empowered student learning, particularly with respect to technical competence, mastery of concepts, and group efficiency. The teachers also said that the students exhibited a more positive (than usual) attitude to their learning.

These two cases and several other ones with similarly impressive innovation profiles provide glimpses of what classrooms of the future could look like – classrooms in which the learning tasks address authentic problems, resulting in products that contribute to the community. While the cases differ greatly in terms of the grade level of the students, the subject area concerned, and the specific activities involved, they show high levels of innovation across all six dimensions. The students involved were taking on the main responsibility for autonomous learning to tackle authentic real-life problems. In each instance, the learning process was dynamic, open, and well connected to the community. The use of technology in these examples was crucial; the students could not have accomplished the designated tasks without it. Although the forms of technology used in these highly innovative cases were often not specifically designed as "learning resources," they were the same as those that professionals in similar work contexts use.

Sophisticated ICT Use, High Connectedness, and Traditional Pedagogical Roles

Overall, well-balanced highly innovative cases were rare. One common profile that we observed in the case studies analyzed had the following features: relatively traditional in terms of teachers' and learners' roles but highly innovative in terms of ICT use and connectedness. Examples of this profile included cases US020, UK009, and FI002, all of which used technology to overcome distance. More specifically, these cases took strong advantage of the connectivity provided by the Internet to break down classroom walls, allowing students to learn from experts outside of the school as well as to learn with peers distributed across wide distances.

In Case US020 (see Fig. 3.9), the Online High School (OHS), catering to 2,516 students from 87 schools located across 29 North American states, sought, during academic year 1999/2000, to broaden the educational opportunities available to the students). This innovation saw all of the OHS teachers taking part in a graduate-level online professional development program on how to create and teach a "net-course" for high school students. Although the teachers were encouraged to use a variety of innovative pedagogical approaches (such as cooperative learning, inquiry-based projects, and performance-based assessment), it became evident that student-to-student interaction was rare in most of the OHS courses, and that students generally did the assignments independently.

In both Cases UK009 (see Fig. 3.10) and FI002, the focus was on enhancing students' opportunity to learn foreign languages. The innovation in UK009 involved using videoconferencing to improve students' conversational skills in French. This voluntary course was available to students studying towards a public examination in French, and its particular aim was to help them gain better oral skills. During the 10 weeks leading up to the public examination, the students could engage in videoconference sessions, each 40 min in duration, over lunchtime. During these sessions, students spent half of the time talking in French and half of the time talking in English. In case FI002 (web-based distance language teaching in archipelago schools of Turku), a teacher who taught German in the Turku teacher-training school used virtual-meeting software and a web-based learning environment designed for distance learning to teach five Grade 5 students in a small primary

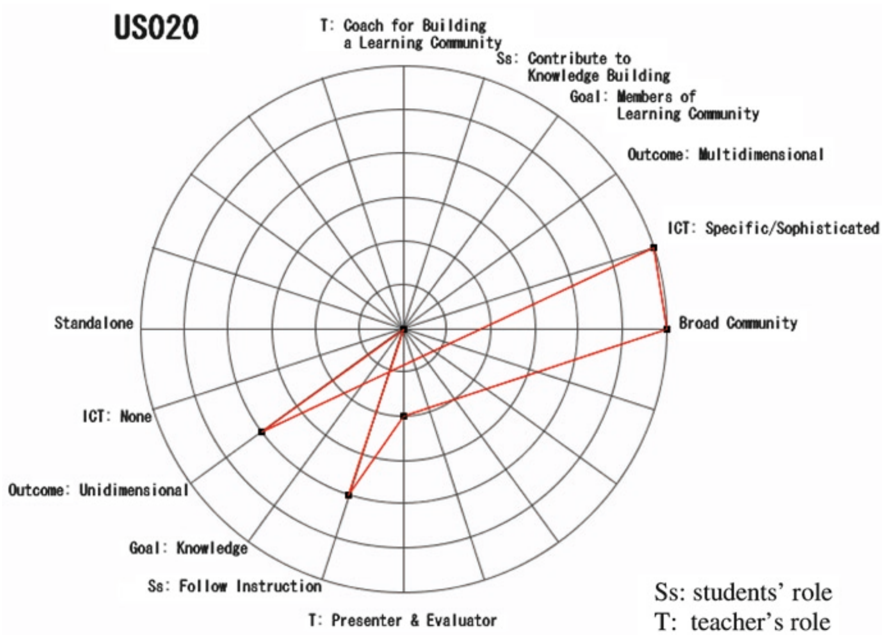


Fig. 3.9 Innovation profile for Case US020: online high school: classrooms without walls

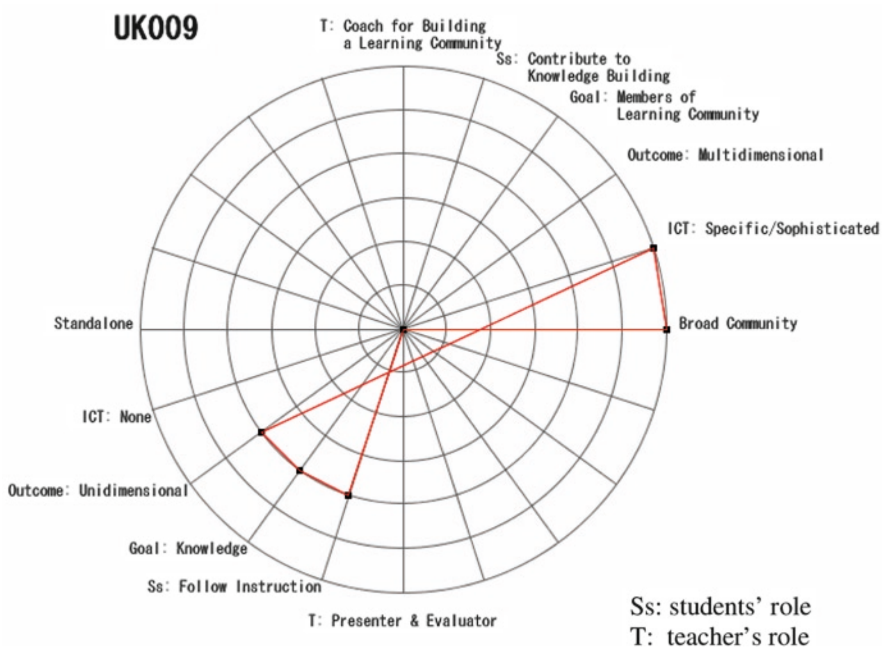


Fig. 3.10 Innovation profile for Case UK009: videoconferencing to improve conversational skills in French

school in the archipelago. Without this innovation, the students would not have had opportunity to learn the foreign language.

In these examples, the roles of the teachers and the learners were not very different from those found in traditional classrooms: the curriculum was well structured and defined by the teacher, and the students' roles were mainly to follow the teachers' instructions. However, both teachers and students had to brave the challenges of teaching and learning through unfamiliar media. The teachers involved also had to take on new roles involving liaison and collaboration with teachers and other professionals in distant locations.

Innovative Pedagogical Roles in Isolated Classrooms

Another prominent profile found within the analyzed cases can be interpreted as complementary to the previous profile. These cases were highly innovative in terms of the roles played by the teachers, but the classrooms were isolated; none of them offered learning interactions involving people outside the classroom. In these instances, the teachers explored new pedagogical approaches that provided students with opportunities to use technology to undertake more self-directed, open-ended, authentic and inquiry-oriented learning tasks. The ICT used tended to include cognitive tools and/or information tools.

Case CN012 (see Fig. 3.11) provides an example of pedagogical practices with this type of profile. The case involved two physics teachers and a laboratory technician within a Hong Kong secondary school collaborating to provide students studying advanced-level physics to develop a better understanding of scientific theories as models and to design experiments directed at verifying the scientific principles or laws that they learned in their physics lessons. The students used highly specialized tools, such as Modellus (http://modellus.fct.unl.pt/), a software for building scientific models. They also used digital video-cameras and video-editing/image-processing equipment to capture and analyze visual images taken during experiments on motion. They furthermore used data-loggers and graphing software to conduct scientific investigations. These learning experiences were only made possible through use of the various technology tools.

Another example sharing a similar innovation profile was Case TH001 in which students were guided to conduct collaborative inquiries on Thai culture and heritage. This process required students to engage in a variety of activities, from formulating problems to findings ways to search for information, and on to peer evaluation of individual learning portfolios. Figure 3.12 sets out the profile for this case.

These two cases and others with a similar innovation profile all made excellent use of technology to support students in their learning process. This use enabled the students to become more autonomous learners and to engage in learning activities that would not have been possible otherwise. However, the students and teachers worked in the relative isolation of their own classrooms and did not communicate

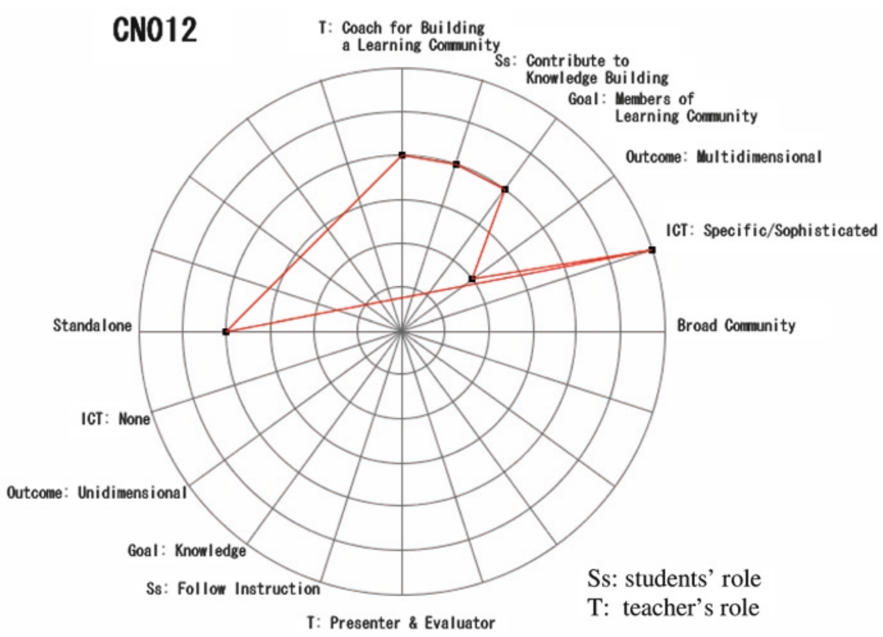


Fig. 3.11 Innovation profile for Case CN012: project-based model-building in physics

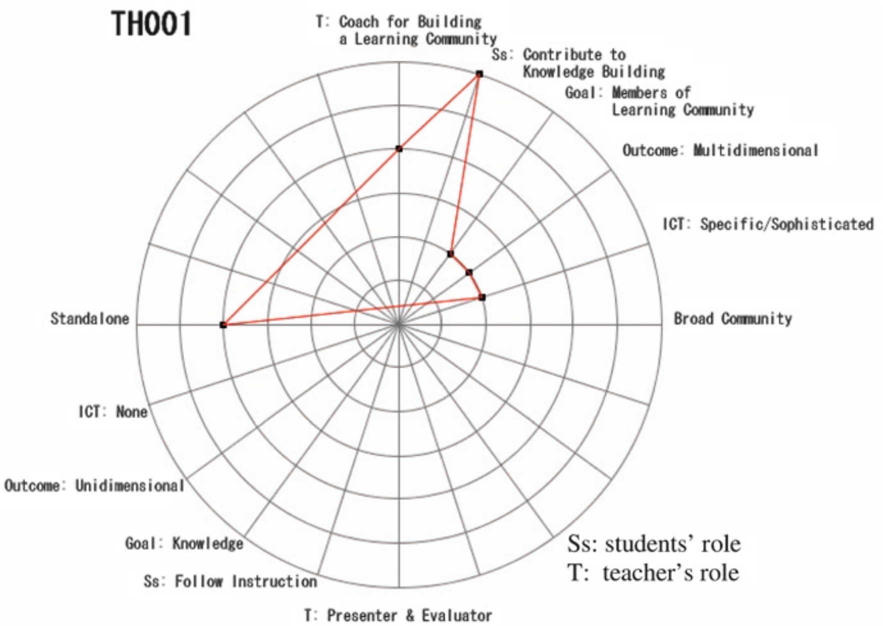


Fig. 3.12 Innovation profile for Case TH001: learning Thai heritage through ICT

with people outside their school, even when there was easy access to the Internet, as was the situation in the two cases just described.

Technologizing the Pedagogical Process

All of the innovations with an innovation profile similar to any of the previous three typologies ventured beyond the challenge of adopting new technologies into the learning and teaching process, such that curriculum goals, the nature of the learning activities, and the pedagogical roles of learners and teachers underwent various levels of change. However, we found some cases that were not innovative in any of the pedagogical dimensions beyond adopting ICT into the pedagogical process. One example of this type of profile was evident in Case TW006 (see Fig. 3.13) in which the teacher used ICT to technologize her geography presentations. The innovation was essentially teacher-centered and instruction-driven. The whole class worked in a lock-step manner, and the ICT in the classroom was designed to give the teacher maximum control. Even though the students had one-to-one access to a computer, all they generally saw was the same materials broadcasted through the system and displayed either on the big screen or on the students' individual computer screens. When students

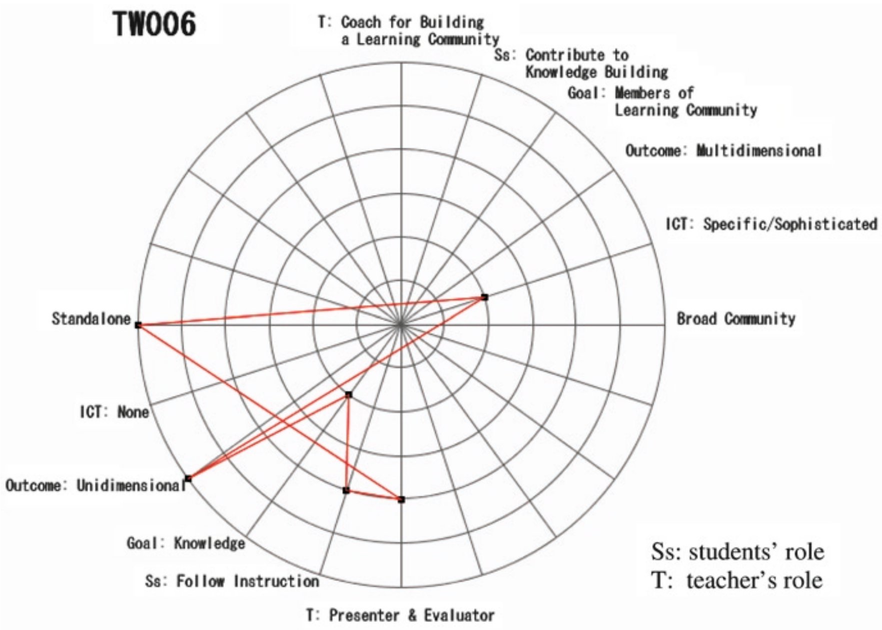


Fig. 3.13 Innovation profile for Case TW006: ICT-based geography lab

worked on the computers by themselves, their task was to complete well-structured worksheets designed by the teacher.

The nature of the classroom activities in cases sharing an innovation profile similar to that of TW006 was no different from the profile evident for traditional classrooms. The innovation was confined to the adoption of technology to carry out traditional classroom interactions, that is, teachers making presentations and students completing assigned, close-ended learning tasks. We were heartened by finding very few cases with this kind of profile in the 83 SITES-M2 cases that we analyzed. This situation indicated that the steering committees in participating countries were all looking for innovative examples in which learning activities and pedagogical roles went beyond the simple integration of technology into existing practices, even though the latter was likely to have been most prevalent use of technology in the classrooms of these countries.

Innovation Profiles as Lenses for Understanding Innovations

The broad and varied nature of the case studies collected in SITES-M2 meant that not all fell neatly into the four types of profiles described above. However, the above four innovation profiles are typologies that capture the variations across the cases and so can be used as a lens for interpreting and learning from ICT-supported innovative pedagogical practices.

Variations Across and Correlations Between Different Innovation Dimensions

The innovations presented above not only illustrate the degree of diversity across cases, but also the levels of innovativeness across the six dimensions. Many of the cases showed higher innovation in only one or a few of the dimensions, a situation which indicates that the change agents experimenting with new ways of organizing teaching and learning did not give the same priority to the six dimensions.

Using as our basis the innovation mean scores and standard deviations scores on the six innovation dimension for all 83 cases, we were able to determine which of the six dimensions were innovativeness most evident across the cases and which were the least evident. Table 3.2 sets out the results of this analysis. Of the six dimensions of innovation, ICT sophistication was the dimension that had the highest mean score as well as the smallest standard deviation. This result indicates that although overall ICT availability differs greatly across different countries around the world (Pelgrum & Anderson, 1999), the cases that the different SITES-M2 countries selected as innovative were much more similar in terms of the technology used than in terms of any of the other dimensions.

Table 3.2 Mean innovation score and related descriptive statistics along each of the six dimensions of innovation for the 83 cases analyzed by Law et al. (2003)

Dimension of innovation	Mean innovation score	Minimum score	Maximum score	Standard deviation
Curriculum goals (G_SCORE)	4.18	1	6	1.30
Teachers' roles (T_SCORE)	4.34	2	7	1.35
Students' roles (S_SCORE)	4.31	2	7	1.61
ICT sophistication (ICT_SCORE)	5.71	5	7	0.74
Multiplicity of learning outcomes (M_SCORE)	4.13	1	7	1.66
Connectedness of the classroom (C_SCORE)	4.16	1	7	2.06

Table 3.3 Correlation matrix of the innovation scores of cases across all regions ($N=83$)

	G_SCORE	T_SCORE	S_SCORE	ICT_SCORE	M_SCORE	C_SCORE
G_SCORE	1					
T_SCORE	0.74**	1				
S_SCORE	0.67**	0.77**	1			
ICT_SCORE	0.14	0.22*	0.06	1		
M_SCORE	0.56**	0.59**	0.72**	0.07	1	
C_SCORE	0.21	0.31**	0.26*	0.31**	0.28**	1

*$p<0.05$, **$p<0.01$

The connectedness of the classrooms had the largest standard deviation, indicating that while some practices took advantage of technology to break down classroom walls (see, for examples, Cases US020 and UK090 described above), there were still many that took place in isolated classrooms. A reason for this situation may be that connectedness depends more on factors other than hardware/software availability and connectivity, such as the prevalent classroom culture.

While the levels of innovativeness across the six dimensions were often not balanced, even within the same practice, the innovation scores are interrelated. Table 3.3 presents the correlation matrix of the six innovation scores.

The correlation matrix in Table 3.3 shows that, of the correlation coefficients for the six innovation scores, the ones for ICT sophistication was the lowest. This score correlated significantly only with teacher's role scores and the classroom connectedness scores, indicating that the sophistication of the ICT used had a relatively weak influence on the overall innovativeness of the case studies analyzed. The teacher's role score was the only dimension that showed significant and mostly very high correlation coefficients with all the other five dimensions, indicating that teachers' roles had the strongest influence on the overall level of innovation for the cases analyzed.

Regional Comparisons of Innovation Profiles

The earlier, Module 1, survey of the SITES program found cross-national differences in the pedagogical approaches that schools employed when integrating ICT in their curriculums (Pelgrum & Anderson, 1999). These differences appeared to be linked to the school and classroom cultures in the different countries. We were interested to determine whether we would observe similar cross-national differences in the most innovative pedagogical practices identified. Because the average number of case studies analyzed per participating country was fewer than five and because the number of cases collected from each country varied enormously from one to 11, it was not possible to examine cross-national differences. However, given that countries within a region tend to have a good degree of cultural and curricular similarity, we decided to look for differences across regions.

We found sizeable regional differences in terms of the mean profiles of innovation (see Table 3.4). Of all the six dimensions, the multiplicity of learning outcomes exhibited had the lowest mean score for nearly all the regions. This dimension also had a score below "four" for all regions except Western Europe, indicating that change along this dimension had, at the time of SITES-M2, generally not reached the emergent level, or the mid-point of the innovation scale. Western Europe also had the highest mean innovation score for all dimensions, except ICT sophistication.

The mean innovation scores for Asia were below four for all the five dimensions other than ICT sophistication. One interpretation of this finding is that the predominant pedagogical practice characteristics found in Asia are still relatively traditional, even for practices selected as the most innovative exemplars. This traditionalism, in turn, may reflect the East Asian heritage of Confucianism, in which the teacher is a figure of respect and authority (Watkins & Biggs, 1996, 2001). (East Asia includes such countries as China, Korea, and Japan.)

Table 3.4 Mean innovation scores and related descriptive statistics distributed across geographical regions along each of the six innovation dimensions for the 81[a] cases analyzed by Law et al. (2003)

Innovation dimension	Western Europe (42)[b]	America (8)	East Europe (6)	Asia (25)
Curriculum goals	4.60	4.25	3.67	3.48
Teachers' roles	4.74	4.13	4.00	3.64
Students' roles	4.57	4.13	4.50	3.76
ICT sophistication	5.79	6.00	5.50	5.52
Multiplicity of learning outcomes	4.45	3.88	3.33	3.76
Connectedness of the classroom	4.67	4.50	4.00	3.16

[a]The two cases from South Africa are excluded from this regional analysis

[b]The figures in brackets are the number of case studies from countries within the respective regions that are included in this analysis. To reduce the number of regions in the tabulation, the four Australian cases analyzed are categorized as West European cases

Examinations of the correlation between the different innovation scores across the different geographical regions revealed further prominent differences. In Western Europe and America (the two regions with the longest history of infusing ICT into the curriculum), the only positive correlation to emerge between the ICT scores and the other dimension scores was for connectedness. These results were not replicated in Eastern Europe and Asia, the two regions with a relatively short history of ICT integration across the school curriculum. However, in these two regions, the ICT sophistication score correlated strongly (and positively) with the other dimensions, except for multiplicity of learning outcomes exhibited.

It is apparent from these results that in Asian and East European countries, the teachers involved in practices using sophisticated technology tended to be more willing to experiment with more innovative, less traditional pedagogies. However, in Western Europe and America, where teachers had been exposed to and had longer experience of using technology in their own teaching, the level of sophistication of the technology used in the innovative practices collected were not significantly related to the level of innovativeness associated with any of the other dimensions, and the relationship was sometimes negative.

Further, regionally based correlation analyses reveal that the pattern of correlation differed across the different geographical regions. Specifically, the IT sophistication score correlated much more strongly (and positively) with the other dimensions for cases collected in Asia and Eastern Europe. In Western Europe, however, the IT sophistication score correlated positively and significantly only with the connectedness dimension. These findings are consistent with the conclusion that Venezky and Davis (2002) drew from their study of ICT-supported educational innovation in the OECD countries. They concluded that ICT is only a lever for change – not a catalyst. Thus, the presence of ICT per se does not lead to the emergence of innovation. Instead, it seems that ICT can be used to leverage educational innovations and thereby produce more effective transformation. The regional correlation statistics indicate (not shown here in the interest of space) that the impact of ICT on education innovation is complex and is likely to be most marked in systems where schools have different levels of general access to ICT.

Discussion

Our analysis of technology-supported pedagogical innovations from the perspectives of the six dimensions revealed a rich and complex picture of pedagogical change brought about by the diverse forces influencing classroom practice. Examples included (among the many evident) curriculum reform initiatives at national and regional levels to bring school education into the twenty first century, technological advances and pressure on schools to introduce ICT into their teaching and learning processes, and how school effectiveness and student learning outcomes are measured and monitored. Our findings indicate that, even among the small numbers of innovative cases selected by the national expert committees, pedagogical practices that were highly innovative across all six dimensions were rare. That said, most of the cases were innovative in some of the dimensions. If we interpret the case examples collected as emergent responses to the changes in the education ecology, then the diversity and the variations in the innovation profiles are consistent with the responses we would expect from a complex system. The kinds of innovation profiles identified in the analyses furthermore revealed important features of not only the educational systems from which these emerged but also the forces (both pressures and supports) that were at work.

We also observed that the level of pedagogical innovativeness of the practices rarely matched the technological competence of the teachers involved. The most sophisticated technological skills were usually exhibited in practices where the teachers had created digital courseware, including online and face-to-face presentation materials and student exercises. Such courseware was generally being used in teacher-centered settings, and the pedagogical goals were largely knowledge or skills oriented and hence relatively traditional in terms of pedagogy. We find innovations motivated primarily by the technological sophistication of the ICT tools made available to schools to result in practices belonging to the profile category of *technologizing the pedagogical process*.

Using ICT to connect classrooms to the wider community is certainly one important dimension of change emerging in twenty first-century classrooms. However, the level of connectedness that we observed in this study appeared to be relatively independent of the other four non-ICT-related innovation dimensions. We noted stronger correlations among the four pedagogical dimensions of curriculum goals, teachers' roles, students' roles, and the multiplicity of exhibited learning outcomes. Pedagogical practices at the most innovative end of these four dimensions were evident in classrooms where teachers facilitated situations that allowed students to engage in self-directed collaborative inquiry related to authentic problems.

If we label the continuum of these four interrelated dimensions as a collective dimension and if we then label that dimension as the collaborative-inquiry vs. traditional-instruction dimension, we can conceptualize the six dimensions of innovation as consisting of three relatively independent dimensions: ICT use, connectedness, and extent of collaborative inquiry. As we show in Fig. 3.14, the four typologies of innovation profiles reported in this chapter fall neatly into the four broad combinations of innovation characteristics along the two dimensions of connectedness and extent of collaborative inquiry.

We can interpret pedagogical practices with innovation profiles other than that of *technologizing the pedagogical process* (Type 4 profiles) as efforts to take advantage of ICT to address specific educational needs. Cases that have profiles demonstrating *sophisticated ICT use, high connectedness and traditional pedagogical roles* (Type 2 profiles) denote attempts to improve students' opportunities to learn by overcoming geographical isolation and/or taking advantage of connectedness to engage with experts beyond the classroom as in the Online High School (Case US020) or web-based distance language teaching (Case FI002).

Cases with profiles demonstrating *highly innovative pedagogical roles in isolated classrooms* (Type 3 profiles) generally signal innovations developed in

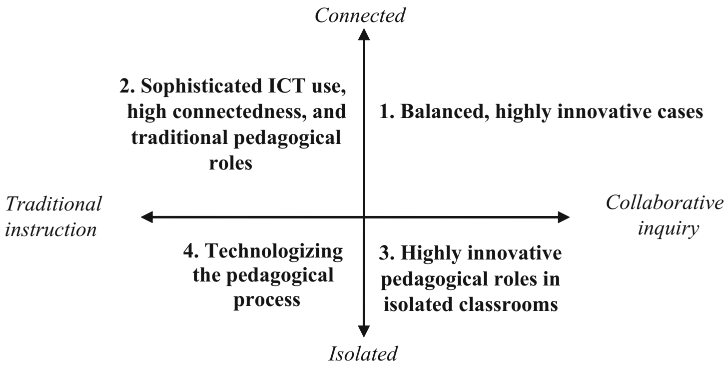


Fig. 3.14 The four typologies of innovation profiles in relation to the pedagogical characteristics of the practices

recognition of the need for students to develop inquiry and collaboration skills. The new kinds of activities encompassed by these innovations encourage students to take up more responsibility and agency for their own learning. We found many Type 3 examples in Asian countries, which tend, on the one hand, to have a strong policy focus on curriculum reform to prepare students for the twenty first century but, on the other hand, to have traditional and isolated classrooms.

The SITES-M2 case studies not only highlight the spontaneous, emergent efforts of teachers and schools to respond to changes in the local and national educational milieu, but also reflect the ICT-related priorities and resources available at national, local, school, and individual levels. As such, they aid our understanding of the extent to which schools are using ICT to change pedagogical practice and improve student learning outcomes. They also allow us to consider the sustainability of technology-supported pedagogical innovations from an ecological perspective, a theme that we pursue further in the rest of this book.

Chapter 4
Student and Teacher Roles in ICT-Supported Innovations

In the previous chapter, we analyzed the case studies of innovation according to a rubric developed on the basis of a six-dimensions framework for rating pedagogical innovativeness. So that we could identify how and in what ways the innovations differed from traditional pedagogical practices, our focus was on the ecological niches that these innovations occupied. In this chapter, we focus on teacher and student roles. We consider these the two key dimensions (i.e., dependencies) in terms of the scalability of an innovation. In reality, in pedagogical practices in general, irrespective of whether a practice is an innovative or a traditional one, teachers design and engineer their practices across all six pedagogical dimensions. Nonetheless, because changes in teacher and student roles involve changes in teaching and learning as a social practice, these two sets of roles remain the critical dimensions. This supposition was confirmed by our earlier findings that teacher-role and student-role scores had the highest correlations with the other four dimensions. To gain a better understanding, from a social practice perspective, of teachers' and students' roles in the innovations, we examine in this chapter, through analysis of the SITES-M2 case studies, the activities they were engaging in, and from there endeavor to identify holistic and "concrete" activity patterns.

We conducted our analyses according to a two-step approach. First, we systematically coded the case studies according to the kinds of observable student and teacher activities explicitly described in the case reports. As we noted in Chap. 2, we considered that only 83 out of the total 174 cases contained sufficiently detailed descriptions of the teaching and learning process to be coded for this purpose. Our second step involved cluster analysis of the sets of coding for student and teacher activities respectively. This allowed us to identify the key roles played by students and teachers in the case studies. We describe the two cluster analyses results in the following sections. We also describe and discuss the relationships between these results and the innovativeness scores of the case studies.

N. Law et al., *Educational Innovations Beyond Technology: Nurturing Leadership and Establishing Learning Organizations*, DOI 10.1007/978-0-387-71148-5_4,

Student Learning Activities and Roles

We identified 17 learning activities in the 83 innovations analyzed. Table 4.1 lists the frequency of presence of these activities. We have listed these learning activities according to a process in which those activities involving relatively passive participation from students, as generally found in traditional practices, such as listening and understanding presentations (S1) and following task instructions (S2), appear at the top of the table. We listed the emerging learning activities, which were less common in occurrence but likely to become mainstream student practices in the classrooms of the future towards the end of the table. With the exception of S4 (presenting own learning in non-electronic formats), all the other activities were likely to have made profitable use of ICT. For example, all 49 cases in which students engaged in information search (S3) involved using the Internet for this purpose.

The most popular student activity, as evident in Table 4.1, was engaging in collaborative tasks (S7), which occurred in 75% of the cases. Other collaborative activities reported in the case studies included peer tutoring (S8) in almost 50% of the cases, technical support to teachers or other students (S9) (17%), and peer evaluation (S11) (28%). While most of the collaborative activities were with peers in the same school, we found examples of collaboration with remote peers, often in distant countries, in 17% of the cases. In some learning activities, S8 and S9, the students played the role of a tutor by helping other students. In one case, the students provided computer training for their teachers – an example of role reversal in the classroom. We note from the case reports that even young children increasingly exhibit higher technical competence than their teachers.

In 30% of the cases, students were involved in designing and creating products, an indication that learning as a productive process (as opposed to learning as

Table 4.1 Learning activities engaged in by students

Code	Student learning activities	Frequency	Percentage of cases
S1	Listen and understand presentations	14	17
S2	Follow task instructions	35	42
S3	Search for information	49	59
S4	Presentation of own learning (non-electronic)	28	34
S5	Electronic presentations of own learning	24	29
S6	Design and create products	25	30
S7	Engage in collaborative tasks with other students	62	75
S8	Peer tutoring	40	48
S9	Provide technical support to teachers/other students	14	17
S10	Reflect on own learning	28	34
S11	Peer evaluation	23	28
S12	Data-gathering and data-processing	32	39
S13	Analyzing and drawing conclusions from data	20	24
S14	Identifying inquiry focus	27	33
S15	Determining own learning schedules and strategies	35	42
S16	Providing computer courses for teachers	1	1
S17	Collaborating with remote peers	14	17

consumption of learning materials and services) is becoming increasingly popular as an innovative form of learning activity. The products so created were various and were in electronic (e.g., creation of digital drawings in Case SG001) or non-electronic formats (e.g., construction of an actual bathroom in Case NO011).

Some student activities related to the inquiry-based nature of classroom innovations. These included data-gathering and data-processing (S12), found in 39% of the cases, and analyzing data and drawing conclusions from the analysis (S13) (24%). In 33% of the cases, students identified the inquiry focus, thereby taking part in determining the objective of their own learning, rather than being wholly dependent on the curriculum and/or the teacher. Another common occurrence was engaging in planning and self-monitoring of own learning schedules and strategies (S15), found in 42% of the cases.

Information search (S3) was, in fact, the second-most popular activity, explicitly reported in 59% of the cases. This finding is relatively unsurprising given that information search is not only an important part of many inquiry-based learning activities, but also often crucial in the process of accomplishing projects involving the creation of digital products. Also noteworthy is the finding that listening and understanding presentations (S1) was among the least popularly reported activities (17% of the cases), even though 42% of the cases reported students engaging in activities that involved following instructions (S2). This apparent discrepancy indicates that when selecting cases of technology-supported pedagogical innovation, the national expert teams generally gave preference to practices that provide more opportunities for student engagement, even though both S1 and S2 are student activities found in traditional practices.

Student-Role Clusters

It is clear from the data presented in Table 4.1 that the students seldom engaged in only one kind of activity in any one of the innovations analyzed. Some activities appear to have been more likely to co-occur in the same pedagogical practice, so forming meaningful groupings of activities. Anticipating that identification of such groupings would provide us with a more holistic understanding of student roles in these innovations, we used the K-means cluster statistical analysis technique to look for co-occurrence patterns. Table 4.2 presents the results of this analysis.

In order to provide readers with a more concrete understanding of student role in each cluster, we describe a case closest to the cluster center (i.e., a case with features most characteristic of this cluster).

Follow instructions

Follow instructions emerged as the largest role cluster: it comprised 29 of the 83 cases. Out of the entire list of 17 learning activities, only two commonly appeared in cases belonging to this cluster – following task instructions and engaging in collaborative tasks. Due to the extensive presence of collaborative activities, seldom

Table 4.2 Five types of student roles and the corresponding key student activities identified through cluster analysis

Type of student learning activity (number of cases in each role cluster)		Follow instructions (29)	Search for and present information (11)	Create digital products (18)	Conduct online inquiry (7)	Conduct inquiry (18)
S1	Listen and understand presentation					
S2	Follow task instructions	✓	✓			
S3	Search for information		✓	✓	✓	✓
S4	Present own learning (non-electronic)		✓			✓
S5	Present own learning (electronic)				✓	
S6	Design and create products			✓		
S7	Engage in collaborative task with other students	✓		✓	✓	✓
S8	Peer tutoring			✓		✓
S9	Provide technical support to teachers/other students			✓		
S10	Reflect on own learning			✓	✓	✓
S11	Evaluate peers					
S12	Gather and process data				✓	✓
S13	Analyze and draw conclusion from data					✓
S14	Identify inquiry focus				✓	✓
S15	Determine own learning schedules and strategies			✓		✓
S16	Provide computer courses for teachers					
S17	Collaborate with remote peers				✓	

Note: A “ticked” cell indicates that the weighting for the particular activity in a specific cluster was ≥50%

found in conventional classroom settings, there was already some innovation in the role of the students in this cluster. However, student roles were still rather traditional in nature because the tasks they engaged in, whether collaborative or not, were mostly assigned to them through direct instructions. We therefore labeled "following instructions" to highlight the mainly passive role of students.

Example: Web-Based Distance Learning

The case study closest to the cluster center was FI002 – web-based distance language teaching in archipelago schools of Turku, Finland. This innovation was a collaborative effort between a teacher-training school and a primary school. Five students were involved in learning German at a distance. The goal of this innovation was to provide equal opportunities for students in this small rural school to choose an optional foreign language. The practice involved a web-based learning environment designed for young language learners. No teacher was physically present in the same classroom with the students. Students were required to do a series of language-learning exercises in NetMeeting and Virtual Notebook. The exercises, developed by their remote teacher, included both individual and collaborative tasks. The students' roles were not too different from those evident among students learning a foreign language in a conventional classroom. However, the Turku students had to be relatively self-regulated in their learning, given there was no teacher in close physical vicinity, and they needed to be sufficiently technology-savvy to use the variety of general and purpose-built technology tools necessary to accomplish their various learning tasks. Figure 4.1 presents the innovation profile for this case, which we rated as innovative (at the innovative level or above) for the ICT and connectedness dimensions.

Search for and Present Information

In this cluster of 11 practices, searching for information and presenting findings in non-electronic formats were an essential part of student activities. Following task instructions was also an important component of student learning activities in more than half of the cases in this cluster. Information searches were conducted online through the Internet or through the use of traditional media such as books and audio-visual resources. Student presentations in non-electronic formats were normally in the form of written texts or verbal presentations.

Example: Computer-Based Instruction and Information Search

The innovation closest to the geometric center of this cluster was Case Study PH011, which featured Internet-based learning in a science and technology class (see Fig. 4.2). In this instance, computer-assisted instruction (CAI) was integrated into the teaching and learning of science and technology for the group of 53 students, ages 12–14, participating in the special science program.

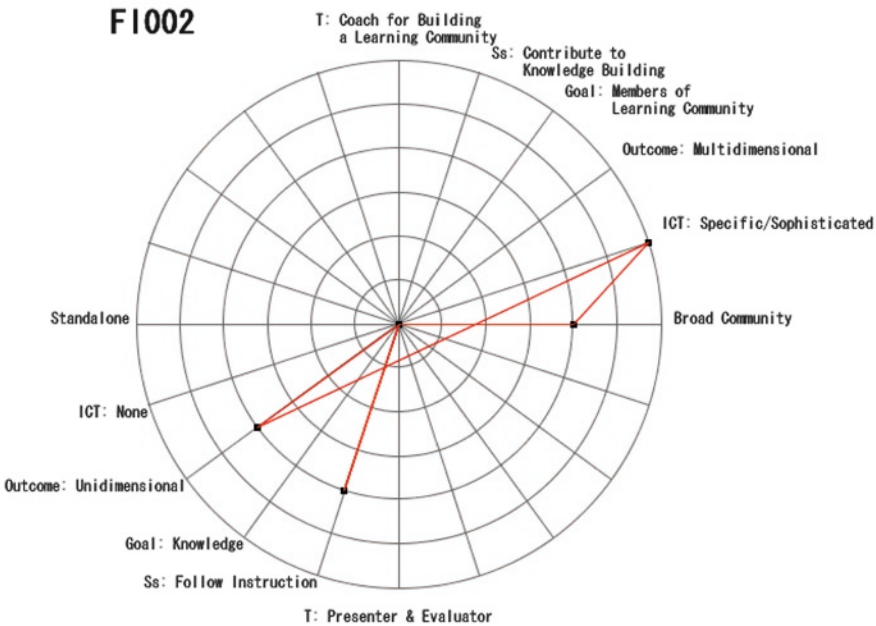


Fig. 4.1 The innovation profile for Case FI002, in which the student activities belonged to the *follow instruction* cluster

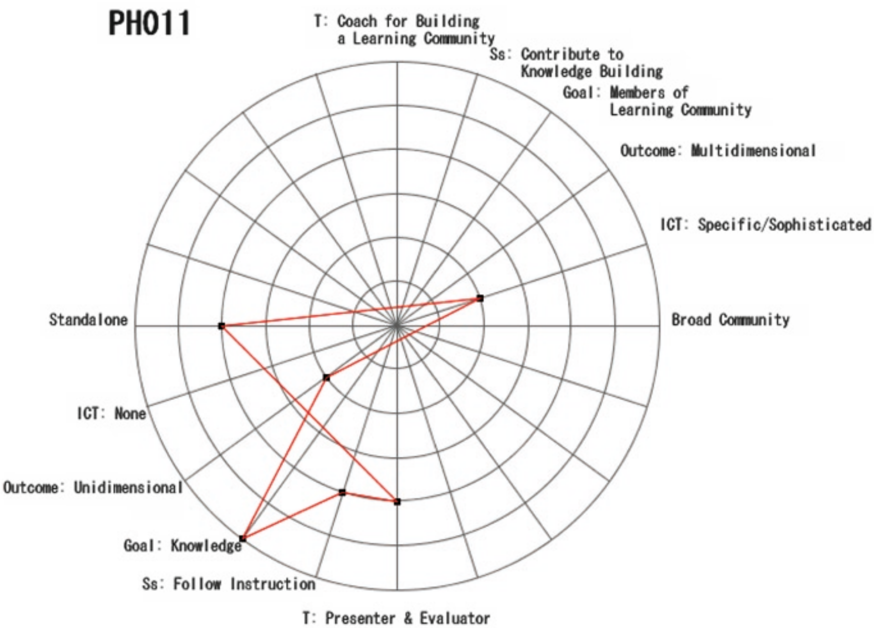


Fig. 4.2 The innovation profile for Case PH011, in which the student activities belonged to the *search for and present information* cluster

The teacher's general pedagogical strategy in Case PH011 was to set questions for the students, which required them to look up information and, in some cases, conduct experiments. The teacher also prepared and previewed the sources of information. During one 80-min session each week, when computer access was available, the teacher divided the class into three groups; each group assigned to learning tasks in one of three different locations – the computer room, the learning resources center, and the library. Depending on which group they had been assigned to, the students were required to gather information from one of three sources – the Internet, video materials, and books. The computer teacher, the learning resources center coordinator, and the librarian collaborated to provide instructional support. Students prepared their reports for presentation to the class. Learning was measured in terms of how extensively the students had searched the websites and how well they were able to present their findings. The entire learning process was essentially teacher-directed, even though students were instructed to take up more active roles in the learning process.

Create Digital Products

The most prominent learning activities in this cluster of 18 innovations saw students engaging in collaborative tasks and designing and creating products. Many of the cases in this cluster included other student activities, such as searching for information, peer tutoring, and providing technical support to others. Also, in more than half of the cases, the learning goals included enhancing students' metacognitive development by requiring students to reflect on their own learning (56% of cases) and to determine their own learning schedules and strategies (61%).

We note that, within the cases in this cluster, students were encouraged and supported to become autonomous learners. While the creation of a shareable product as a learning outcome is not necessary for autonomous learning, it provides an easy platform for developing a learning environment that shares common features with authentic workplaces, namely, collaboration, team work, and obtaining help from experts while taking responsibility for one's own work schedule and learning strategy.

Example: Visual Communication Products

The innovation closest to the geometric center of the create digital products cluster that we found was Case NO005 (visual communication strategies and project-oriented pedagogy using iMovie). This innovation involved Grade 8 students from a Norwegian junior secondary school with a large proportion of students from lower socioeconomic and minority language backgrounds. The children worked in groups of 40–60 students to produce visual communication products, such as animated films, on subject-related themes and concepts.

The teacher selected visual communication as the focus in order to stimulate student interest in the different subject areas and to cater for the wide range of

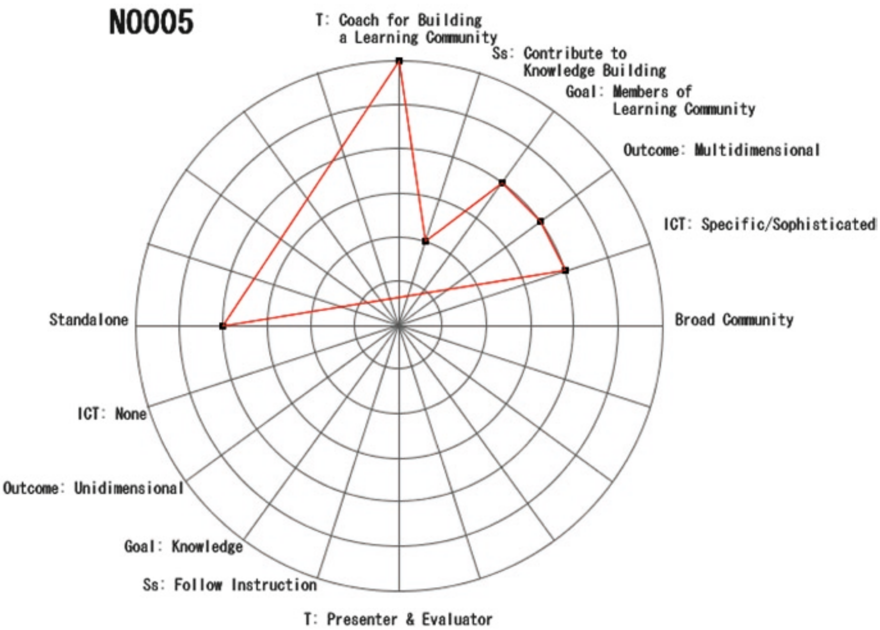


Fig. 4.3 The innovation profile for Case NO005, in which the student activities belonged to the *create digital products* cluster

individual student abilities. Many of the students with poor academic achievement were competent with visual communication media, so this approach built on their strengths. The students compiled electronic portfolios, which contained all the projects they had been involved in, and the teacher assessed these. Each student received a written comment from the teacher highlighting both positive and negative aspects of the work presented. The use of these portfolios for assessment purposes promoted students' metacognitive development because the work involved in compiling them encouraged the students to reflect on their own learning processes.

From the innovation profile for this case presented in Fig. 4.3, it is apparent that this innovation case was innovative in all dimensions except connectedness.

Conduct Online Inquiry

In a situation similar to that for the students involved in cases in the create digital products cluster, students in the conduct an online inquiry cluster had to perform information searches, collaborate with others, and reflect on their own learning. However, they differed on two significant aspects. First, instead of engaging in activities focused on creating products, the students worked on learning activities that were inquiry-oriented. Identifying the inquiry focus and collecting and processing data were the most prominent activities in this cluster. Second, a high percentage of the cases (86%) saw students collaborating with remote peers. The need to work with remote peers may explain why the students in all of the cluster cases were required to present their work electronically.

Example: Distance Communication Using Telecommunication Tools

One of the innovations closest to the geometric center of this cluster was Case ES007, in which students at all levels of a secondary school in Catalonia, Spain worked cooperatively on a project designed to help them learn about the traditions of several European countries. The work involved various activities, each of which required the students to use telecommunication tools. The students involved in this project participated on a voluntary basis and communicated with peers in six European schools. Both the Catalan students and their peers in the other countries collected and shared information about their schools and local traditions. All of them focused in particular on family and school celebrations.

The youngest students (12–14 years of age) in the Catalan school designed celebration cards for different family and school celebrations, while the older students (14–16 years of age) collected and processed information on all the celebrations. The senior students (16–18-years-old) produced a video and an illustrated document about the history and current state of local and national traditions. They translated most of the information into English to post on a web page shared by all schools participating in the project, with the intention of creating a CDROM containing all collected information. The teachers' assessment of this focused not on content and final products but rather on the project process. This focus allowed the teachers to take into account factors such as students' attitudes toward the project and their learning, the extent and nature of the students' participation, including contribution of ideas, and the level and type of creativity evident.

Figure 4.4 shows the innovation profile for ES007, which clearly indicates that the practice involved in this example was innovative across all six dimensions.

Our consideration of Case ES007 led us to ask just how different the roles and activities between this case and the previous one we described, NO005, were. The focus in ES007 was on understanding European traditions and creating different kinds of digital presentations to communicate findings. In NO005, the focus was on creating visual products that illustrated key concepts in specific subject areas. While the former might be seen as an inquiry and the latter as the creation of a visual product, the learning activities and the roles of the students in each were similar. To create a product that successfully communicates certain ideas requires a deep understanding of the subject matter, which in turn entails inquiry. However, anyone engaged in any form of collaborative inquiry needs to be able to communicate findings and thoughts through some form of media. We consequently concluded that the differences between the student roles in these two clusters were just a matter of emphasis. Both required students to be autonomous, to communicate, to work with others, and to reflect on their own learning in order to successfully achieve the learning goals.

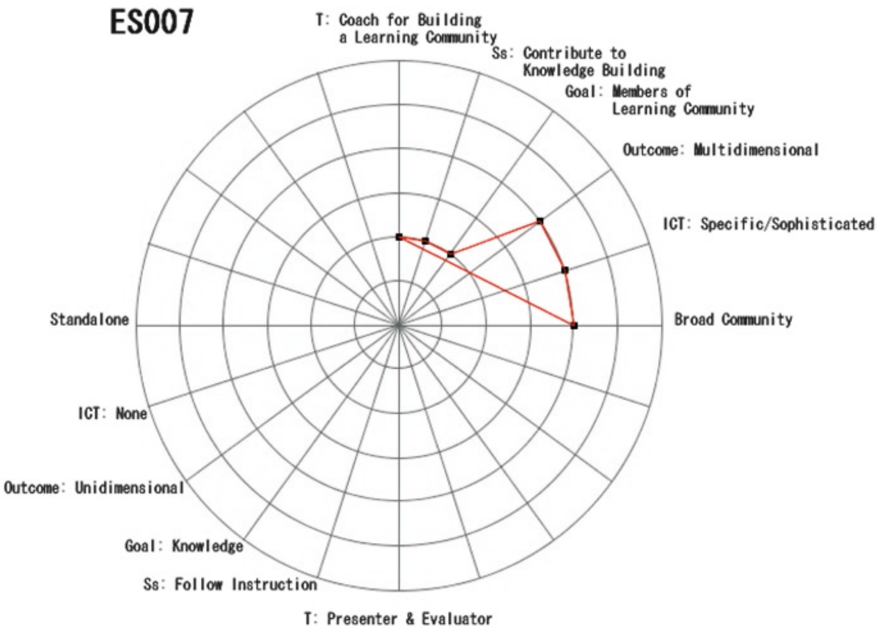


Fig. 4.4 The innovation profile for Case ES007, in which the student activities belonged to the *conduct online inquiry* cluster

ES007 and NO005 thus reflected similarities in terms of student activities and roles in the two respective clusters. However, the distribution of student activities, as presented in Table 4.2, indicates that innovations in the conduct online inquiry cluster rarely required students to create digital products, while most of the innovations in the create digital products cluster focused neither on inquiry nor on collaboration with remote peers.

Conduct an Inquiry

When we compared the students in this cluster of innovations with their counterparts in the four other clusters, it was immediately apparent that the former group of students was engaged in the widest variety of learning activities; nine out of the 17 learning activities were evident in more than half of the cases in this cluster. Although the learning activities profile for this cluster were very similar to those in the online inquiry cluster, in that innovations in both clusters centered on inquiry-oriented learning (identifying the inquiry focus and collecting and processing data being the focal activities), none of the cases in this present cluster involved collaboration with remote peers.

Collaboration with remote peers often involves complex technology and a heavier communication burden, and there is the possibility that the communication might not be as effective as in face-to-face situations. Perhaps because of the assumed advantage of face-to-face communication, 72% of the cases in this cluster reported students being required to present their work in non-electronic formats. It appeared to us that the innovations in this cluster had achieved a deeper level of inquiry compared to that apparent in the online inquiry cluster. For example, the cases in this cluster had a much higher occurrence of peer tutoring (67% compared to 29% in the online inquiry cluster), as well as analyzing and drawing conclusions from data (89% compared to 0%). There was also a higher probability for students in this cluster to determine their own learning schedules and strategies (67% compared to 43%).

Example: Computer-Assisted Scientific Investigations

The innovation that we considered closest to the cluster geometric center was CN008, which featured computer-assisted scientific investigations. The Grades 10–13 science students who participated in this innovation were organized into small groups, and the members of each group were asked to identify a problem that they considered interesting and/or important to investigate. Each group then formulated a method of inquiry and designed and conducted an investigation that required them to use a data-logging system and associated software while collecting and analyzing their data. Finally, the students had to determine whether they had been able to successfully address the problem they started with, based on the results they obtained.

The problems that the students identified were authentic, real-life problems. For example, a student who often suffered from heartburn asked why different brands of antacid tablets differentially affected heartburn relief. This focus on real-life problem situations meant that the facilitating teachers learned alongside the students. The investigation process required the students to translate their problems into the form of scientific experiments. For example, in order to find out whether solubility was one of the properties affecting the effectiveness of antacids in heartburn relief, the students design an experiment that they considered a valid test of solubility. During their work, the students had access to highly sophisticated tools, such as data-loggers and graphing software, similar to those that scientists use in their laboratories.

This provision allowed the students to conduct aspects of scientific investigations that could not be achieved with conventional school laboratory equipment, a case in point being data collection rates that need to be achieved more quickly than manual operations typically allow. The data-analysis and graphing software also allowed the students to do many more experiments within a short period of time, such that they achieved fruitful results on genuine scientific investigations within the tight time constraints of the school timetable At the end of their work, each group had to produce a laboratory guide containing instructions that would allow other students interested in investigating the same problem to conduct the necessary experiment.

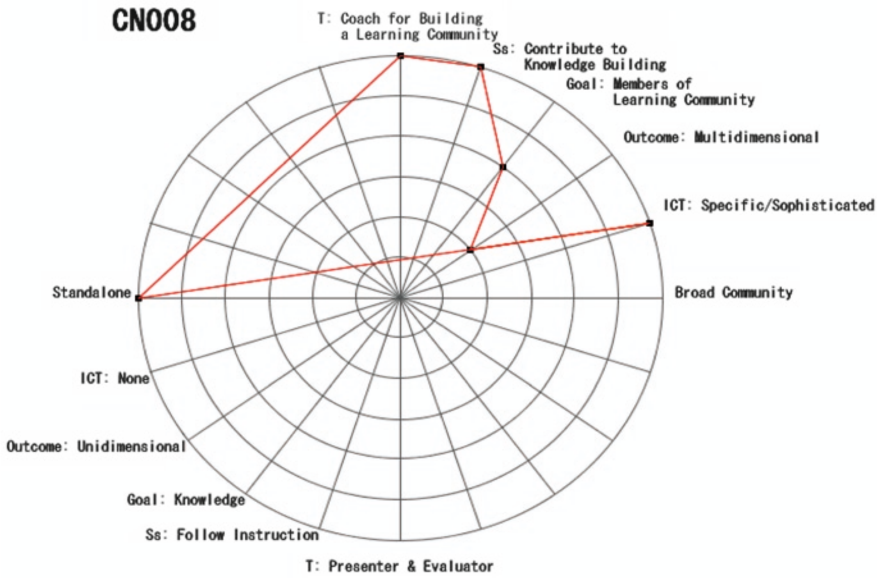


Fig. 4.5 The innovation profile for Case CN008, in which the student activities belonged to the *conduct inquiry* cluster

In this innovation, the students in CN008 worked as scientists in a laboratory, tackling genuine problems, formulating researchable questions for investigation, designing experiments, collecting and analyzing data, and ultimately drawing conclusions about the research questions and problems. They were thus not only autonomous learners but also autonomous problem-solvers, searching for relevant information and contributing to the creation of knowledge in a community. An innovation such as this clearly contributes to preparing students for work in the knowledge age of the twenty-first century.

Figure 4.5 shows the innovation profile for CN008. As is evident, this practice was innovative on all dimensions except for the connectedness. It was not innovative on this dimension because all activities were conducted without the involvement of people outside the school.

Student Roles and Extent of Pedagogical Innovation

The rating scales for the six dimensions of innovation that we reported in Chap. 3 were determined a priori, and the innovativeness of each case study was then scored against the scale rubric. The clustering of student roles reported here arose out of empirical explorations into patterns of co-occurrence of student learning activities. The innovation profiles of the five cases nearest to the geometric center of the five student role clusters showed differences across these cases not only in terms of their scores on the student role dimension, but also on the other five

Table 4.3 Means of the six innovation scores across the five student-role clusters ($n = 83$)

Innovation scores	Student role clusters: Follow instructions ($n = 29$)	Search and present info ($n = 11$)	Create digital products ($n = 18$)	Conduct online inquiry ($n = 7$)	Conduct inquiry ($n = 18$)	Total F (6, 76)
g_score	3.69	3.18	4.22	4.86	5.28	8.76**
t_score	3.69	3.09	4.5	5.43	5.56	15.08**
s_score	3.07	3.09	4.83	6.00	5.89	30.71**
it_score	5.72	5.64	5.67	5.86	5.72	0.11
m_score	3.14	3.18	4.78	5.86	5.00	10.82**
c_score	3.86	3.82	3.94	6.29	4.22	2.29

**$p < 0.01$

dimensions. Table 4.3 presents the mean scores for the six innovation dimensions computed for all the cases in each of the five student-role clusters.

No statistical difference emerged from among the cases in the five student-role clusters in terms of their scores along the IT sophistication dimension (it_score) and the connectedness dimension (c_score). However, we found significant differences in all the other four innovation scores ($p < 0.01$) across the cases in the five student-role clusters: g_score for the curriculum goal dimension, t_score for the teacher roles dimension, it_score for the IT sophistication dimension, and m_score for the multiplicity of learning outcomes dimension. This outcome provided a very pleasing triangulation for the two methods of analysis that were independently employed (i.e., scoring the cases on the six dimensions of innovation, and clustering on the independent codings of student activities).

The lack of relationship between student roles and level of innovativeness in ICT sophistication and between student roles and connectedness is consistent with the lack of correlations between the it_score and c_score repectively with the other four innovation scores reported in Chap. 3. Practices in the more traditional student-role clusters of follow instructions and search for and present information had much lower means (<4, i.e., having characteristics more traditional than emergent) on their innovation scores on the four pedagogical dimensions of curriculum goal, teacher role, student role, and multiplicity of learning outcomes. The mean innovation scores for the other four dimensions for each of the three more-innovative student-role clusters were higher than 4, indicating that all of these showed emerging characteristics as defined by the innovation rubric described in Chap. 3. This finding points to the importance of facilitating changes in student roles in pedagogical practices if the focus of the change is on pedagogical transformation.

Teacher Pedagogical Activities and Roles

This section presents the teacher activities and roles that we identified in each of the innovation cases and our subsequent cluster analysis of these activities and roles. Table 4.4 presents a summary of the frequency of occurrence of the 13 different

Table 4.4 Pedagogical activities engaged in by teachers

Code	Teacher pedagogical activities	Frequency	Percentage of cases
T1	Explain or present information	38	46
T2	Give task instructions	32	39
T3	Monitor student task progression	57	69
T4	Assess students	46	55
T5	Provide feedback to students	53	64
T6	Develop teaching materials	37	45
T7	Design curriculum and learning activities	41	49
T8	Select ICT tools	7	8
T9	Support/model inquiry process for students	31	37
T10	Co-teaching	27	33
T11	Support team-building and collaboration of students	19	23
T12	Mediate communication between students and experts	5	6
T13	Liaise with parties outside school	22	27

teacher activities that we identified from the 83 case studies analyzed. We list these activities in sequence, such that those at the top of the table (T1–T4) are ones that teachers traditionally engage in, namely, explaining or presenting information, giving task instructions, monitoring student progress, and assessing student learning outcomes. The activities listed towards the bottom of the table are the emerging activities – ones seldom found in traditional classrooms and likely to become more prevalent as they develop into the mainstream pedagogical practices of the future.

The only teacher role that was specifically ICT related was selection of ICT tools (T8). However, ICT use was evident, among the cases, in all of the other activities, particularly mediating communication between students and experts (T12) and liaising with parties outside the school (T13). In addition, the teaching materials developed by the teachers (T6) were generally in digital format, implying that the teachers had some level of media-production expertise.

The type of support denoted by T9 (supporting the inquiry process) most typically occurs when students are engaged in open-ended enquiries. It was evident from the case studies that teachers tended to provide this support when they were working as co-learners with students. In these instances, rather than issuing direct instruction, the teachers modeled the inquiry process. Teachers also tended to support team-building and student collaboration (T11) in situations where students worked in groups. In these situations, the inquiries being undertaken are usually collaborative in nature.

The activities associated with the codes T10, T12, and T13 are all connectedness related. Many of the classrooms in the case studies were much more open and connected to the outside community than were the traditional classrooms, where teachers worked as individuals in isolation from other classrooms or the wider community. In 33% of the innovations analyzed, we found teachers collaborating with other teachers within and outside their schools in order to organize activities. We also observed a relatively strong tendency for learning to be organized as a collaborative activity. We were therefore not surprised that supporting team-building and student collaboration was one of the activities that the most innovative teachers engaged in. The relatively low percentage of cases (23%) reporting teachers engaged in supporting team-building and student collaboration of students (T11) may indicate a lack of teacher awareness and/or expertise in supporting team learning.

Teachers usually found it necessary to mediate communication between students and experts (T12) and to liaise with parties outside the school (T13) whenever external parties were involved in the teaching and learning process. In some instances, outside experts contributed to student learning when the learning focus went beyond the normal school curriculum and/or the scope of expertise of the schoolteachers. In such instances, the teachers often mediated the communication between the students and the outside experts (T12). Other instances requiring liaison with people from the broader community were evident in endeavors relating to organization of field trips and other learning activities (T13).

Teacher-Role Clusters

As in our effort directed at forming student-role clusters, we used K-means cluster analysis to look for patterns of co-occurrence of teacher activities among the innovations in the 83 case studies. The cluster-solution that provided the most meaningful interpretation was a five-cluster solution, summarized in Table 4.5.

Descriptions of the key features of the teacher activities and roles within each of the five clusters follow. In order to provide a more vivid and contextual understanding of the nature of the teacher's role within each cluster, we describe the innovation for that cluster found to be closest to its geometric center.

Instructing

The teacher activities most frequently found in this cluster of practices were presenting information, giving instructions, monitoring and assessing student progress, giving learning support to students, and designing and developing curriculum materials and learning activities. These activities denote the role teachers traditionally played before the introduction and use of ICT. We labeled this role as *instructing* to highlight the didactic, teacher-centered nature of this role in this cluster of pedagogical practices.

Example: Using Technology to Explore Poetry

The innovation that we identified as closest to the geometric center of this cluster was Case PH006 ("Filipino Literati in Motion"). The instructional goal was to enable students to express their ideas and concepts about *tula* (Filipino poetry)

Table 4.5 The five types of teacher roles and the corresponding key teacher activities identified through cluster analysis

Type of teacher activity (number of cases in cluster)		Instructing (22)	Developing learning resources (18)	Coordinating student learning (12)	Facilitating exploratory learning (18)	Guiding collaborative inquiry (13)
T1	Explain or present information	✓				
T2	Give task instruction	✓		✓		
T3	Monitor student-task progression	✓		✓	✓	✓
T4	Assess students	✓			✓	✓
T5	Provide feedback to students	✓		✓	✓	✓
T6	Develop teaching materials	✓	✓			
T7	Design curriculum and learning activities	✓	✓			✓
T8	Select ICT tools					
T9	Support/model inquiry process for students				✓	✓
T10	Co-teaching			✓		✓
T11	Support team-building and collaborative process of students					✓
T12	Mediate between students and experts					
T13	Liaise with parties outside school			✓		

Note: A "ticked" cell indicates that the weighting for the particular activity in a specific cluster was >50%

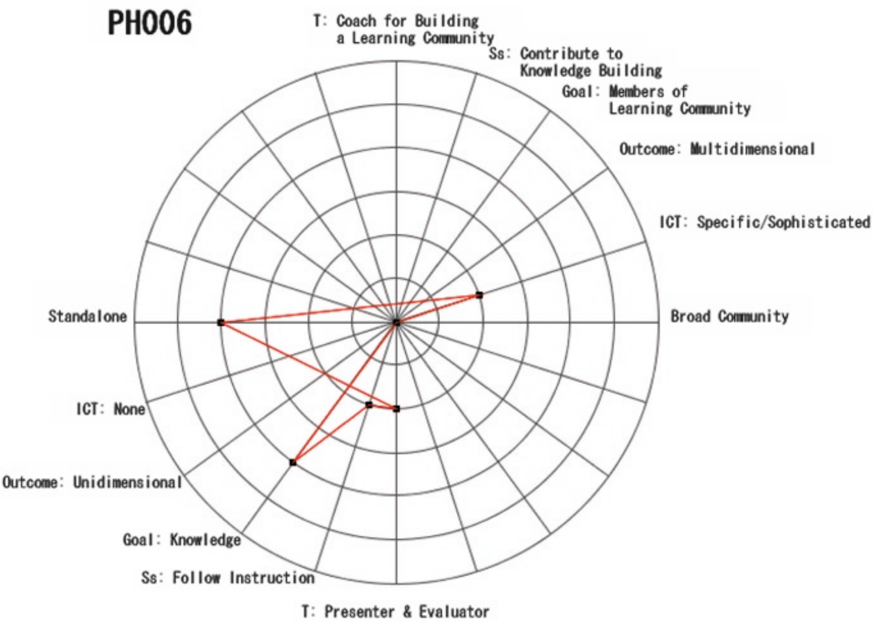


Fig. 4.6 The innovation profile for Case PH006, in which the teacher activities belonged to the *instructing* cluster

through technology-aided activities such as poster-making, devising slogans, writing poems, painting, and preparing slide presentations. This innovation took place in two class meetings (40 min per period) at the end of a teaching unit. During the first lesson, the teacher used different multimedia presentations throughout the various stages of the lesson (i.e., introduction, discussion, generalization, and setting of assignments). At the end of the lesson, the teacher flashed on screen the activities that the class would do in the next lesson. The teacher explained to the case study researchers that the presentations were a useful means of capturing students' attention. The teacher also acted as an "adviser" when the students prepared their presentations, giving comments and suggestions on, for example, layout, color, and picture quality, when necessary.

Figure 4.6 presents the innovation profile for Case PH006. Here we can see that this practice was rated as innovative for the ICT sophistication dimension only.

Developing Learning Resources

The cases in this cluster shared two teacher activities, in particular: developing teaching materials and designing curriculum and learning activities. The other activity with relevance for this cluster was explaining or presenting information, which we found in only 39% of the cases analyzed. We labeled the teacher role for this cluster as *developing learning resources*. Teachers in this cluster spent a major part of their effort on designing and developing learning resources. Most of these teachers also gave up their instructional and/or monitoring role during this process, thereby requiring students to take more responsibility for their own learning.

Example: Simulated Science Experiments

One of the innovations closest to the geometric center of this cluster was Case KR004, in which the teacher concerned created an interactive learning environment in which students had access to a shared database and where they could simulate scientific experiments. The teacher, who considered lecturing non-conducive to deep learning, wanted to promote self-initiated learning by giving students opportunities to perform simulation experiments and to read relevant information. The teacher designed curriculum materials for projection to the whole class, and programmed video simulations using Flash. The teacher also organized digital information and curriculum resources in folders for students. Students worked in the computer lab once a week, during which time they set up hypotheses, performed simulation experiments, and searched the Internet for information pertaining to their project.

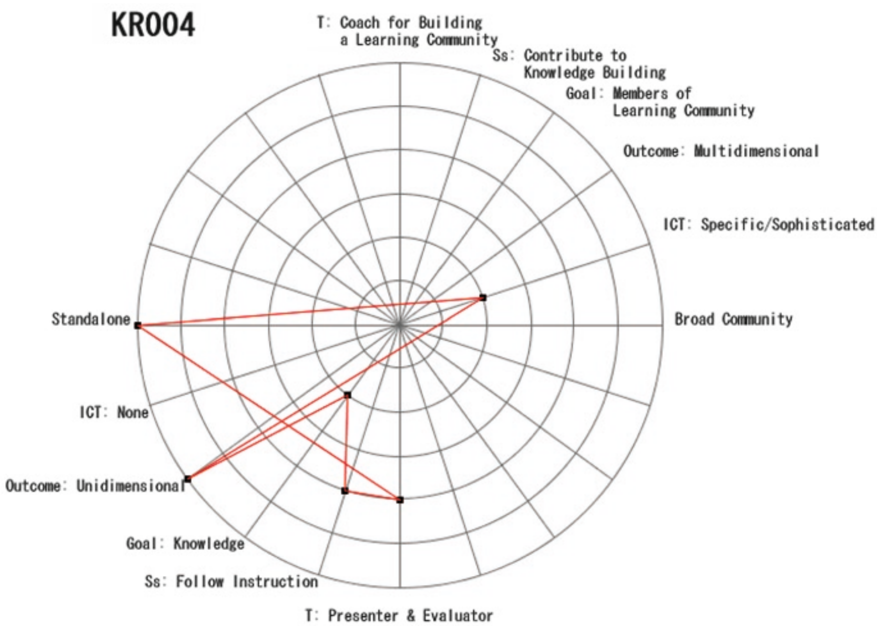


Fig. 4.7 The innovation profile for Case KR004, in which the teacher activities belonged to the *developing learning resources* cluster

Figure 4.7 presents the innovation profile for KR004, which shows that the only dimension for which we rated this practice as innovative was ICT sophistication.

Coordinating Student Learning

The most common teaching activities involved in this cluster of innovations were entirely different from those found in the developing learning resources cluster, even though in both clusters the presentation of information and the assessment of students were no longer important activities for the teachers concerned. In this cluster, the focus of the teachers was on providing activity structures and coordinating with other teachers and outside parties to facilitate the learning process. Hence, we labeled the teacher role in this cluster as *coordinating student learning*.

Example: Newspaper Reporters

The innovation closest to the geometric center of this cluster was Case DE005, in which students were given opportunity to acquire media competence by working as part of a newspaper editorial team. This supplementary media course was offered to 20 Grade 7 students in a comprehensive school in Germany. The students in this course took up the role of "city reporters" to interview different people, including politicians, actors, and musicians. The students' aim was to find out how these "personalities" used the Internet. The students posted their edited interviews on the Internet.

During this activity, the students learned to use software for publishing (word-processing, graphics, and editing programs) as well as media equipment, such as mini-disc recorders and digital cameras. This course was organized in the form of a project, and students spent four lessons per week in the media center. The head of the media center, who was also a qualified teacher of mathematics, physics, and information technology, was present during the lessons.

At the start of the project, the teacher assigned and explained the tasks to the students. During the second (working) phase, the teacher stayed mostly in the background, observing the students while they worked, making suggestions on new ideas, and pointing out mistakes (e.g., grammatical errors). The teacher also accompanied the students to their interviews and stayed in the background during these occasions, except for giving tips to the students from time to time. However, by this time, the teacher was no longer the expert, and in general the students developed greater technical competence than the teacher.

Figure 4.8 shows the innovation profile for Case DE005, which we rated as innovative on all six dimensions.

Facilitating Exploratory Learning

The most prominent feature of this role cluster was the strong focus on supporting and modeling the inquiry process (reported in 72% of all cases), which was the only teacher

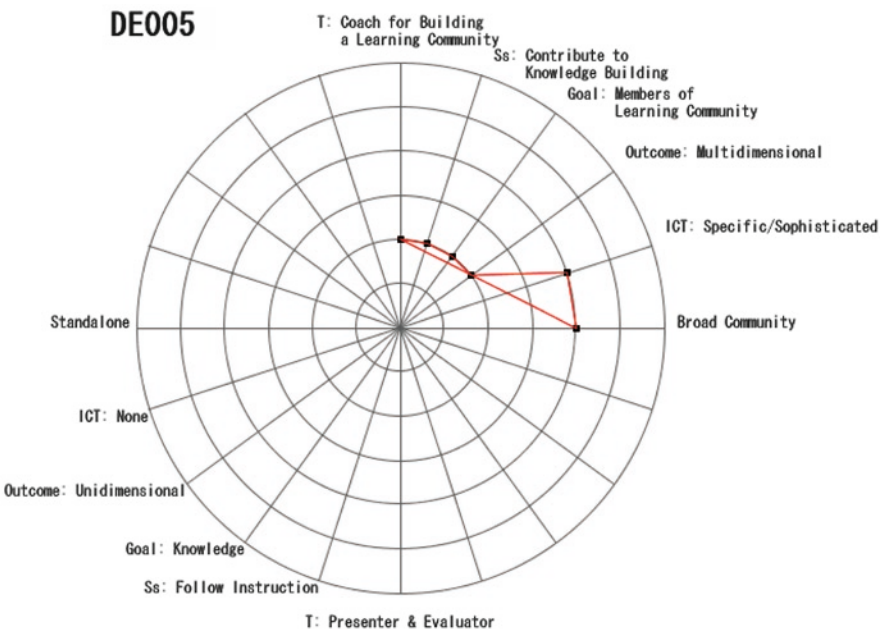


Fig. 4.8 The innovation profile for Case DE005, in which the teacher activities belonged to the *coordinating student learning* cluster

activity found in more than half of the cases in the cluster, other than the traditionally important roles of monitoring, assessing, and providing feedback to students.

Example: Integrated Use of Technology to Support a "Student-Active" School

The innovation closest to the geometric center of this cluster was Case NO004. This case featured a whole school in a small rural primary school about an hour's drive from Oslo, Norway. The innovation involved fundamental changes in the school's curriculum goals and content, and in how it delivered and organized that content. Students met as a class on a regular basis for only 20 min at the start of each school day to discuss what they were going to do for the week or the actual day and for a few minutes at the end of the day to review progress and to discuss what should be done next. During the rest of the day, students worked on projects for which their teachers had set the framework. Students decided which theme they wanted to work on and which methods to use in their projects, which were various, throughout the year: big and small, international and local.

The school organized itself as an office landscape, where the students could use all available resources and every available room, including the computer room, whenever needed. Students were free to organize their own day, choose whether to collaborate and who to collaborate with. Students could easily contact students and teachers from other classes and levels, and they were used to finding solutions by themselves or in collaboration with other students, instead of asking the teacher in the first instance. Teachers assisted students when needed, and held short talks relating to a topic for students who wanted to attend. Students who experienced difficulty keeping up with a weekly work program received a day-to-day plan. Assessment was designed to engage students in the process. Each week, students used a logbook to enter the subjects they had worked on, noted down how and what they had done in relation to those subjects, and stated what they thought they needed to do better.

Compared to many of the other innovations in this cluster, NO004 required a higher degree of collaboration among the teachers. Teachers were divided into two teams: teachers of Grades 1–4 and teachers of Grades 5–7. Each team met for 4 h each week on curriculum and school development matters, during which they took into account and discussed differences in student ability and student special needs. Figure 4.9 shows the innovation profile for Case NO004.

Guiding Collaborative Inquiry

Of the teachers across the five clusters, the teachers in this cluster engaged in the widest variety of teaching activities. Seven out of the 13 activities were present in more than half of the practices in this cluster. Explaining and presenting information was an important teaching activity in nearly half of the cases (46%). Teachers

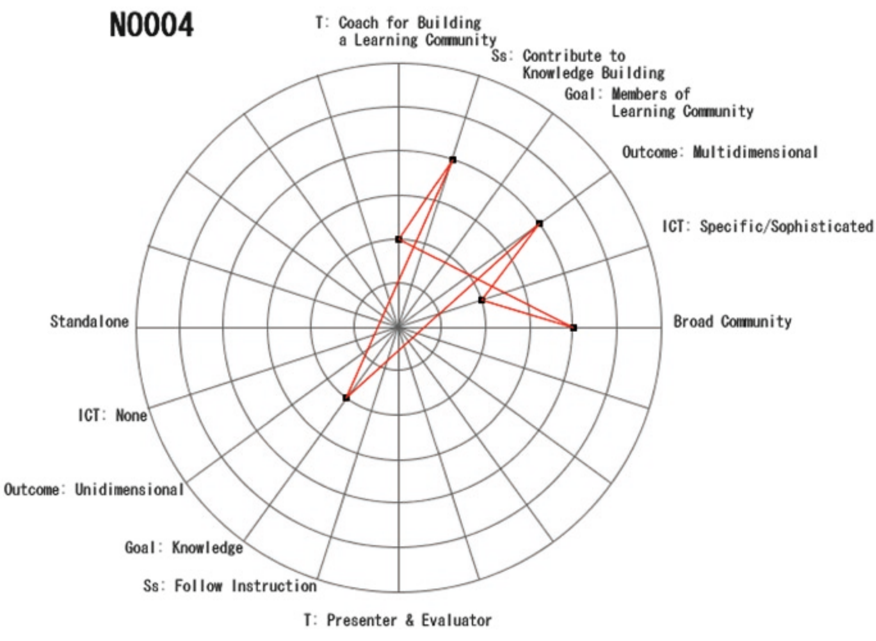


Fig. 4.9 The innovation profile for Case NO004, in which the teacher activities belonged to the *facilitating exploratory learning* cluster

involved in this cluster of innovations engaged in all teaching activities characteristic of the instructing role, except for giving task instructions and developing teaching materials. Co-teaching to support or model the inquiry process and to support team-building and student collaboration were also significant aspects of teacher activity.

Facilitating collaborative inquiry was clearly an important teacher activity in this cluster. Because the focus was on inquiry, there was little direct task instruction and developing teaching materials was not important. Teachers, however, still gave strong guidance to the students in the form of presentations, monitoring, assessment, and feedback. We labeled the teachers' role in this cluster as *guiding collaborative inquiry*.

Example: Project-Based Learning Using Wireless Laptops

The innovation closest to the geometric center of this cluster was Case US003. This innovation was implemented in the kindergarten through to Grade 5 classrooms of in an elementary school in the state of Virginia in the United States. The focus was on providing students with meaningful learning tasks linked to everyday life. Projects were not initiated within the context of a specific content area; instead, students selected real-world problems, and with the guidance of a teacher, collaborated to make connections between problems and to identify possible solutions. The flexible organization of the projects meant that they could vary in length from several weeks to an entire semester. Each project generally encompassed several subjects, including mathematics, reading, science, social science, and technology. Students worked collaboratively in and outside the classroom to manage their project, to collect, analyze, and synthesize information, and to present their results.

Each classroom was equipped with a printer and wireless-network enabled laptops containing integrated applications, multimedia software, organizing tools, and communications tools for email and web browsing. This set-up allowed students to work anywhere in the school grounds, to share information with one another, and to access content stored in a central school network, as well as to place materials in it.

The school identified the key role of the teachers as guiding collaborative inquiry. During the initial planning phase of the project, teachers posed questions to students in order to relate the curriculum (project) to students' interests and life experiences, and to elicit relevant information from students. In the second (fieldwork) phase, the teachers frequently circulated among the students, asking questions, helping them find information, use materials and ICT, and determine future directions. The teachers also regularly modeled how ICT could be used in different phases of the project cycle. Another important function for the teachers was grouping students into heterogeneous groups to ensure that low-performing students played a significant part in each group's work. The teachers regularly dedicated classroom time to help students develop the capabilities necessary for accomplishing the projects and to work effectively individually and in groups. These capabilities included self-monitoring and group process skills. The teachers also

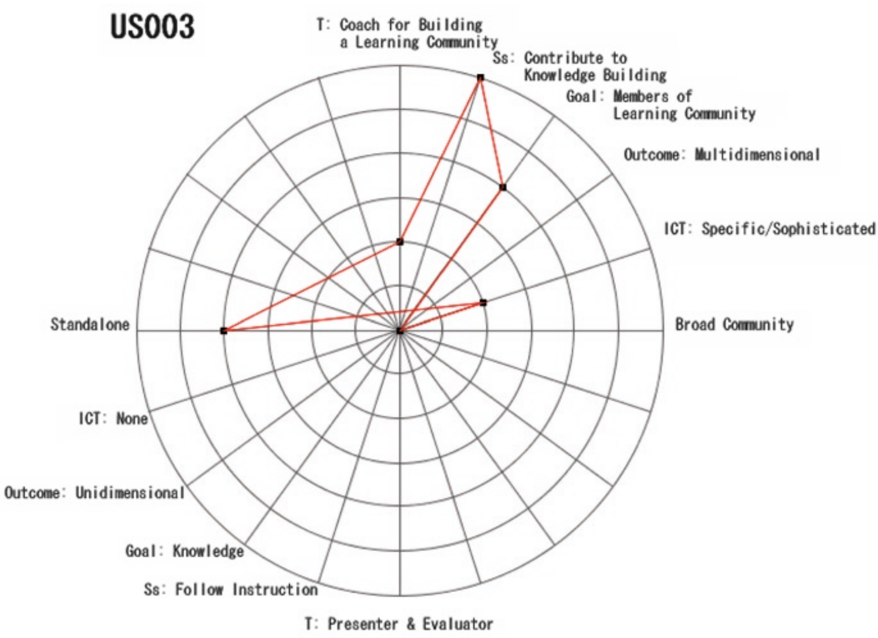


Fig. 4.10 The innovation profile for Case US003, in which the teacher activities belonged to the *guiding collaborative inquiry* cluster

collaborated with one another on a regular basis, particularly among those who teach the same grade level.

The innovation profile for US003 is shown in Fig. 4.10. Given the strong focus on developing students' ability to work on collaborative inquiry, we, not surprisingly, rated this innovation very highly on the curriculum goal and students' role dimensions. However, we assigned a low connectedness score because the students had no contact with parties outside of the school during the learning process. The teachers at the school had developed rubrics for a variety of content areas to assess student performance, but the need to ensure that the curriculum met the Virginia Standards of Learning (SOL) strongly influenced their assessment focus. As such, we rated the multiplicity of learning outcomes exhibited as emergent.

Teacher Roles and Extent of Pedagogical Innovation

The cluster analysis results revealed different combinations of teacher activities in the 83 innovations analyzed, each of which exhibited different extents of change from the roles played by teachers in traditional classrooms. Although listening attentively to teacher presentations did not figure predominantly in any of the five student-learning activity clusters, explaining or presenting information was reported in 86% of the cases in one of the clusters, which we subsequently labeled *instructing*. Explaining or presenting information was explicitly reported in 46% of the 83 cases analyzed, and also in 46% of the cases in the *guiding collaborative inquiry* cluster. This apparent contradiction suggests that creating and presenting multimedia materials figures as an important change in teachers' daily milieus as professionals. However, the national experts involved in compiling the case studies considered that this type of activity as having a negligible impact on students' learning process and achievement outcomes. It is important to note that monitoring student progress and providing feedback to students were prominent teacher activities in all of the teacher-role clusters, except for the *developing learning resources* cluster. Prominent teacher activities in the two clusters *instructing* and *developing learning resources* were no different in scope and characteristics from what teachers generally do in traditional classrooms, other than the fact that the teachers used ICT to accomplish these tasks.

The roles played by teachers in the other three clusters exhibited greater differences from those evident in traditional classrooms. We suspect that these differences will become more prevalent if the forces and conditions producing these pedagogical innovations continue to strengthen and so achieve the curriculum reform goals launched in many countries around the world, starting from the last decade of the twentieth century. For teachers in the *coordinating student learning* cluster, the nature of their interactions with students was not too different from that found in traditional practices. The unique feature of this cluster is the prominence of liaison with parties outside school as a teacher activity. Co-teaching was also reported in 75% of the pedagogical practices in this cluster.

The strong connectedness of the classrooms in this cluster provided students with valuable opportunities to learn with and from people outside of the school walls, which would not have been possible if the teachers had not played the coordinating roles. While ICT played an important role in facilitating communication with distant peers and experts, the teachers' vision and desire to facilitate this connectedness was the critical condition for achieving it. We note, however, that these teachers had to feel comfortable about having others share their roles as instructors and curriculum designers.

Another emerging feature in the roles played by the teachers was that of facilitating inquiry. Here, teachers modeled the process for the students and then supported them once they were engaged in it. The cluster analysis results seem to reflect two levels of fluency in the facilitation of inquiry. With respect to the first level, teachers in the guiding collaborative inquiry cluster were able to integrate the facilitation of the inquiry process with support for team-building and collaboration. With respect to the second level, there teachers in this cluster were more likely than those in the facilitating exploratory learning cluster to bring the more teacher-centered activities of designing curriculum and learning activities and presenting information into the facilitative process.

As was the case with our findings relative to the student-role clusters, the innovation profiles for the cases near the geometric center of the five teacher-role clusters revealed different extents of innovativeness along the six innovation dimensions (see Table 4.6). And as was the case with the corresponding results for

Table 4.6 Means of the six innovation scores across the five teacher-role clusters ($n = 83$)

	Teachers' role clusters					
Innovation scores	Instructing ($n = 22$)	Developing learning resources ($n = 18$)	Coordinating student learning ($n = 12$)	Facilitating exploratory learning ($n = 18$)	Guiding collaborative inquiry ($n = 13$)	Total F (6, 76)
g_score	3.41	3.50	4.33	4.89	5.31	10.12**
t_score	3.50	3.78	4.75	4.78	5.54	8.57**
s_score	3.59	3.33	4.50	5.06	5.69	8.30**
it_score	5.59	6.00	5.67	5.67	5.62	0.90
m_score	3.45	3.11	4.83	4.78	5.15	6.42**
c_score	3.86	3.83	5.42	3.67	4.62	1.84

**$p < 0.01$

the student-role clusters shown in Table 4.3, we found no statistically significant differences across the five teacher-role clusters in terms of their mean IT sophistication score (it_score) and connectedness score (c_score). We did, however, find statistically significant differences among the other four mean innovation scores ($p < 0.01$) across the different teacher-role clusters. This consistency in findings between a priori innovativeness rating of teacher roles and empirical coding of teacher activities and the subsequent cluster analysis into role clusters provides further triangulation evidence for the validity of these two methods of analysis and the findings that ensued.

Practices in the more traditional teacher-role clusters *instructing* and *developing learning resources* had much lower means on the four pedagogical dimensions of curriculum goal, teacher role, student role, and multidimensionality of learning outcomes, as well as on the connectedness dimension. These innovation scores were all lower than 4, defined as the emergent level, and so showed only the initial features of innovative characteristics. The mean innovation scores for the four pedagogical dimensions were higher than 4 for the other three teacher-role clusters, even though these typify different activity profiles of teachers.

It is clear from Table 4.4 and the descriptions of the exemplar cases near the cluster geometric center that the changes in teachers' daily milieus and the expertise required to facilitate and accommodate these changes is probably much greater for the *guiding collaborative inquiry* cluster and relatively less for the *coordinating student learning* cluster. One important implication of this finding is that the activities and roles of the teacher have a major influence on student activities, roles, and learning outcomes. More importantly, it demonstrates that as long as the teacher's focus is not only on using ICT to improve traditional teacher activities and roles but also on introducing even one new pedagogical focus – be it connecting students with the outside world or developing students' inquiry skills or collaboration ability – significant changes in the other pedagogical dimensions will result. While we observed many new activities and roles in the teacher practices in the pedagogical innovations collected in SITES-M2, the findings of our analysis indicates that it is not necessary for teachers to adopt the full variety of new activities for the innovations to bring about beneficial outcomes.

Teacher and Student Roles: How Related Are They?

The exact roles played by teachers and students in the 83 innovations analyzed might differ, but the curriculum and pedagogical designs were still the teachers' domain of responsibility. Thus, we could expect a close correlation between the roles that teachers play and the roles that students play in relation to the same practice. For example, if the teacher's role is one of instructing, then we can assume that the role of the students involved in the practice would be that of following instructions. If the students are learning through inquiry, then the corresponding teacher roles are likely to be those of facilitating exploratory learning and guiding collaborative inquiry.

The cross-tabulation of the cases across the different student- and teacher-role clusters presented in Table 4.7 indicate broad confirmation of these expectations. The column maxima (the bold figures in the table) represent the most likely teacher-role cluster for each of the student-role clusters. These fall along the diagonal of the table, indicating a high correlation between teacher and student roles. In 28 of the cases, both the students and the teachers were performing relatively traditional roles. A slightly higher number of cases (31 cases) had both students and teachers playing more emergent roles. Thus, overall, 59 of the 83 cases analyzed are located in the speckle-shaded boxes in Table 4.7, indicating that the extent of innovativeness in student and teacher roles matched in the majority of the innovations (71%).

But does the quadrant in which an innovation is located matter in terms of its scalability? From an ecological perspective, the cases in the upper-left quadrant of Table 4.7 do not really require changes in social practice because the roles of both

Table 4.7 Cross-tabulation of the distribution of cases across the different combinations of student-role and teacher-role clusters ($n=83$)

	Students' roles					
Teachers' roles	Follow instructions	Search for and present information	Learning through digital production	Learning through inquiry online	Learning through inquiry	Total
Instructing	**10**	4	5	1	2	22
Developing learning Resources	9	**5**	2	1	1	18
Coordinating student learning	5	0	2	**2**	3	12
Facilitating exploratory learning	4	2	**6**	**2**	4	18
Guiding collaborative inquiry	1	0	3	1	**8**	13
Total	29	11	18	7	18	83

Note: The speckle-shaded boxes indicate a match in the degree of innovativeness in the roles played by teachers and students. The bold figures are the column maxima, which indicate the most likely roles played by teachers for cases in each of the student-role clusters the teacher and the students remain traditional. The main change involved is the introduction of ICT into the instructional process. Hence, from a theoretical perspective, these cases should be relatively straightforward to sustain or transfer, although whether they are really worthy of scaling up is another matter. The teachers and students involved in the innovations in the lower-right quadrant had to engage in many new activities involving new skills and significant changes in the roles they played. It is likely that sustaining or transferring these cases would be much more difficult.

And what about the cases where there were mismatches in the two pedagogical roles? The 12 cases in the un-shaded lower-left quadrant of Table 4.7 are ones where teachers took up innovative roles and experimented with many new activities requiring much professional learning while the students were still playing much the same traditional roles of *follow instructions* (10 cases) or *search for and present information* (two cases). The situation of the 12 cases in the un-shaded upper-right quadrant denotes the reverse situation. Here, students were able to play more innovative roles in the learning process even though their teachers were playing traditional roles.

It appears that in the former group of cases, the teachers had the motivation to change their own practices, but were not certain about giving a more autonomous, responsible role to the students. However, in the latter group of innovations, the teachers were willing to let the students try out new activities and roles while keeping their own practices largely unchanged. Hence, one group of cases involved risk-taking in terms of the teachers' own activities and roles while the other involved risking-taking through giving a freer hand to the students.

Ecologically, both situations involve change that is likely to be propagated through the other contextual elements in the education environment at both the classroom and school levels, but the challenges are different. Would innovations involving less change on the part of the teachers be easier to implement and scale? Do students' learning outcomes relate more to teacher role or student role? Can we identify observable features of pedagogical practices at the classroom level for the innovations in the different quadrants? We explore these issues in the following chapters by analyzing the innovations from the perspectives of pedagogical design, teacher competence, and organizational context and support.

Chapter 5
Pedagogical Practices, Technology Use, and Teacher Competence

During our investigations reported in the previous two chapters, the role of the teacher emerged as the most critical ecological niche; we found that it significantly correlated with the other five dimensions of innovation. We also found that the teacher role was not necessarily innovative, even in the SITES-M2 innovation case studies. Further analyses revealed that, in some cases, the teacher's activities and roles remained traditional even when the students' activities and roles had changed. In this chapter, we move from ecological analyses to an examination of how teaching and learning is organized in the complex everyday milieu of the school in the different case studies.

In Chap. 2, we used the butterfly as an ecological metaphor to describe the highly complex activity referred to as pedagogical practice. We describe students' role metaphorically as the crop species, as we are interested in the seeds (learning outcomes) of the mature plant. In the same vein, we consider the role of the teacher as the keystone species. A keystone species is one whose impact on the structure of the ecological community is greater than would be expected based on its relative abundance. Although the plant whose leaves are feeding the caterpillars need not be overly abundant in comparison with the abundance of the crop species, it will nonetheless greatly influence the population composition of the entire ecosystem. The interaction between the plant that the caterpillars feed on (teacher role) and the flowering plant (the student role) is mediated through the butterfly (pedagogical practice).

A pedagogical practice encompasses the full set of teaching activities (often referred to as "methods of teaching") that a teacher engages in to support student learning. It requires planning as well as complex decision-making – effort that is conducted in a dynamic yet often poorly-defined environment. When, in this book, we refer to types of pedagogical practice or methods of teaching, our focus is on how teachers organize teaching and learning activities and tools and their interactions withlearners, other teachers, and (if applicable) other involved parties. Gagné (1965) identified six types of instruction method: tutoring, lecturing, recitation, discussion, laboratory-based, and homework. This classification no longer sufficiently encapsulates the teaching approaches employed in classrooms today.

N. Law et al., *Educational Innovations Beyond Technology: Nurturing Leadership and Establishing Learning Organizations*, DOI 10.1007/978-0-387-71148-5_5,

Joyce and Weil (2000), for example, provide descriptions of many more formats for organizing teaching.

Formats for organizing instruction are normally included as a core component of pre-service and in-service teacher education programs. In this chapter, we examine the case studies to identify major formats of organizing teaching and learning in the innovations, the kinds of ICT used for each of these formats, and the corresponding competences demanded of the teacher. Two of our aims in conducting this particular exploration were to provide insight that could inform the design of professional development programs for teachers and to shed light on the findings reported at the end of Chap. 4.

The literature contains two popular inter-related perspectives on teaching methods. The first is generally referred to as "approaches to learning" (Fenstermacher & Soltis, 2004). This perspective focuses on the philosophical commitment and orientation underlying pedagogical decisions. The second perspective focuses on the kinds of learning and teaching activities involved and related specific arrangements and concerns. We consider the second perspective best suited to provision of holistic concrete descriptions of the SITES-M2 innovations, for two main reasons. First, it is easier to describe and categorize the cases according to observable data and activities. Second, pedagogical practices that are highly similar in their activity and organizational configurations may differ greatly in terms of the underpinning curriculum goals and teaching philosophy held by the teachers concerned. Goals and philosophy are more difficult to probe and are prone to multiple interpretations. In this chapter, we focus on the format, structure, and organization of the teaching and learning activities involved in the innovations. We refer to the resulting categorizations as "pedagogical practice types" rather than "methods," because the latter term may give the impression that we are providing strict operational descriptions and directives.

Using as our basis the nature and format of the most prominent teaching and learning activities reported in the case studies, we identified six types of pedagogical practice. We describe each in the following sections, highlighting its key features and how ICT was being used. This is followed by an exploration of the relationship, if any, between the pedagogical practice type and the level of innovativeness of the case studies that adopted it. Our analyses revealed that some practice types had higher mean innovation scores for the teachers' roles and the students' roles than others. However, there was also large variability in innovativeness for cases of the same pedagogical practice type. On exploring further, we found that some types of pedagogical practice have the potential for higher innovativeness. However, to realize this potential, teachers have to master new competencies that go beyond learning how to use technology. In the latter part of this chapter, we examine several case studies in detail in order to highlight the new competencies and knowledge that teachers require if they are to successfully implement the various pedagogical practice types. We also discuss the implication for teacher professional development and teacher support in the concluding section.

Table 5.1 Distribution of the 83 innovations across the six types of pedagogical practice

Types of pedagogical practice	Number of cases
Expository lessons	3
Virtual schools/online courses	11
Task-based activities	10
Scientific investigations	7
Media production	18
Project work	34

Characterizing Pedagogical Practice

The six major formats used to organize pedagogical practices that we identified were expository lessons, virtual schools or online courses, task-based learning, scientific investigations, media productions, and projects. Table 5.1 summarizes the distribution of the 83 analyzed innovations across these six types of pedagogical practice.

Expository Lessons

The least common type of pedagogical practice was expository lessons, accounting for only three of the 83 cases analyzed. Classroom practice consisted mainly of the teacher giving presentations and explanations on selected content and providing students with exercises and feedback. The main activities for students were listening to the teachers' presentation and engaging in drill and practice exercises. Technology was used to enrich the teachers' expositions as well as to deliver drill and practice exercises, often with feedback. Case ES006 (Internet in the classroom) provides an example. The school implemented ICT extensively in the teaching and learning of various subjects, such as technology, physics, and chemistry. Teachers used multimedia tools to make their presentations more vivid and interesting. They also provided their students with drill and practice software with immediate-feedback functions.

Virtual Schools and Online Courses

In 11 of the case studies analyzed, the Internet was being used as a medium to deliver lessons or courses. Virtual schools and online courses was the only type of pedagogical practice that depended totally on digitally mediated interactions. Virtual schools are typically offered by educational organization, which provides, on a year-round basis, a variety of subjects via online means, including a comprehensive website, a detailed curriculum, and a timetable. The case study virtual schools had generally been set up to offer subjects that would not have a sufficient level of enrolment and/or teaching expertise to be offered in a single school. It is probably not accidental that many of the subjects offered were multidisciplinary in nature.

Some of the virtual schools were operated by one central course provider, and interested schools subscribed to their services. This was the situation with Case AU003, which reported Education Queensland's (Australia) virtual schooling service (VSS). The 18 "virtual" teachers involved in this innovation planned and prepared online learning materials and teaching for six subjects for a total of 320 secondary students in 49 schools throughout the state. Students typically attended two "real time" lessons per week, which took place within a class of distributed students, and a VSS teacher delivered the lessons via audio teleconferencing and shared computer graphics (audiographics). This provision was supplemented with scheduled independent study time. During this time, the students worked in an online "study room," where they used a range of communication tools, including email and "real time" chat rooms, to complete activities and assignments. Each participating school provided a "study coach" from their staff to guide and assist students locally. In some of the relevant cases that we considered, the virtual school was being operated through the coordinated efforts of a network of schools, which had brought together their online courses under a central administration. The online high school in Case US020 (see Fig. 3.2) provides one such example.

Other than virtual schools, which were relatively formal establishments of some scale, there were also online courses organized by schools as a supplement to the general school curriculum. Some of the online courses were organized to deliver a complete course; others covered only a few learning units for specific subjects. Online courses were generally organized as supplementary enrichment rather than as a significant component of the existing school curriculum. The innovation involving IT-enabled experiential learning (Case SG006) in a Singaporean high school was one of the examples we came across of building an online course as enrichment for students. The teachers developed extensive sets of online materials, which covered a full range of topics in physics and Chinese language and included visualizing tools, audio clips, interactive exercises, and chat rooms. Every week, the classes spent either one or two periods of their physics or Chinese lessons in the computer laboratory, where they worked on their own with the online materials to learn assigned topics.

The innovations belonging to this type of pedagogical practice were highly diverse with respect to how the learning was organized, the stakeholders involved, the technologies involved, and the pedagogies employed. However, these 11 cases shared a common goal of providing learning opportunities for students who were separated in space and/or time from one another. This common goal led to other common features among the cases of virtual schools and online courses. The need to overcome this major hurdle of separation in space and time led to teachers and students using a range of sophisticated technology. We observed that the goals of these courses were essentially the same as those for subjects delivered in a face-to-face mode. As Law (2003) points out, this new mode of learning requires learners to develop a greater sense of autonomy and self-direction as well as the skills and dispositions for lifelong learning. They also require teachers to exercise new tasks brought about by the emergence of differentiated teaching roles, such as study coaches and education professionals who specialize in developing online course materials.

Task-Based Activities

The assignment of task-based learning activities to students was a major focus for learning in the cases analyzed. The design of the tasks themselves comprised an important component of the teachers' planning and preparation work, although the nature and variety of the tasks involved differed across the ten cases belonging to this type of pedagogical practice. Teachers usually designed task-based activities with the aims of helping students master specific subject-matter knowledge or skills and allowing students to play a more active role than they would during expository lessons. However, the task-based activities reported in the case studies tended to be close-ended, short, and clearly focused, and ICT use was generally confined to task delivery online.

An example of tasks designed to help students consolidate their conceptual understanding by accessing designated digital resources and following step-by-step procedures for task completion was evident in a physics lesson on atomic structure described in Case TW003. The teacher prepared and then gave students worksheets containing instructions that directed the students to learn key concepts by searching for specific information on the Internet and observing computer simulations. Another example is the innovation "digi-lessons in primary education" (Case NL002). The digi-lessons were Word documents that set out assignments containing website links, so that students could search for information on the Internet. The strength of this innovation, as reported in the case study, was that students could master subject-content knowledge and ICT-based skills at the same time.

The case report authors often referred to innovations involving task-based activities as representing a move towards a more "student-centered" pedagogy. Certainly, the students in these cases were often busily engaged in task completion. However, the cognitive and metacognitive demands on them were often little different from those experienced in traditional classrooms because all the students were required to do was to closely follow instructions. The teacher still played a prominent role in determining the learning goals, activities, and procedures.

Scientific Investigations

Seven of the 83 cases reported innovations that involved scientific investigations. Although these practices were inquiry-focused, the students worked on ill-structured questions. Students usually worked in groups, and the investigations often took place over an extended period of time. This type of practice shared many common features with *projects* (see below). In our categorization framework, we distinguished scientific investigations from projects on the basis of several significant features. First, the investigations had a clear subject-matter focus on science. Second, an important goal of the investigations was to help students understand the targeted scientific concepts by engaging them in experiments and having them work with the primary data collected. Students were involved in laboratory experiments or simulations to test their hypotheses about specific scientific phenomena. For example, in an interschool innovation that required students to use telecommunication tools to study the climate and weather (Case ES001), students from four schools worked together to investigate and compare the climate at different places. They used meteorological instruments to collect information on various weather variables at their respective school locations and shared the data with remote peers online. And, third, the technology used and the facilitation required were specific to the scientific area concerned. Case ES001 again provides a relevant example because the students involved used meteorological instruments to collect their data on weather. These features probably explain why we found only seven scientific investigations among the 83 case studies analyzed.

Media Productions

The key distinguishing feature for this type of pedagogical practice is its central focus on the production of a media product, which may comprise web pages, visual images, animation, and music or video productions. The innovations categorized within this type of pedagogical practice showed wide variations in terms of the targeted media products, the complexity of the activities involved, and the length of time over which the practice took place. Some media-production cases were relatively short in duration and relatively close to traditional classroom learning. For example, in the innovation "Digital Art" (Case SG001), students used artwork applications to draw. The students could complete each learning unit within one to two class periods, and, except for the adoption of technical tools to empower the students' learning, the manner in which the activity was organized was the same as that associated with traditional art classes.

Other media-production innovations also differed little in organizational terms from that evident in traditional learning settings, but collectively they involved an extensive range of activities and subjects. For example, the international collaborative project, "MI LUGAR" (Case CL009), a semester-long interdisciplinary project that involved all Grade 10 students in a Chilean secondary school, produced a website for introducing the province in which this secondary school was located. The innovation was conducted under the framework of an overarching international project, WorlDLink, a World Bank Economic Development Institute program. The aim of this program is to create interactive and co-operative learning communities in schools through the use of communication technologies. One of the most distinctive features of this innovation was its coverage of 11 subject disciplines. Teachers developed, within each of these disciplines, a sub-project scheme that required students to conduct inquiry-based work in teams, with each team focusing on a particular aspect of the topic. The students worked in the computer lab for 2 h each week throughout the semester in order to construct a website featuring the topic.

The pedagogic features of many of the media-production innovations, especially those involving extended cases, were similar to those evident in the innovations categorized under the pedagogical practice type, projects. The media productions were, in fact, sometimes also referred to as projects in the case reports. Both practice types typically require students to work on ill-defined tasks for an extended period of time, and some project activities also include creation of a website, as evident in Case DK007. However, in projects, the purpose behind producing a website was mainly to present student learning outcomes as a final phase of the learning process and not as a major component of the learning activities. In a media-production practice, the creation of products was central; all other activities in the practice were geared towards facilitating it.

The process of learning, therefore, in a media-production innovation was encapsulated in the production process, and the learning focus was on the quality of the product, including its technical sophistication. To give another example, in the case "Educational Radio Station" (Case IL006), 50 Israeli students worked together to operate a radio station, which daily broadcasted a student-produced program. To maintain the operation of the station and its programs at a professional level, students had to learn a lot of knowledge and skills, and engage in a variety of activities. More specifically, they had to attend courses directed at giving them theoretical knowledge about mass communications, they had to acquire the technical skills needed to operate broadcasting devices and systems, to prepare and produce radio programs, and they had to take part in evaluation meetings, including self-evaluation and receiving feedback from the teacher and fellow students.

Project Work

Project work is a label often used to describe learning activities that are extended in time and that have well-defined aims and intended products. It often involves students working in groups through different stages of project progression, targeting learning goals that include not only knowledge and skills in specific content areas, but also metacognitive and sociometacognitive skills. Some pedagogical strategies considered conducive to the development of twenty-first-century abilities, such as collaborative learning and problem-based inquiry, can accordingly be easily integrated into projects as a form of pedagogical practice.

We were not surprised to observe that project work was the most commonly found pedagogical practice type, comprising 41% of the 83 cases analyzed. Depending on the criteria for categorization, one may even consider media-production and scientific investigations to be specific forms of project work. However, the 34 cases categorized as projects differed greatly in terms of their curriculum goals, organizational characteristics, and the roles played by the teachers and students involved. For ease of understanding the diversity across these innovations, we further categorized projects into four types: thematic projects (18 cases), study trips (2), online discussion projects (10), and aggregated task projects (4).

Thematic Projects

Students involved in these projects are assigned a theme that can be as varied as understanding the El Nino phenomenon, developing a business plan, or tackling local conservation problems. The theme usually acts as a context within which students gather information and develop a product to demonstrate the understanding they have gained from the process. In some cases, the different groups of students may be required to work on the same set of tasks; in other cases, the different teams may work on different tasks related to the same theme in order to contribute to a large, coordinated product.

Some of the thematic projects in the case studies had a strong research element, such as a project from Germany titled "The Economy and Schools" (Case DE014, see Fig. 3.2), which required the students to conduct extensive research on two enterprises before developing their own business plan. During the project, the students obtained information available on the Internet and in databases (e.g., business reports) about a large organization. They then analyzed that material. They also examined a smaller, local company through analysis of documents, visits to the company, and interviews. They furthermore developed a business plan that was backed up with research and set out financial and personnel requirements and a business strategy. They ended their work with a public presentation. The teachers played a crucial role in enlisting the participation of companies, coordinating activities, and monitoring project progress. They played the dual role of co-learners and assessors by participating in the information retrieval and information research activities with the students and giving grades to those students.

While the project reported in Case DE014 was a sophisticated, year-long project organized around an authentic real-world problem, not all of the thematic projects that we identified were as complex. Some focused mainly on developing students' ability to search for information and to create presentations via technology. Case LV002 from Latvia provides an example. It featured integrative use of ICT in geography and informatics lessons. The project required each student to perform internet searches and then develop presentation materials and reports using ICT. The geography teacher planned the lesson activities, set the tasks, distributed the responsibilities to the students, monitored task progression, and helped the students to solve learning problems. In this project, the teacher still played a dominant role in decision-making in all stages of the project, which made this kind of thematic project very similar in nature to task-based activities.

Study Trips

Only two of the 83 cases were organized as study trips. While the study trips in both cases were of short duration, they were, in fact, a culmination of the learning process that extended through a much longer period of time. As part of their preparation for their trip, students searched for information and identified learning problems. Essentially, the trips were a thematic project in which the final phase was the trip. The two classes of Grade 10 French students in Case FR005 that took part in a study trip to Rome were involved in a year-long project about the Roman Empire. The teachers concerned assigned various tasks to the students, which included collecting information about the Roman Empire, watching an Italian film, writing a learning diary, and taking part in a short movie production. The students' trip encompassed a week of study in Rome under the guidance of six teachers at a late stage of the project. The aim of the trip was to give the students a better understanding of the topics they had been studying. During this innovation, the students used ICT to support information retrieval, write up fiction scenarios and trip diaries, engage in film production, and then distribute these products through websites and on a CD-ROM.

Online Discussion Projects

The distinguishing feature of this type of project is the use of online discussions to support the collaborative co-construction of knowledge, usually involving students from different schools, on an identified theme. One example of this kind of project that emerged from among the case studies was one titled "Springtime in Our Part of the World," which involved an email discussion-based exchange between classes in Denmark's Southern Jutland and Faeroe Islands (Case DK007). This project aimed to extend students' "horizons" by having them explore the conceptions of springtime held by people living in different geographic, climatic, and culture contexts. The students completed the project by creating a website on which they presented their learning outcomes.

The project was organized as follows. The first step saw the students engaging in class discussions, during which they identified five sub-themes for studying springtime. They then worked on each sub-theme via a range of activities, such as writing email texts, searching out information on the Internet, reading and recording poems to send as voice mails, and constructing web pages linked to the class home page. One group of students was responsible for collecting and presenting another group's work in the form of web pages, as well as updating the class on emails sent from the Faeroese students. The Southern Jutland teacher and the Faeroe Islands teacher collaborated to plan out the students' program of work. They monitored the students' written work, editing each text alongside the students concerned. They also provided supervision and guidance to individual students and groups, and directed the project during classroom-contact time.

Not all online discussion projects aim to produce tangible deliverables at the end of the learning process. Some discussion projects may involve communication with members of the wider community instead of peers, and the focus for the projects may simply be to extend understanding. One example of this kind of discussion project involved learning through web-based discussion (Case CN009). During their discussions, students raised questions related to any physics, chemistry, biology, or mathematics matter that they wanted to understand better. Because the forum was open to all students, teachers, school supervisors, and school alumni, the students could post questions and receive feedback from teachers and peers, as well as from outside experts. The teachers did not designate which topics should be discussed; nor did they commit to providing the students with answers to their questions. Instead, they provided the students with direction on how to search for relevant information and then left the students to solve the problems by themselves.

Aggregated Task Projects

This type of project organization is very similar to task-based activities in that these are generally short and without inherent linkage between the different tasks. However, they still fall within the project category, as they are put together under a single learning theme. One example of this kind of project was the innovation relating to the Whitbread Yacht Race "Searching for information on the Internet in the 'Whitbread Race' Project in Lower Secondary Education" (Case NL013). Over 10 weeks (a quarter of the school year), the secondary school students involved worked, for two 45-min lessons per week on a number of internet-based tasks, all related to a virtual sailing tour.

While the project as a whole was extended, the individual tasks were not (see Fig. 3.3). The teacher set up a project website, on which were eight chapters containing several assignments, along with folders for each student containing their particular assignment work. The students often worked in groups to collect information from reference books and the Internet about the relevant seaport or country, discuss the assignments, share the tasks, exchange answers, and help one another. They also had to complete a paper-and-pencil test about the Whitbread Race and, as a final product, design and then make a game featuring this race.

This aggregated task project was very similar to the task-based activities in terms of pedagogical approach and task design, but it was constructed as a coherent sequence around a theme that the students had to follow through. Also, aggregated task projects generally are more extended in time and magnitude than task-based activities, which are generally completed within one or several lessons.

Summary

In summary, there is great diversity among the innovations categorized as projects. With the increasing emphasis on developing students' self-directed, lifelong-learning ability, projects are becoming a very popular form for organizing student learning in many schools. However, even among the projects collected in the SITES-M2 study, we found substantial differences in terms of the complexity of the project themes, the deliverables expected, the extent to which the students were given responsibility to determine their own learning goals, the duration of the project, and whether the students worked in collaborative teams or as individuals.

Depending on the nature of the project, the ICT tools used also differed greatly. Those that incorporated collaboration with distant peers or community experts relied heavily on communication technology. Those with a strong emphasis on information search needed Internet connection and search engines, while those involving the production of digital deliverables as outcomes of the learning process required the use of multimedia production tools and web-page editors.

Pedagogical Practice Type and ICT Use

In this section of Chap. 5, we explore the kinds of ICT tools that the case-study teachers and students were using. We also look at preferences for specific tools for particular pedagogic practices. We identified 15 different types of technology in the 83 cases examined, which we grouped into general hardware, software, and network communication tools. We further categorized these technologies into the seven groups listed in Table 5.2. The table makes evident that while most of the tools were not designed specifically for educational purposes, many of the specialized, discipline-specific tools, such as simulation and modeling software and data-loggers (for sensing and recording experimental data), were. Teachers and other relevant individuals often derived this latter group of tools from tools used by professionals in the respective disciplines.

Table 5.2 Types of ICT tools used in the SITES-M2 cases analyzed

Specialized/discipline-specific tools/software	Simulation and modeling software
	Data-logging tools
	Data-analysis software
Tutorial/reference resources	Tutorial/drill and practice software
	Learning support resources, reference resource materials
Mobile technology	Laptop computer, hand-held devices
Network and computer-mediated communication (CMC) tools	Asynchronous communication tools
	Synchronous communication tools
	LAN
Multi-media production tool	Web page/multimedia authoring tool
	Media capture equipment
Basic Internet access	Email
	Internet browser and search engines
General office application	Word-processor
	Presentation software

Table 5.3 Use of various ICT tools in the different pedagogical practices[a]

ICT tools used / Type of practice	Basic Internet access	General office application	Multimedia production tool	Network and CMC tools	Tutorial/ references	Specialized tools	Mobile technology	Total cases
Project-based learning	29 (85%)	25 (74%)	19 (56%)	15 (44%)	11 (32%)	9 (26%)	9 (26%)	34
Scientific investigation	4 (57%)	4 (57%)	3 (43%)	5 (71%)	1 (14%)	6 (86%)	1 (14%)	7
Media production	16 (89%)	12 (67%)	16 (89%)	6 (33%)	3 (17%)	2 (11%)	4 (22%)	18
Task-based learning	7 (70%)	4 (40%)	5 (50%)	6 (60%)	6 (60%)	3 (30%)	3 (30%)	10
Virtual schools	9 (82%)	3 (27%)	3 (27%)	9 (82%)	3 (27%)	2 (18%)	1 (9%)	11
Expository lessons	3 (100%)	2 (67%)	1 (33%)	1 (33%)	1 (33%)	1 (33%)	0 (0%)	3
All practice types	68 (82%)	50 (60%)	47 (57%)	42 (51%)	25 (30%)	23 (28%)	18 (22%)	83

[a] The figures in brackets indicate the percentage of cases for a particular practice type using that kind of ICT tool

Table 5.3 presents the frequency of use of the various ICT tools in the innovations belonging to each of the six types of pedagogical practice. The most commonly used type of tool was basic internet access, followed by general office applications and multimedia production tools. Mobile technology and the more education-specific tools had a relatively low level of use among the cases collected.

ICT use across the different types of pedagogical practice varied considerably. Virtual schools and online courses had the most widespread use of network and CMC tools. Nearly all of the scientific investigations used specialized tools, while media productions and virtual schools had the lowest level of use for these tools. Tutorial and reference tools were most popular for task-based learning and least popular for scientific investigations and media productions.

Innovativeness of Different Pedagogical Practices

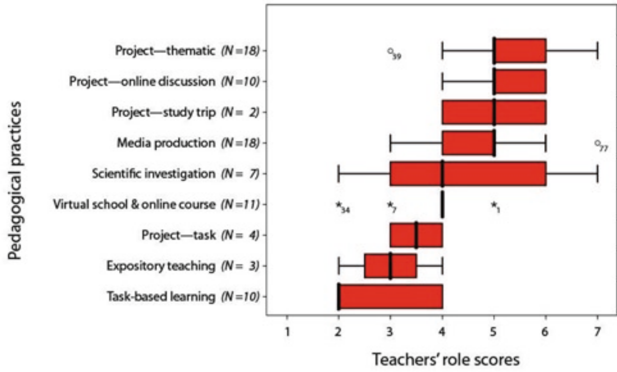
Innovations belonging to the same pedagogical practice type share the same activity format and structure. However, as we reported earlier, similarity in activity structure may not result in teachers and students playing similar roles. Although activity structure does not determine the extent of innovativeness of a pedagogical practice, we were interested in determining if we could detect a relationship pattern between pedagogical practice type and extent of innovativeness.

As we discussed in Chap. 3, teachers' roles and students' roles are pedagogically the most important dimensions among the six key dimensions of innovation. Figure 5.1 shows the box plots of the median and quartile scores as well as the range of teacher-role and student-role scores across the different types of pedagogical practice.

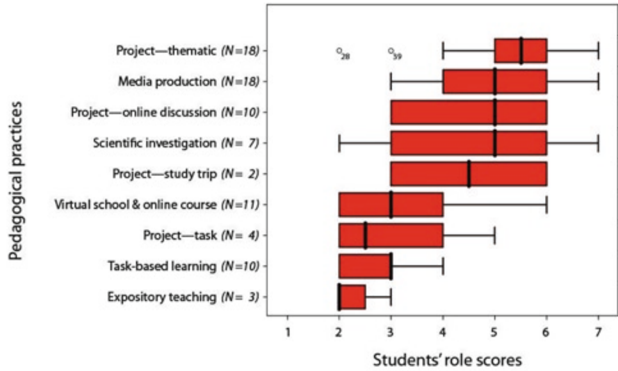
The means and medians for the teacher's role scores and the students' role scores presented in Fig. 5.1 clearly show that the different types of pedagogical practice differed from one another in terms of the average level of innovativeness. Furthermore, there is consistency in terms of rank-ordering of teacher's and students' role scores for the different types of pedagogical practice.

In Chap. 3, we noted that innovation scores higher than or equivalent to 4 signify innovativeness and scores lower than 4 signify traditionalism. Figure 5.1 therefore also shows that teachers were more likely to play more innovative roles in relation to thematic projects, study trips, online discussion projects, media productions, and scientific investigations. Teachers in the three types of practice categorized as aggregated-task project, task-based learning, and expository lessons generally played relatively traditional roles.

These findings indicate that when teachers use ICT simply to enhance traditional pedagogies, such as expository lessons and task-based learning, rather than use ICT in their efforts to organize newer forms of open-ended, collaborative, and extended learning activities, they do not play more innovative pedagogical roles.



	Min	Max	Median	25th percentile	75th percentile	Mean
Project—thematic (N=18)	4	7	5.00	5.00	6.00	5.17
Project—online discussion (N=10)	4	6	5.00	5.00	6.00	5.10
Project—study trip (N= 2)	4	6	5.00	4.00	6.00	5.00
Media production (N=18)	3	6	5.00	4.00	5.00	4.61
Scientific investigation (N= 7)	2	7	4.00	3.00	6.00	4.43
Virtual school & online course (N=11)	4	4	4.00	4.00	4.00	3.82
Project—task (N= 4)	3	4	3.50	3.00	4.00	3.50
Expository teaching (N= 3)	2	4	3.00	2.50	3.50	3.00
Task-based learning (N=10)	2	4	2.00	2.00	4.00	2.70



	Min	Max	Median	25th percentile	75th percentile	Mean
Project—thematic (N=18)	4	7	5.50	5.00	6.00	5.33
Media production (N=18)	3	7	5.00	4.00	6.00	5.06
Project—online discussion (N=10)	3	6	5.00	3.00	6.00	4.60
Scientific investigation (N= 7)	2	7	5.00	3.00	6.00	4.57
Project—study trip (N= 2)	3	6	4.50	3.00	6.00	4.50
Virtual school & online course (N=11)	2	6	3.00	2.00	4.00	3.36
Project—task (N= 4)	2	5	2.50	2.00	4.00	3.00
Task-based learning (N=10)	2	4	3.00	2.00	3.00	2.80
Expository teaching (N= 3)	2	3	2.00	2.00	2.50	2.33

Fig. 5.1 Box plots of teacher's role scores and students' role scores across the types of pedagogical practice

The students' role scores displayed a distribution pattern across the pedagogical practice types similar to that of the teacher's role scores. This finding indicates that the newer types of pedagogical practice also tended to be more student-centered, especially with respect to giving students better opportunities to take responsibility for their own learning, collaboration, and inquiry (see Fig. 5.1).

While the types of pedagogical practice had a strong influence on the roles that teachers and students played, there was also great variability in the degree of innovativeness of cases within the same pedagogical practice type, particularly in relation to the newer types of practice that attracted the higher mean innovation scores. For example, the teacher's role scores and the students' role scores for the seven cases of scientific investigations ranged from a rather traditional score of 2 to a maximum of 7. It is reasonable to expect that teachers and students would therefore play different roles in the different kinds of learning activities associated with the different pedagogical practice types. In the next section, we consider possible reasons for the very large variability in innovativeness within the more-innovative types of pedagogical practice.

Teachers' Roles, Students' Roles and Pedagogical Practice Types: Consistency and Anomalies

So far, we have reported the variation in role scores for teachers and students separately for the different pedagogical practice types. The analysis that we present in this section was based on this question: did the cases with innovative teacher-role scores have innovative student-role scores, and was this also the situation for the traditional role scores? Taking a score of 4 or above as innovative and below as traditional, we categorized the 83 case studies into four groups featuring the relative innovativeness of the teacher's role score (T_score) and the students' role scores (S_score):

- Group A – both teachers and students played innovative roles
- Group B – the teacher role was innovative but the student role was traditional
- Group C – both teachers and students played traditional roles
- Group D – the teacher role was traditional but the student role was innovative

Table 5.4 presents a summary of the distribution of the innovation cases across the four groups of pedagogical practice. Here we can see that the teacher and student roles for cases in Groups A and D are "consistent" (i.e., both traditional or both innovative). These two groups account for 28 and 31 cases, respectively, thus making up the majority of the 83 analyzed cases. These figures triangulate well with the high correlation ($r = 0.77$; $p < 0.05$) between these two role scores (for details, see Chap. 3). Of the remaining 24 cases, 12 went to Group B and 12 to Group C.

The cases in Groups B and D warrant particular attention. Given our assumption that the types of roles that students play have a greater or lesser impact on students' learning outcomes, then we can consider the cases in Group B as somewhat disappointing. Although the teachers in this group of cases played innovative roles, their students still played relatively traditional roles. The Group D cases, however, we found both surprising and pleasing: the students played innovative roles even though their teachers' roles remained traditional.

Table 5.4 Teacher- and student-role categories of innovativeness and traditionalism, by types of pedagogical practice

Pedagogical practices	Group A	Group B	Group C	Group D
Project: thematic ($n = 17$)	11	4	1	1
Project: study trip ($n = 2$)	1	1	0	0
Project: online discussion ($n = 10$)	2	3	2	3
Project: research ($n = 1$)	1	0	0	0
Project: task ($n = 4$)	1	1	2	0
Media production ($n = 18$)	11	1	2	4
Scientific investigation ($n = 7$)	4	0	3	0
Virtual school and online course ($n = 11$)	0	2	7	2
Task-based learning ($n = 10$)	0	0	9	1
Expository lessons ($n = 3$)	0	0	2	1
Total ($n = 83$)	31	12	28	12

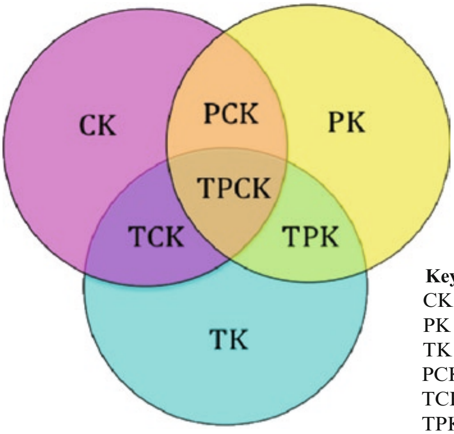
The results in Table 5.4 also show that the cases within each type of pedagogical practice type are not similarly distributed across Groups A to D. For example, most of the cases in Group A are thematic projects and media productions (each comprising 11 cases out of a total of 31 cases), while most of the cases in Group C are task-based learning and virtual school/online courses (comprising nine and seven cases, respectively, out of a total of 28 cases). We can also see that the cases within each pedagogical practice type are distributed among at least two of the groups, and sometimes across all four groups. These results indicate that the pedagogical practice type only prioritized particular combinations of teacher and student roles, but did not determine them.

Teachers play a pivotal role with respect to making decisions, orchestrating learning activities, and facilitating student activity at the classroom level. When implementing pedagogical innovations, teachers often have to go beyond their comfort zone, as they face new challenges and try new practices requiring new expertise. The reason why teachers in some of the innovations were still playing traditional roles was probably because they did not have the necessary expertise. But why, then, were the students of some of these teachers able to play innovative roles? We were also puzzled by the apparent concentration of particular types of pedagogical practice within each of the four groups. In an effort to gain greater clarity on these matters, we examined some of the cases in each of the four groups from the point of view of the expertise that the teachers needed to perform competently.

Teacher Competence and Pedagogical Innovation

It is generally expected that an effective teacher possesses not only knowledge about the subject matter (content) to be taught but also general pedagogical knowledge, such as their students' prior knowledge and the kinds of activities likely to interest those students. According to Shulman (1986), teachers with mastery of both content knowledge (CK) and pedagogical knowledge (PK) are not necessarily able to apply the PK needed to effectively teach specific content. He therefore proposed that teachers need a third kind of knowledge, that relating to the pedagogy associated with teaching specific content, which he termed pedagogical content knowledge (PCK). Mishra and Koehler (2006), Koehler and Mishra (2005), and Suharwoto (2006) extended Shulman's typology by adding technological knowledge (TK), so that teachers are capable of "understanding and negotiating the relationships between these three components of (technological, content and pedagogical) knowledge" for true technology integration (Koehler & Mishra, 2005, p. 134).

Bringing TK into the typology would allow, the above researchers argued, for additional kinds of knowledge, namely, technological pedagogical knowledge (TPK), technological content knowledge (TCK), and technological pedagogical content knowledge (TPCK) (see Fig. 5.2). TPK refers to knowledge of the existence of generic types of technology, and how these can be used to change pedagogical practice. TCK describes the knowledge teachers need to have to understand



Key:
CK Content knowledge
PK Pedagogical knowledge
TK Technical knowledge
PCK Pedagogical content knowledge
TCK Technological content knowledge
TPK Technological pedagogical knowledge
TPCK Technological pedagogical content knowledge

Fig. 5.2 The technological pedagogical content knowledge (TPCK) framework proposed by Mishra and Koehler (2006)

how specific technology can change the teaching and learning of specific subject matter. TPCK describes knowledge derived from a good understanding of the interaction of all three components, such that teachers can thoughtfully interweave them for effective technology integration.

In the remainder of this section, we examine several SITES-M2 case studies in order to identify the types of knowledge that each case required of the teacher or teachers concerned, especially with respect to competent pedagogical performance. We also consider whether the different types of pedagogical practices evident in these cases required different kinds of teacher knowledge for competent performance.

Teacher Expertise Required for Innovative Thematic Projects in Group A

Most of the thematic projects were evident in the Group A cases, an example of which is one of the cases from South Africa (Case ZA001). During this innovation, Grade 7 students worked on a thematic project about HIV/AIDS. The project not only required students to conduct research on interrelated questions of world overpopulation and the influence of HIV/AIDS, but also to gain computer literacy, problem-solving, collaboration, and presentation skills. The activities included in the innovation took place during two 1-h lessons per week over a period of 7 weeks. Student group-leaders coordinated these activities, thus structurally shifting leadership away from the teacher to the students. Each student was responsible for a different part of the project, an organization practice that differed from the students' traditional way of working in class. The student groups used different technologies to accomplish the various tasks during the different stages of their inquiry. These tasks included collecting information from the Internet and electronic encyclopedias, online discussion with outside experts, data analysis using spreadsheet software, and compiling reports with the aid of word-processor and presentation software.

To accommodate the changes in teacher-role and student-role occasioned by the project, the four teachers involved in this project needed the following types of knowledge: new PK in order to design and facilitate the project; new CK for a topic not part of the formal school curriculum); and new PCK to apply their CK in their design of this cross-curricular (human and social sciences, life orientation, and technology) project. Because the student groups used different technologies during the project, the teachers also needed TK, that is, to be competent users of those technologies. They furthermore needed TCK to select the right tools and digital resources for the appropriate learning activity, and they needed TPK in order to organize use of these tools among the students and to help the students use them. TPCK also emerged because the four teachers had to interweave the three components (T, C, K) when designing and implementing the innovation.

It is clear, from this example, that successful implementation of a technology-supported thematic project requires teachers to develop new knowledge in all seven domains identified. Doing so is no simple feat.

Teacher Expertise Required for Thematic Projects in Group B

The example we use here is that of Case SG003. Titled "An IT-Enabled Standards-Based Approach to Project Work," Case SG003 reported an attempt by 15 mathematics, science, and English teachers to develop an interdisciplinary project in six Grade 8 classes in support of the IT Masterplan launched by the Singapore Ministry of Education in 1997. The innovation piloted the use of a suite of web-based communication tools developed by an industry partner. Students received information about the various stages of the project and what they would need to do during it, through the Instructional Planner software, and both teachers and students used a collaborative platform in the software suite, Team Projects, to manage the project and conduct online discussions. For assessing students' project work, the teachers used the software Authentic Assessment Tool, incorporating into it the necessary rubrics and benchmarks.

The 15 teachers had to engage in significant curriculum and assessment development in order to bring the project to their students. They had to plan out all the instructions on the Instructional Planner and set up the assessment rubric. Like their colleagues in Case ZA001 above, the teachers had to master all seven kinds of knowledge depicted in the TPCK framework in order to implement this innovation. In particular, the teachers had to work with the industrial partner to overcome an initial lack of user-friendliness in the suite of communication tools (TPK) and then to customize those tools for their own specific curriculum context (TCK and TPCK). Moreover, the interdisciplinary project work that the project involved was new to the school, which made for a steep learning curve for the teachers in terms of PK (designing and facilitating project work), CK (identifying and developing the interdisciplinary themes), and PCK (facilitating the interdisciplinary project to achieve the set subject curriculum goals).

The teachers who participated in this innovation understood that its success depended on them leaving behind a didactic mode of teaching to become supervisors and facilitators of learning. They particularly appreciated the possibility of providing more comprehensive feedback to students – assuming the rubric-based assessment module functioned in a manner appropriate for their needs. However, both students and teachers were not used to this new mode of teaching and learning. Much of the students' learning activities was made up of well-structured step-by-step tasks, and most students still preferred to ask their teachers questions directly during class time instead of using the online discussion platform. The teachers found it difficult to control noise level and the disruptive behavior of some unengaged students while groups worked on their projects. The knowledge required of the teachers in this thematic project was therefore no less than that required of teachers in the Group A innovative thematic projects, even though the Group B students played relatively more traditional roles than the Group A students.

Teacher Expertise Required for Online Courses in Groups B, C, and D

Virtual schools and online courses greatly reduce the obstacles to educational access associated with geographical distance. Of the 83 analyzed innovations, 11 belonged to this category. Our analysis of the roles played by the teachers and learners in these online courses led to us placing a large majority (7) of these cases in Group C, and only two each in Groups B and D. We were particularly interested to find out whether there were different requirements on teachers' competence for the examples of online courses within the three groups.

UK009 was one of the seven cases of online courses in which both teachers and students played traditional roles. This innovation took place in a co-educational high school (catering to students 13–18 years of age) located on the outskirts of a small coastal town in the north-east of England. In order to improve students' conversational skills in French, the teachers in this school arranged lunchtime video-conference sessions between students at the school working towards their GCSE qualifications and students from a remote school in France. (Students at both school could volunteer to participate; they were not compelled to do so.) For 20 min each week across 10 weeks, the English- and French-speaking students met via video-conferencing to discuss assigned topics. Ten minutes of each session was given over to the French students asking questions and the English students responding in French, and 10 min was spent with the English students asking the questions and the French students responding in English.

The teachers from both countries had to collaborate to decide the discussion topics for each session, and to prepare discussion sheets containing ten questions pertinent to each topic. Although the students learned from discussing with peers from another country instead of from their own teachers, they did not determine the topics of or questions for discussion and hence assumed rather traditional roles during the learning process. This, of course, does not mean that the students did not benefit from the innovation; the case study authors reported that the students improved their listening and speaking skills by engaging in these more authentic conversational contexts.

The teachers involved in Case UK009 had to master new knowledge in a wide range of areas. First, they had to master the complex technological skills (TK) involved in establishing a video-conferencing link with another school. They had to set up the computer link via a ISDN2 line, use a remote control to position the camera effectively for the visual link, and put the microphone in place. They also had to master new pedagogical skills (PK) involved in setting up the 10 weeks of lunchtime sessions and offering those sessions to students on a voluntary basis. They had to plan and organize an effective program separate from and in addition to the main timetabled curriculum. They had to exercise new knowledge in the form of TPK in order to acquaint students with the video-conferencing system and to enable them to use these tools independently. They also had to exercise this form of knowledge when determining topics and questions appropriate for discussion during short video-conferences and likely to engage and interest the students. That said, organizing discussions conducive to learning foreign languages is a very common learning activity. Having students engage in discussions via video-conferencing does not require teachers to exercise new CK, TCK or TPCK. Based on this analysis, we decided that the greatest challenge for the teachers who implemented the UK009 innovation was acquiring and then using the necessary technological knowledge (TK).

The Virtual Schooling Service (Case AU003), a project initiated by Education Queensland in Australia to provide students with access to subjects not offered by their schools, provides an example of flexible delivery of subject matter via a range of synchronous and asynchronous learning technologies. In 2001, 18 teachers prepared online materials and taught six subjects to 320 secondary students in 49 schools throughout the state of Queensland. Students were grouped across schools to make up viable virtual classes, which together attended "real-time" lessons taught by a Virtual Schooling Service teacher. Each school provided its complement of distance learners with a staff member (designated a study coach) to guide and assist.

Examination of cases UK009 and AU003 makes obvious the fact that designing, developing, implementing an online course requires very extensive new knowledge that cannot easily be acquired and then exercised by one teacher alone. The extent to which there is a significant input of external expertise, support, and pedagogical leadership has a large influence on whether an online course belongs to Group A or Group C.

Teacher Expertise for Media Productions in Group D

The three cases in Group D were particularly interesting because the students in these practices took on innovative roles, while the teachers' roles remained traditional. All three cases were media productions, two of which involved digital art – one in a primary school (Case SG001) and the other in a secondary school (Case CN001). The third involved the production of an electronic journal (magazine) (Case IT001). In the interest of space, only the two digital art cases are discussed below for illustration purpose.

Although Cases SG001 and CN001 involved the introduction of a new medium (digital art), the teaching practices evident were not fundamentally different from those in traditional art classes. However, computer access allowed teachers and students to source (e.g., from museum websites) and use different examples of art pieces as well as pictures and information related to the themes encompassed by the students' art productions. The new medium also allowed students to experiment with a wider range of artistic effects and, importantly, to modify their artworks more easily than before, which heightened their willingness to explore their artistic creativity and ability. Another advantage was that of sharing artworks. Digital artwork not only can be shared more easily with others, but also make self- and peer-evaluation simpler to organize. The case study authors reported that some students were able to master the new medium (and technology) more readily than some of the teachers, and so tutored other students, and sometimes even their teachers.

In these two digital art cases, the teachers had to master new TK and new TCK in order to demonstrate to students how they could use the different functionalities of the technology to create different forms of art. The teachers also had to master new TPK and TPCK so that they could effectively organize their art classes in the new setting. However, they had to make only negligible changes in their CK, PK, and PCK.

Teacher Expertise Required for Task-Based Learning in Group C

Of all the different types of pedagogical practices, task-based learning had the greatest proportion of Group C cases – the cases in which both teachers and students played largely traditional roles. One of the cases within this category was Case SG005, which reported the use of ICT to teach food tests and nutrition to students at the lower secondary school level. The innovation involved nine biology teachers within the school, one of whom took the key responsibility of developing the learning package. This teacher designed the package so that students could access its content during four 50-min lessons spread over 3 years, from Grades 7 to 9.

During either their Grade 7 or Grade 9 year, students accessed a web-based video demonstration, a simulation, and a quiz to learn about food tests as part of the science curriculum at these two levels. In Grade 9, students also engaged in a quiz, a web-based exercise that required them to produce a diet plan for three people with different food requirements, and an online chat and forum on the topic, "world food problems." This work also served as a means of reviewing students' understanding of the food test concepts. If they met the assessment criteria, they then proceeded to learn a component on nutrition.

The teacher who designed the package had to possess extensive TK, TCK, and TPK to accomplish this task. However, the types and levels of knowledge required of the other eight teachers who used the package in their teaching were minimal. The structure of the learning activities involved in the four lessons was such that neither teacher nor student had to change their traditional roles. The activity structure was, in fact, familiar to the teachers because well-defined tasks are commonplace in the biology curriculum. Hence, developing and implementing task-based learning is generally much less demanding on the teacher, unless he or she has to develop a full-blown learning package from scratch.

Discussion: Teacher Professional Development and Policy Implications

The findings reported in this chapter support the claim that how a pedagogical practice is organized can have an important influence on the innovativeness of an ICT-supported pedagogical practice. However, the findings also show that this influence is not always deterministic and that variability in innovativeness within the same type of practice can vary markedly. The profiles of ICT tools used in the different types of pedagogical practice were also different, reflecting the different kinds of learning activities involved in the different practice types. Again, there was large variability in ICT use within the same type of practice, indicating that while the pedagogical-practice categorization is a helpful way to describe and understand how ICT was being used and how learning was being conducted in the SITES-M2 innovations, it should not be taken as providing strict definitions of the typologies.

Koehler and Mishra (2005), Mishra and Koehler (2006), and Suharwoto (2006) propose that teachers wanting or required to introduce ICT into their pedagogical practice and their students' learning need to attain and exercise types of knowledge additional to those that Shulman (1986) offered (i.e., CK, PK, and PCK). Our analysis of the kinds of teacher knowledge evident in several selected case studies point to several important findings.

Practices necessitating significant changes in teachers' and students' roles require teachers to master not only new knowledge relating to technology, but also new PK, PCK, and (sometimes) new CK, such as in the case of a thematic project involving the study of an authentic problem, such as HIV/AIDS (see description of case study above). These requirements explain why some of the case study teachers played relatively traditional roles in some projects and scientific investigations.

Online courses cannot be implemented without the establishment of a sophisticated technology infrastructure and online resources, which requires very good mastery of specialized TK, TCK, TPK, and TPCK. We observed that, unless the online course was part of a larger innovation with pedagogical and technological support involving multiple schools, the course tended to focus simply on bridging the geographical divide and not on bringing about significant role changes for the teachers or the learners. Perhaps the teachers in these instances were overwhelmed with the learning they need to acquire to cope with the technology-related aspects of the online course and so were not able to take on further changes involving more kinds of new knowledge.

Media productions, on the other hand, are practices that typically encourage students to take on the more active role of creating useful products. We noted that teachers only needed to master TK and TCK to implement this type of practice and still allow their students to take on innovative roles. In some instances, when other professionals in the school, such as an ICT coordinator, could digitize the products created by the students, the teachers did not have to master the technology-related knowledge for the students to benefit from using the new media.

These findings have important implications not only for policy and strategic planning of ICT integration in learning and teaching in schools and at regional and national levels, but also for professional development opportunities for teachers. Our first recommendation with respect to these matters is for schools and other relevant organizations to collaborate in the setting-up of an innovation framework and infrastructure as well as a curriculum support network for teachers. This, we consider, would reduce the burden that teachers experience when coping with the acquisition and implementation of new knowledge. Our second recommendation is that professional development provisions for teachers must include not only the four kinds of technology-related knowledge but also PK, PCK, and CK if the goal is to bring about more student-centered and collaborative inquiry-oriented pedagogical innovations. We also consider, as our third recommendation, that the process used to select pedagogical practice type is strategic, so that the teachers do not have to cope with extensive learning in many different areas of knowledge at the same time. Rather, it would be better if the innovations were scheduled. This practice would allow the changes taking place to become progressively more complex. Our fourth, and final, recommendation relative to the findings in this chapter is that pre-service teachers should be scaffolded not only to master the rudimentary knowledge in all seven areas, but also be given opportunities to observe and to experiment with orchestrating these different kinds of knowledge in actual pedagogical settings using ICT.

Chapter 6
The Nature of Innovation Schools

Classrooms are embedded inside schools and, in turn, embedded in larger, contextual units such as school districts all the way to an entire education system. We have examined ICT-using pedagogical innovations at the classroom level, in particular the features that characterize the innovations as different from "normal practice." This section of the book comprises three chapters in which we extend the ecological study of innovations in order to examine the contextual conditions at the school level. Our overarching question at this point is how can pedagogical innovative practices be supported, sustained, and scaled up?

This chapter begins with a review of literature on types of innovation implementation and their promise for educational change. The studies reviewed highlight the importance that certain contextual factors have for the effective implementation of educational innovations. These factors include school vision, history, and culture, school development priorities, organizational structure, leadership and change management strategies, staff development provisions and organization, technology resource management, and external support. We grouped these factors under five themes – school background, school strategies, principal leadership, school ICT-infrastructure, and government and community support, and used these in order to explore the 82 SITES-M2 case studies[1] for examples of factors relating to these themes. The results of this analysis not only highlight the common contextual conditions within each theme but also associations between some school-level profiles and various characteristics of the pedagogical innovations at the classroom level.

Innovation Implementation and Educational Change

Rational planning, one popular approach to implementation of change, comprises elements such as needs analysis, research and development, strategy formation, resource support, implementation and dissemination, and evaluation (Lueddeke, 1999).

[1] Although we analyzed 83 case studies at the pedagogical-practice level, there were actually only 82 schools involved because two of the cases featured the same school.

N. Law et al., *Educational Innovations Beyond Technology: Nurturing Leadership and Establishing Learning Organizations*, DOI 10.1007/978-0-387-71148-5_6,

While a systematic approach is attractive, change in schools is often complex and chaotic (Fullan, 1999). Fullan (2007) draws two basic conclusions in relation to educational change: "First, change will always fail until we find some way of developing infrastructures and processes that engage teachers in developing new knowledge, skills, and understandings. Second, it turns out that we are talking not about surface meaning, but rather deep meaning about new approaches to teaching and learning" (p. 29).

The rapid evolution of computer technology necessitated a change of approach to corporate technology management (Applegate, McFarlan, & McKenney, 1999). Numerous studies of technology implementation in organizations first appeared in the 1950s and led to efforts to translate what was learned in these settings to school settings. However, applying theories about managing technology implementation in corporations to school systems proved inexact. Approaches focused on understanding the needs of school systems entered the literature. Taking the approach of instructional system design, Ely (1990), for example, suggested eight conditions that facilitate the adoption, implementation, and institutionalization of educational technology innovations: (1) dissatisfaction with the status quo, (2) the existence of necessary knowledge and skills, (3) available resources, (4) available time, (5) existence of rewards or incentive for participants, (6) expectation and encouragement of participation, (7) commitment from those who are involved, and (8) evident leadership. The International Society for Technology in Education (ISTE) today lists these conditions as essential for effective ICT integration (Davis, 2008). Certainly, this list gave us a lens through which we could analyze what schools need to have or to put in place during the change process associated with the implementation of educational innovations.

In his consideration of changes involving curriculum and pedagogy, Fullan (1993) provides a useful framework that considers the complexity of the change process in schools. He proposes formulation of a common vision as the most critical step in the implementation process. Fullan's framework can also be usefully applied during efforts to understand the nature and challenges of change associated with ICT implementation directed at effecting pedagogical innovation in schools. Kearsley and Lynch (1992) also note that the ability to develop and articulate a vision of how ICT can produce changes is a critical element of effective leadership of educational innovations.

School change involving ICT implementation is complex, even when it does not involve changes in classroom practice. Having adapted, for school contexts, a framework designed to facilitate management of information systems in organizations, Telem (1996) argues that the school-based framework needs to include five components, namely, technical, structural, psychosocial, goals and values, and managerial. In his case study account of implementation of computers in schools in Ontario, Canada, Fullan (1992) emphasizes the need to examine the change process as experienced by teachers. This perspective, he explains, allows one to identify the key factors associated with the implementation of computers in classrooms. These include the characteristics of the innovation, the degree of commitment and support, access to professional development, and the nature of the principal's leadership.

In responding to the question of whether schools necessarily have to work through developmental pathways or models when implementing ICT in order to bring about educational change, Mooij and Smeets (2001) suggest a five-phased model of increasing levels of ICT transformation, with each level more profound than the last. They list the phases as follows:

1. Incidental and isolated use of ICT by one or more teachers
2. Increasing awareness within the school of the relevance that ICT has for all levels of the school
3. An emphasis on coordinating the implementation and integration of ICT (hardware especially) within the school
4. An emphasis on didactic innovation and ICT support
5. Use of ICT-integrated teaching and learning that is independent of time and place

Mooij and Smeets generalized all of the phases except the last one from their analysis of case studies of ICT implementation in ten secondary schools in the Netherlands. The authors explain that the fifth phase could be construed as a theoretical construct only, because it was not yet evident in the observed practices in the schools. Mooij and Smeets also suggest, as an outcome of their work, ways that schools can learn about and from one another's ICT implementation experiences. They furthermore suggest how national policies and school management and leadership can be directed towards supporting desired ICT-related school development. However, we consider that Mooij and Smeets' five-phased model may not provide an appropriate basis for these purposes. This is because the model focuses on the technical history of ICT use in schools rather than on the implementation and development history in schools.

In their studies of implementation of information systems, Laudon and Laudon (1998) summarize four types of organizational change that ICT enables in the business sector. These are automation, rationalization, reengineering, and paradigm shift. Automation refers to bringing in ICT in order to help employees perform their jobs more efficiently and quickly. Rationalization of procedures means "streamlining of standard operating procedures … [and] eliminating bottlenecks so that automation makes the procedures more efficient" (p. 391). In general, automation and rationalization are similar processes because they focus on designing, planning, constructing, and controlling. Reengineering refers to radically redesigning the processes used to produce services and/or products, such that business costs are significantly reduced. Paradigm shift is a more radical form of reengineering. It involves reconceptualizing the nature of the business and the nature of the organization. Each of these four types of change offers the organization different rewards and risks.

Yuen, Law, and Wong (2003) propose three models of change that have similarities with Laudon and Laudon's (1998) typology. Yuen et al. put forward their models after analyzing the strategies that 18 schools used when endeavoring to integrate ICT in teaching and learning within their respective curricula. The authors found that the strategy each school adopted (and the outcome of that strategy with respect to ICT pedagogical innovation) was strongly dependent on several factors: school-leaders' vision and understanding of the role and impact of ICT in the curriculum; the leaders' goals and objectives for ICT integration; and the history, culture, and background of the school; and the school's general vision and mission relative to teaching and learning.

Yuen and colleagues termed the first of their three models, the technological adoption model. It is akin to Laudon and Laudon's automation and rationalization approaches because it focuses on the need for schools to manage the adoption of technological infrastructure, to consider organizational structures, and to take into account teachers' technical skills. The second model, the catalytic integration model, in which ICT integration plays a vital role in effecting curriculum innovation and changed roles for teachers and students, is similar to Laudon and Laudon's reengineering model. Schools associated with Yuen et al.'s third model, the cultural integration model, have a strong sense of mission and a clearly identifiable vision of educational change that permeates school practices. These schools can be said to have adopted Laudon and Laudon's "paradigm shift" process even before they initiate any form of ICT integration.

School Contextual Factors: Understanding the Nature of Innovative Schools

Figure 6.1 provides a diagrammatic representation of the five groupings (themes) of school contextual factors that we drew from our brief review of literature on ICT-related innovation models. These themes should be taken as "working outlines," useful for guiding our analysis of the case reports. They are not meant to represent a comprehensive or mutually exclusive list of concepts in a theory of educational change.

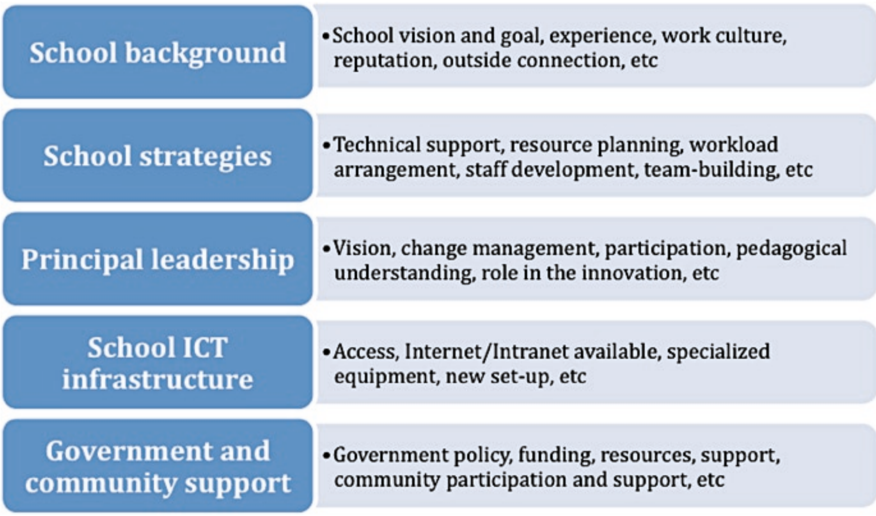


Fig. 6.1 School contextual factors

We used a thematic coding and grounded approach (Miles & Huberman, 1994) to analyze the 82 case reports from the perspective of school-contextual factors characteristic of innovative schools. This approach allowed us to simultaneously code and analyze the data, taking as our reference point the five earlier developed themes. We began by reading each report and underlining key terms and phrases in the text. We then restated these as descriptively and literally as possible. Our third step involved us comparing our own set of codings with those of our colleagues so that we could group all codings under the five themes. We repeated this third step several times over until we had developed consensually-agreed categories of factors relating to each theme. A description and discussion of the results of this analysis follows.

School Background

Our analysis yielded 13 school-background categories (Table 6.1). Although the 13 categories are not mutually exclusive, they do, as a group, delineate two major kinds of school characteristics. The first concerns the school's experience in relation to innovative use of ICT and the other relates to the vision and goals of the school.

The school-background category that most commonly featured in the 82 case schools was BA13: *ICT as a tool to empower students' learning* (reported in 54 schools, i.e., 65% of the schools). This characteristic appeared in relation to the schools' vision and goal statements. For example, the school in Case DE012 had set its focal goals on social learning, learning in authentic situations, and promoting good reading habits and ICT skills. The school's vision was for students to acquire the skills – including ICT-competence – that they would need in the twenty-first

Table 6.1 School-background categories and their frequencies of reported occurrence

Code	Description of categories	Frequency
BA1	Experience of carrying out innovation	33
BA2	Experience of carrying out ICT innovation	39
BA3	Innovation aligns with government's education policy	27
BA4	Innovation aligns with government's ICT education initiative	26
BA5	Reputation for being an innovative school	24
BA6	Use of ICT in other school activities for students	11
BA7	Collaborative work culture among staff in school	40
BA8	School vision and goal: promote lifelong learning	33
BA9	School vision and goal: promote active learning	34
BA10	School vision and goal: develop positive values, cater for individual differences, and emphasize students' personal development	40
BA11	School vision and goal: use ICT to enhance information literacy	17
BA12	School vision and goal: ICT as a tool to motivate students	18
BA13	School vision and goal: ICT as a tool to empower students' learning	54

century. The next most frequently reported school-background category, also evident in vision and goal statements, was BA10: *develop positive values, cater for individual differences, and emphasize students' personal development*. Forty of the 82 schools (49%) shared this vision. The case report for CN006 contained the following description:

> The school had its vision on the implementation of ICT in teaching and learning … To foster creativity, analytical inquiry, constructive and collaborative learning will eventually be established in the school … In the school, the spirit of cooperation, mutual trust and understanding between students and teachers were emphasized.

Forty schools (49%) reported *collaborative work culture among staff in school* (BA7) as a special school characteristic. The principal and teachers in Case CN003 all regarded the close collaboration and team work arising out of the school's Cyber Art project (CN003) as one of the most successful elements of that project. Thirty-nine (48%) schools reported the *experience of carrying out the ICT innovation* (BA2) as an important feature of the school. The school in Case ZA008, for example, reported a history of providing students across all areas of the curriculum with access to wireless laptops.

To determine if any of the school-background features had statistically significant associations with any of the six dimensions of innovativeness described in Chap. 3 and listed in Table 6.2, we conducted a one-way ANOVA. The six dimensions were the dependent variables and the school-background features were the independent variables.

Table 6.2 One-way ANOVA results showing relationships between the six innovation dimensions and BA7 (collaborative work culture among school staff)

Dependent variables	BA7 groups	*N*	Mean	Std. deviation	*F*
Curriculum goals (G_SCORE)	No	42	3.60	1.53	5.55*
	Yes	40	4.38	1.46	
	Total	82	3.98	1.54	
Teachers' roles (T_SCORE)	No	42	3.93	1.69	4.23*
	Yes	40	4.65	1.48	
	Total	82	4.28	1.62	
Students' roles (S_SCORE)	No	42	3.79	1.92	4.37*
	Yes	40	4.60	1.58	
	Total	82	4.18	1.80	
ICT sophistication (ICT_SCORE)	No	42	5.64	0.76	1.15
	Yes	40	5.83	0.78	
	Total	82	5.73	0.77	
Multiplicity of learning outcomes (M_SCORE)	No	42	3.83	1.83	3.37
	Yes	40	4.58	1.82	
	Total	82	4.20	1.86	
Classroom connectedness (C_SCORE)	No	42	4.21	1.99	0.071
	Yes	40	4.33	1.76	
	Total	82	4.27	1.87	

*$p<0.05$

We found statistically significant relationships between the innovation dimensions discussed in the previous section and five of the school-background characteristics – BA7: *schools with a collaborative work culture among staff*, BA8: *school vision and goal: promote lifelong learning*, BA9: *school vision and goal: promote active learning*, BA10: *school vision and goal: develop positive values, cater for individual differences, and emphasize students' personal development* and BA13: *ICT as a tool to empower students' learning*. However, only BA7 and BA9 showed statistically significant relationships with more than one classroom innovation dimension.

Table 6.2 presents the one-way ANOVA results for BA7. Schools coded as having this feature had significantly higher G_SCOREs, T_SCOREs, and S_SCOREs. Thus, schools reporting a strong collaborative work culture among staff were more innovative on three core dimensions – curriculum goals, teachers' roles, and students' roles. The characteristic BA9, *school vision and goal: promote active learning* showed statistically significant relationship with five of the classroom innovation dimensions: curriculum goals (F-value 12.638), teachers' roles (F-value 4.618), students' roles (F-value 10.667), multiplicity of learning outcomes (F-value 4.056), and classroom connectedness (F-value 8.161).

The only innovation dimension that showed statistical significance for schools coded as *school vision and goal: promote lifelong learning* (BA8) was classroom connectedness (F-value 4.273). The characteristic *school vision and goal: develop positive values, cater for individual differences, and emphasize students' personal development* (BA10) showed statistically significant relationship with students' role scores (F-value 5.558). Finally, the only innovation dimension that showed statistical significance for schools coded as *using ICT as a tool to empower students' learning* (BA13) was teachers' role (F-value 7.083).

To sum up, school vision (BA10, BA13), collaborative culture (BA7), and experience in carrying out innovations (BA2) were the school-background characteristics most frequently reported in the innovation case reports. Statistically significant associations emerged between some of the classroom level innovation dimensions and BA7, BA8, BA9, BA10, and BA13.

Schools' Implementation Strategies

The strategies that schools use to implement innovations are very much influenced by the principal's leadership, as it is usually he or she who determines the change priorities and resource deployment. During our analysis of the case reports, we identified 11 categories of strategies (see Table 6.3), which roughly fell into three groups – staffing arrangements, support, and professional development. The strategies that schools most frequently adopted were *provision of general training for teachers* (SS9, reported by 74 schools, 90%) and *provision of technical support by the technology coordinator, ICT teacher, and/or technician for the innovation* (SS7, reported by 66 schools, 80%). Forty-one schools (50%) established a new team to coordinate

Table 6.3 Categories of school implementation strategies and their frequencies of reported occurrence

Code	Description of categories	Frequency
SS1	Changes in class schedule for the implementation of innovation	14
SS2	Workload arrangement for technical coordination	9
SS3	Workload reallocation to allow for provision of technical support for the innovation	4
SS4	Workload reallocation to allow for collaborative planning for the innovation	5
SS5	Start with teacher(s) who is/are interested in/enthusiastic about the innovation	11
SS6	Establish new team(s) to coordinate the implementation of innovation	41
SS7	Technical support provided by technology coordinator, ICT teacher, technician	66
SS8	Non-specialists' technical support	12
SS9	General training for teachers in school	74
SS10	Innovation-focused staff development	31
SS11	Joint school professional development activities	9

implementation of the innovation (SS6). The CN005 case report, for example, described the composition and function of its team as follows:

> The IT team is composed of 6 members who teach science, mathematics and computer. They are familiar with computers. Instead of having only one IT coordinator, this team can help the technical development in the school more effectively. The IT team is responsible for looking after the system, purchasing hardware and software for the teachers, plus offering courses for teachers. To reduce the workload of the IT team members, one extra teacher is employed with the title of ICT coordinator. This teacher shares some of the teaching load of the 6 IT Team members. On average each team member has five lessons less than the other teachers.

Some of the case-report authors reported making changes to their implementation strategies during innovation development. For example, the school in Case CL009 hired an electronics technician to provide technical assistance for the innovation. He was initially hired for two hours per week, but this number was later increased to 21 teaching hours per week when he was put in charge of teaching computer classes to the students, while simultaneously providing ongoing technical support.

Two forms of professional development were reported. The most common was SS9: *provision of general training to teachers in the school.* The following description from Case TW003 exemplifies most of the descriptions of this strategy in the case reports.

> Last year the case school demonstrated four technology integration cases to the whole county's teachers. Several school-based technology-training events are held during school days each year. Teachers were required by the principal to participate in the training. The principal gave the coordinator and the teachers the necessary authority and support to help the coordinator and teachers fulfill their missions.

Thirty-one schools (38%) said that they provided *innovation-focused staff development* (SS10). This account from Case CA007 is typical of these schools' descriptions.

> Teachers interested in the online program or shell course must go through a professional development program (Level 1). At the end of the Level 1 course, which is delivered online, teachers can decide if they want to be part of the online program. About 20% decline to be involved. The Level 2 course (Active Teaching) redefines their role in an online course and provides ongoing opportunities to exchange ideas and discuss problems. A team of teachers is currently designing and developing additional content (e.g., instructional design) in the professional development program.

No significant results emerged from our one-way ANOVA of the six innovation and the different categories of school strategies. It may be that associations between extent of innovativeness and school strategies adopted are more nuanced than analyses based on single strategies can reveal. Nonetheless, our scrutiny of the case reports indicate that the innovation schools had, among them, adopted many of the school strategies described in the literature as critical for effective implementation of ICT-supported pedagogical innovations. These include staff development, teamwork, and technical support.

Principal Leadership

School leaders exert power and influence in their schools (James & Connolly, 2000; Yukl, 2002), and their key role in implementing educational innovation is well documented. Leithwood, Jantzi, and Steinbach (1999) summarize theories about leadership in education into six different approaches to leadership: instructional, transformational, moral, participative, managerial, and contingent. They also identify four dimensions of influence in relation to these six leadership approaches: who exerts influence, sources of influence, purpose of influence, and outcomes of influence. These typologies suggest, with respect to implementation and use of ICT in schools, that successful implementation is not only about, for example, securing equipment and software but also about influencing and empowering teachers; it is not only about having teachers acquire computer skills but also about supporting teachers in their ongoing engagement with student learning.

Our analysis of the 82 case reports yielded 17 categories of principal leadership. The findings shown in Table 6.4 indicate that while the roles principals play might differ in relation to different types of innovation, all are positive in nature. Principals in more than half of the case reports (56%) indicated that they *welcomed teachers' contributions, listened to teachers' views, and encouraged innovation* (PL15). The principal in Case CN012, for example, was described as highly supportive of innovation, including the development of ICT infrastructure and using ICT in teaching and learning.

> The principal is an open-minded person; she welcomes all kinds of innovations that are good for students. She is playing a supportive role for the implementation of these innovative practices. As she said, "I give freedom for my teachers to try out new things. I believe that they have the professional expertise in their subject area. I just provide the resources for them. I would not intervene with what they are doing because I trust my teachers' professional knowledge."

Table 6.4 Principal-leadership categories and their frequencies of reported occurrence

Code	Description of categories	Frequency
PL1	Has a clear vision (non-ICT) in relation to students' learning, particularly in terms of promoting lifelong learning and active learning, motivating students, catering for individual differences, developing positive values, and emphasizing students' personal development	20
PL2	Has a clear vision (non-ICT) of the school as a learning institute and as a place that emphasizes teachers' development	13
PL3	Has a clear vision (ICT-related) with respect to enhancing information literacy	8
PL4	Has a clear vision (ICT-related) with respect to motivating students and empowering students' learning	23
PL5	Initiates changes/reforms/school activities	32
PL6	Is a supporter and participant of changes/reforms/school activities	28
PL7	Models use of ICT	7
PL8	Initiates innovation	18
PL9	Supports and participates in the innovation	36
PL10	Acts as a champion and implementer of the innovation	9
PR11	Ensures that staff understand how ICT can be used to enhance teaching and learning	15
PL12	Plans the resources required for changes/reforms/school activities/ innovation	35
PL13	Supports professional development of teachers	29
PL14	Maintains good communication with parents about the changes/reforms/ school activities/innovation	18
PL15	Welcomes teachers' contributions, listens to teachers' views, and encourages innovation	46
PL16	Encourages team work among staff	24
PL17	Monitors and evaluates the innovation	7

Plans the resources required for the changes and reforms (PL12) and *supports professional development of teachers* (PL13) were also prominent features of principal leadership, mentioned in 43 and 35% respectively of the 82 case reports analyzed. AU004 is a typical case example for PL12. Here, the principal spent a significant amount of the school budget on hardware, software, and ICT maintenance, as well as on ICT-related professional development support for teachers.

Only one of the principal-leadership characteristics (PL5) had a statistically significant association with one of the innovation dimensions, namely, the M_SCORE. The mean for PL5="yes" was 4.813 and the mean for PL5="no" was 3.800. The *F*-value was 6.182. Thus, schools where principals act as initiators of changes and reforms are significantly more likely to have innovations associated with more diverse kinds of student learning outcomes. Case AU004 (M_SCORE=6) provides one such example:

> The Principal sees himself as having the roles of instructional leader, facilitator, and manager of the school. He favors his role as mentor, which he believes leads to facilitation and builds strengths. The vision of building the school into a learning community, with teachers, students and parents being part of that learning community has been driven by the

Principal. …The use of technology is supported and encouraged across the whole school. These features have been instrumental in the whole school progressing towards a learning community.

According to Bennett (1996), if ICT is to be successfully integrated into the school curriculum, the meaning of educational leadership and the role that school principals play in effecting technological change must be redefined (Bennett, 1996). Kearsley and Lynch (1992) believe that a cultural view of leadership is the most useful perspective to take when discussing ICT integration in education. Under this perspective, leaders shape the culture of individual schools by creating new visions that all members of the school can believe in and act upon. Bennett (1996) argues that both the cultural and physical environments of the school must be considered in any calls for principals to undertake new responsibilities associated with the roles of technology leader, which, according to Flanagan and Jacobsen (2003), includes leader of learning, leader of student entitlement, leader of capacity building, leader of community enhancement, and leader of resource management. Our observation of the different principal-leadership roles reported in the innovations confirm the importance of the following leadership characteristics reported in the above studies: welcoming teachers' contributions, initiating changes, planning required resources, and supporting staff development.

ICT Infrastructure

Here, we were interested in exploring whether the general level of ICT infrastructure available at the school level had any impact on the innovation characteristics at the classroom level. We identified seven school-ICT infrastructure categories (see Table 6.5) from our analysis of the case reports. Almost all of the case schools (95%) had basic ICT infrastructure in place, including specialized ICT equipment (72% of cases), Internet access (90%), and tools specific to the innovation (95%). About half of the schools (46%) allowed students to access ICT facilities outside class time. The following extract from Case NL024 shows that the school concerned had both *basic infrastructure* (IT1) and *specialized ICT tools* (IT4).

Table 6.5 ICT infrastructure categories and their frequencies of reported occurrence

Code	Description of categories	Frequency
IT1	Basic ICT Infrastructure: access to computers	78
IT2	Internet/Intranet available	74
IT3	More specialized ICT equipment available	14
IT4	More specialized ICT tools available	78
IT5	Specific ICT peripherals required for the innovation available	59
IT6	Students have access to ICT facilities beyond classes (e.g., lunch break, after school, during holidays, etc)	38
IT7	Physical renovation/new set-up required for the innovation in place	13

> The school has about 100 computers; most of them are connected to the internal network of the school. About 20 computers are suitable for multimedia purposes. Computers for educational purposes are in the information centre, the computer lab and in some classrooms. … For some experiments, the computer is essential. With other devices, the measurements are not accurate enough. The students could have used an oscilloscope for their measurements, but the computer is more appropriate. In general, the use of the computer in experiments motivates the students; the students like the subject more.

Seventy-two percent of the cases reported that they had, in addition to general ICT provisions, *ICT peripherals specifically needed for the innovation* (IT5). The authors of Case TW006 had this to say:

> Technology used includes a web site, a teacher server, a broadcasting system, a LCD projector, color printers, scanners, Internet connection devices, a TV set, a projector screen, presentation software, web page development software, graphics software, word processing software, e-mail software, and digital camera. The consuming materials and related expenses were covered by the budget of the technology center. The ICT-supported geography teaching lab was created by the teaching requirements of the case teacher. Therefore the lab is well equipped for geography teaching.

When we conducted a one-way ANOVA of the six innovation scores across the various ICT infrastructure categories, we found statistically significant relationships between *Internet/Intranet availability* (IT2) and T_SCORE and S_SCORE. (The F-values were 4.718 and 5.967, respectively.) While we agree with Venezky and Davis (2002) that "technology is not a replacement for education nor is it a revolutionary force that requires traditional education to strip itself naked and be totally recostumed" (p. 38), the present finding indicates that schools with ready access to both Internet and Intranet were significantly more innovative in terms of teachers' roles and students' roles. We argue here that the critical contribution that this specific ICT infrastructure makes to the innovation is the connectedness it provides to teachers and students. It appears that access to Internet and Intranet plays a role that differs from the roles played by other ICT tools and equipment.

Government and Community Support

Many of the case reports mentioned the role of external parties in supporting the innovation. Government support in terms of general and ICT-specific education policies, provision of funding, and ICT-specific support were often reported. The reports also provided instances of support from stakeholders such as parents and alumni. They typically helped formulate the innovation or provided enriched technology infrastructure and support. We identified 16 types of government and community support from our analysis of the cases (see Table 6.6).

We found statistically significant relationships between three of these categories (SU2, SU3, and SU16) and the innovation scores. The first of these relationships concerned those cases where the authors reported that the *government provided*

Table 6.6 Government- and community-support categories and their frequencies of reported occurrence

Code	Description of categories	Frequency
SU1	Government: general education policy	40
SU2	Government: ICT-specific directions in education policies	37
SU3	Government: provision of ICT infrastructure	33
SU4	Government: provision of technical support	19
SU5	Government: provision of funding for ICT infrastructure	22
SU6	Government: provision of funding for schools (ICT related, but not including funding for ICT infrastructure)	28
SU7	Government: provision of funding for schools (general)	7
SU8	Government: provision of extra support the innovation	13
SU9	Government: provision of courses for teachers (general)	25
SU10	Government: provision of courses for teachers required for the innovation	5
SU11	Government: organization of sharing of experiences and knowledge among schools	3
SU12	Community: provision of funding for ICT infrastructure	4
SU13	Community: provision of technical support	9
SU14	Community: participation in the activities of the innovation	9
SU15	Community: provision of training	9
SU16	Community: collaborator in/partner of the innovation	20

ICT-specific directions in its education policies (SU2). Here, the ICT_score of the respective innovations was significantly higher (F-value = 8.978). Typical examples of such cases included AU004 (ICT_SCORE = 6) and CN008 (ICT_SCORE = 7). The following extract is from Case AU004.

> Under the Schooling 2001 initiative all teachers by the end of 2001 are required to attain Level One Minimum Standards-Learning Technology. To date 90 per cent of the total teaching staff at Woodcrest has applied for the credential. One of these goals "demonstrating the use of computers as teaching/learning tools in achieving and extending curriculum goals" has been realized by all teachers observed in this study … The Guidelines for the use of Computers in Learning (Department of Education, Queensland, 1995a) and Computers in Learning Policy (Department of Education, Queensland, 1995b) have also influenced the school's integration of learning technology as a strategic priority. These guidelines have also been a reference for evaluating classroom and school practice.

While SU2 concerns alignment between a government's broader education policy and the innovation, the second significant relationship (SU3) concerned tangible government support in the form of provision of ICT infrastructure. This contextual feature showed a *negative* relationship with the extent of innovativeness of the cases on all six dimensions, and this relationship was statistically significant for three – the T_SCORE, S_SCORE, and M_SCORE. The one-way ANOVA results presented in Table 6.7 show that the mean values of all six innovation scores were lower for the "Yes" group. In short, government provision of ICT infrastructure was associated with significantly lower levels of innovativeness.

Table 6.7 Relationships between the six innovation dimensions and Category SU3 (government provision of ICT infrastructure category)

Dependent variables	SU3 groups	*N*	Mean	Std. deviation	*F*
Curriculum goals (G_SCORE)	No	49	4.12	1.63	1.11
	Yes	33	3.76	1.39	
	Total	82	3.98	1.54	
Teachers' roles (T_SCORE)	No	49	4.67	1.69	7.76*
	Yes	33	3.70	1.33	
	Total	82	4.28	1.62	
Students' roles (S_SCORE)	No	49	4.63	1.73	8.29*
	Yes	33	3.52	1.72	
	Total	82	4.18	1.80	
ICT sophistication (ICT_SCORE)	No	49	5.86	0.79	3.32
	Yes	33	5.55	0.71	
	Total	82	5.73	0.77	
Multiplicity of learning outcomes (M_SCORE)	No	49	4.63	1.65	7.30*
	Yes	33	3.55	1.97	
	Total	82	4.20	1.86	
Classroom connectedness (C_SCORE)	No	49	4.39	1.98	0.49
	Yes	33	4.09	1.72	
	Total	82	4.27	1.87	

*$p < 0.01$

Table 6.8 Relationships between the six innovation dimensions and category SU16 (community collaboration)

Dependent variables	SU16 groups	*N*	Mean	Std. deviation	*F*
Curriculum goals (G_SCORE)	No	62	3.97	1.56	0.007
	Yes	20	4.00	1.52	
	Total	82	3.98	1.54	
Teachers' roles (T_SCORE)	No	62	4.15	1.67	1.791
	Yes	20	4.70	1.42	
	Total	82	4.28	1.62	
Students' roles (S_SCORE)	No	62	4.21	1.79	0.056
	Yes	20	4.10	1.86	
	Total	82	4.18	1.80	
ICT sophistication (ICT_SCORE)	No	62	5.61	0.73	6.449*
	Yes	20	6.10	0.79	
	Total	82	5.73	0.77	
Multiplicity of learning outcomes (M_SCORE)	No	62	4.08	1.77	0.967
	Yes	20	4.55	2.11	
	Total	82	4.20	1.86	
Classroom connectedness (C_SCORE)	No	62	3.98	1.89	6.242*
	Yes	20	5.15	1.53	
	Total	82	4.27	1.87	

*$p < 0.05$

We found this finding a most surprising one. One possible explanation could be that the provision of resourcing (in the form of ICT infrastructure) became an incentive for the schools to "innovate," even though they might not have had any intrinsic vision of how such a change might "look" or any real drive to bring about change. Obviously, more in-depth research is necessary to explore this finding further.

In the ICT_SCORE and C_SCORE rows of Table 6.8, we can see that the mean scores of the "Yes" group for the case coded as SU16 are higher than the scores of the "No" group. This tells us that schools where the *community was a collaborator or partner with respect to the innovation* were significantly more innovative in terms of ICT sophistication and connectedness of the pedagogical practice. The school in Case UK009 (ICT_SCORE = 7 and C_SCORE = 5) was one such example. The project described in the report was said to be well supported by two companies that together provided much of the needed PC-based video-conferencing equipment at reduced cost.

Summary

In his book, *The Innovator's Dilemma: When New Technologies Cause Great Firms to Fail*, Christensen (1997) argues that new technologies foster "improvement in product performance" (p. 9). He calls these "sustaining technologies." A common characteristic of all sustaining technologies is that they improve the performance of established products, along the dimensions of performance that mainstream customers in major markets traditionally value. Occasionally, however, some companies place too much emphasis on satisfying customers' current needs, and fail to adapt or adopt new technologies that will meet customers' unstated or future needs, such that the companies eventually fall behind. Christensen describes innovations that result in poorer product performance as "disruptive technologies." But these, he says, "offer other benefits – typically, they are simpler, more convenient, and less expensive products that appeal to new or less-demanding customers" (Christensen & Raynor, 2003, p. 34). Disruption is a relative term, as an idea that is disruptive to one business may be sustaining to another.

Within education, giving up tried and tested methods of traditional instruction to experiment with innovations, such as those required to foster the development of twenty-first-century skills, presents risks and challenges. For example, the adoption of new technologies and pedagogies may be associated with poorer learning outcomes, particularly when those outcomes are measured by conventional assessment methods. So how can change that is necessary yet disruptive be nurtured so that it becomes mainstream? This chapter has provided us with some ideas, summarized in Fig. 6.2, about the school-level factors that provide positive ecological conditions for the emergence of ICT-related innovations.

From our analysis of the 82 case reports, we identified 64 school-level contextual factors that we grouped under five school-level dimensions: school background, school strategies, principal leadership, school ICT infrastructure, and government

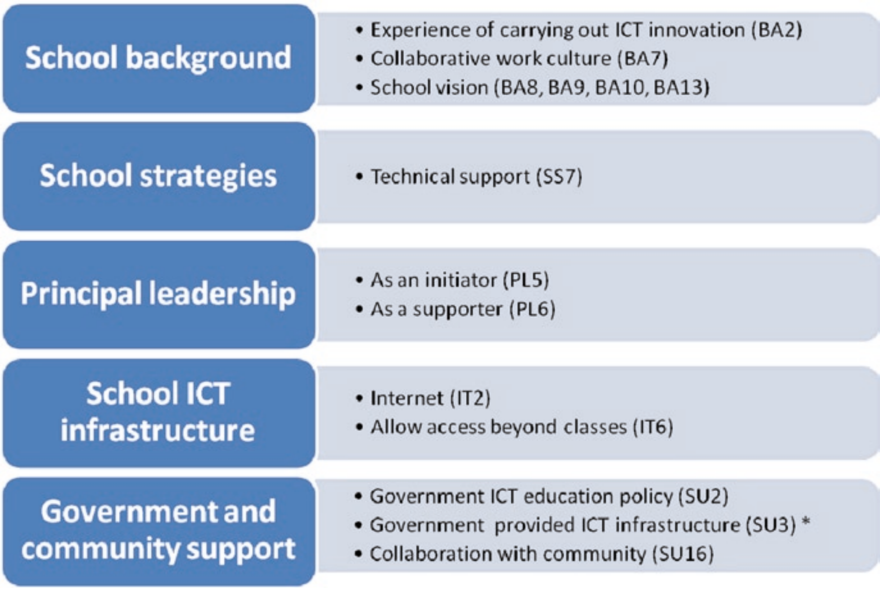


Fig. 6.2 School-level contextual factors most often reported in the innovation case reports. *Note*: *SU3 was the only factor that showed a negative relationship with innovativeness

Table 6.9 Summary of significant associations of school-level factors with the six innovation scores

School-level factors		G	T	S	ICT	M	C
BA2	Experience of carrying out ICT innovation				*	*	
BA7	Collaborative work culture among staff in school	**	**	**		*	
BA8	School vision and goal: to promote lifelong learning						**
BA9	School vision and goal: to promote active learning	***	**	***		**	***
BA10	School vision and goal: to develop positive values			**		*	
BA13	School vision and goal: ICT as a tool to empower students' learning		***		*		
SS7	Technical support provided by technology coordinator, ICT teacher, technician						*
PL5	Initiator of changes/reforms/school activities					**	
PL6	Supporter and participant of changes/reforms/school activities						*
IT2	Internet/Intranet availability		**	**			
IT6	Allows access to ICT facilities beyond classes (e.g., lunch break, after school, during holidays, etc)	*					
SU2	Government provides ICT-specific directions in its education policies				***		
SU3	Government provides ICT infrastructure		***	***	*	***	
SU16	Community as a collaborator in/partner of the innovation				**		**

*$p<0.1$ (marginal significance); **$p<0.05$; ***$p<0.01$

and community support. One-way ANOVA exploration of the interactions between the school-level factors and the innovative classroom practices found several statistically significant associations between school-level factors and innovative classroom practices. Table 6.9 presents a summary of these. Except for SU3 (government provision of ICT infrastructure), the associations were positive. We were intrigued by this finding. Why schools without this provision had higher innovation scores (T_SCORE, S_SCORE, ICT_SCORE, M_SCORE) is a question that merits further investigation. What we can say at this point is that this finding suggests the interactions between innovative pedagogical practices and school factors are complex and cannot be captured through single-factor correlational analysis.

This chapter demonstrates that school-level factors relate to classroom pedagogical practices in various ways. We consider that these associations provide us not only with an understanding of the school contextual conditions that influence the effectiveness of pedagogical innovations within classrooms but also with a possible conceptualization by which we can unpack the ecological features of innovation schools. In the next chapter, we continue our consideration of the nature of these schools by describing and discussing how learning was being organized in four of them.

Chapter 7
Organizational Learning in Innovation Schools

In Chap. 6, our aim was to gain some idea of the kinds of school-level characteristics that are most conducive to the implementation and integration of ICT-related pedagogical innovations. We found statistically significant associations between some of these characteristics and dimensions of innovativeness, indicating that contextual (ecological) factors influence the outcomes of innovation processes. However, pedagogical innovations also bring changes to the school ecology, and so can be viewed as processes that stimulate learning across the school as an organization. In this chapter, we look at how the innovation schools were nurturing innovative practices and thereby fostering (sustaining) themselves as learning organizations – as places where everybody in the organization learns and contributes to that learning. More particularly, we looked at whether and how the innovations differed in terms of the nature and focus of the organizational learning involved, as well as the mechanisms through which the organizational learning was being propagated.

Zhao and Frank (2003) propose, as an outcome of their study of technology use in 19 schools, an ecological metaphor to integrate and organize the factors they consider affects the implementation of technology use in schools. In so doing, they provide a framework for understanding why technology is used, underused, or misused in schools. They suggest that "innovations cannot be implemented without regard to the internal social structures of schools or other pressures that schools face" (p. 833). They accordingly recommend that schools take an evolutionary rather than a revolutionary approach to introducing and integrating technology in schools. Their work brings to mind Cash and McLeod's (1985) application of organizational learning theory to technology innovation and diffusion processes, which the two authors see as threefold: (1) opportunity identification and investment, (2) organizational learning and adaptation, and (3) rationalization and continuous evolution.

While Zhao and Frank's (2003) "ecological metaphor" is valuable in aiding our understanding of the internal and external conditions influencing the implementation of educational change or innovation at the school level, their work tells us little about the dynamics that enable innovation schools to manage the change mechanisms within their different school ecologies.

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The outcomes of our analyses of the SITES-M2 case studies in the earlier chapter made clear the important roles played by teachers and students in this regard, but that information still does not provide the fuller answer we need. In an effort to address this concern, we begin this chapter by reviewing literature on organizational learning in order to depict characteristics of organizational learning in schools and the need for schools to build structures that not only allow organization-wide learning to take place but also produce changes that align with organizational goals and sustain deep changes in pedagogical practice.[1] We follow the review with an in-depth analysis, from the perspective of organizational learning, of four SITES-M2 cases representing different combinations of teacher and student roles. Our overarching aim in this respect is to explore the extent to which different types of pedagogical innovations offer opportunities for organizational learning in schools. We focus, in particular, on how principals, teachers, students, parents, and other stakeholders thought and interacted during the processes of initiating and implementing ICT-related pedagogical innovations, and how they mediated the changes resulting from these processes. We also examine the architectures for learning in place in each of these schools and seek out possible relationships between these and the profiles of innovation described in Chap. 3.

Schools as Learning Organizations

While change, learning, and adaptation are all used in the literature to refer to the process by which organizations adjust to their environment (Fiol & Lyles, 1985), we can trace the concept of learning organizations to the seminal work *Organizational Learning* by Argyris and Schön (1978) in which the authors developed the idea of single-loop and double-loop learning. Single-loop learning is that which leads to an organization simply making short-term responses to an emergent problem. This type of learning does not allow for questioning of underlying assumptions; it results in the organization simply adapting to the circumstances occasioned by the problem rather than truly understanding it and then responding by bringing in changes beneficial to the organization in the long term. Double-loop learning allows the organization to tackle its basic assumptions and beliefs when faced with problems. This stance allows the organization to develop a deeper appreciation of these problems and alternative perspectives on how they can be addressed to the ongoing advantage of the organization. According to Crainer (1998), Argyris and Schön's work formed a bridge between theory and practice in a way few other academics have managed.

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[1] Wenger (1998) refers to the organizational environments that foster teachers' opportunities to learn new ideas and to try out new practices as "architectures for learning."

Lorange (1996) argues that, at the levels of both the individual and the organization, learning has to be inspired by change. He also argues that rapid change leads to strong pressures to learn. Fiol and Lyles (1985), however, in seeking to clarify the distinction between organizational learning and organizational adaptation, contend that change does not necessarily imply learning and that different levels of learning occur in organizations. Learning, they say, is "the development of insights, knowledge, and associations between past actions, the effectiveness of those actions and future actions," whereas adaptation is "the ability to make incremental adjustments as a result of environmental changes, goal structure changes, or other changes" (Fiol & Lyles, 1985, p. 811). We, too, regard organizational learning as higher-level learning that leads to insights, heuristics, and collective consciousness, and so should be distinguished from organizational adaptation, which involves reactive behavioral responses to conditions denoting change. This differentiation is similar to Argyris and Schön's (1978) distinction between double-loop and single-loop learning.

In the business sector, many projects necessitate redesigning the workplace environment so that employees have opportunity to develop the core learning capabilities and skills needed to accomplish those projects. Senge and Käufer (2000) list the learning capabilities as processes that involve (1) clarifying personal vision and values and building shared visions, (2) increasing personal reflectiveness and developing capabilities for dialog and productive discussion within working teams, and (3) developing systems-thinking abilities in order to conceptualize apparently highly independent issues. In a similar vein, in the educational literature, organizational learning is often promoted as the means by which schools can embed schoolwide improvement and reform processes. Advocates of this approach claim that the change process is made viable and long-term because the school has autonomy to address and accommodate the required changes as they see fit and as suits their ecologies (Karsten, Voncken, & Voorthuis, 2000).

A criticism of regarding schools as learning organizations is that "many schools could only be described as learning disabled in terms of their capabilities for organizational learning," not because the "learning-disabled" schools resist the notion, "but because those who control them have not allowed them to become learning organizations" (Hill & Crévola, 2003, p. 395). Senge's (1990) advocacy of five disciplines for building and sustaining learning organizations partially addresses this concern. Certainly, all five dimensions[2] were evident in Johnston and Caldwell's (2001) case study of the management practices of three Australian schools striving to become world-class schools. Senge's fifth discipline, system thinking, is a particularly important dimension of learning organizations because it taps into and harnesses the commitment and capacity of all people within that organization to learn.

[2] The five disciplines are systems thinking, personal mastery, mental models, shared vision, and team learning.

Innovation is also frequently viewed in the literature as an important vehicle for organizational change and learning, and these processes, in turn, are viewed as prerequisite for successful ICT implementation in schools (Larsson, Löwstedt, & Shani, 2001). We accordingly, in this chapter, consider whether the implementation of innovative ICT-related pedagogical practices in the SITES-M2 schools provided opportunities for these schools not only to improve student learning outcomes but also to foster the core learning capabilities that they needed in order to respond successfully to change.

According to Hill and Crévola (2003), "… organizations do not have the option of standing still; they either go backwards or forwards, and going forwards involves organizational learning" (p. 394) Some authors argue that a need to respond to certain demands arising from relatively dramatic events can act as an incentive to organizational learning (Watkins & Marsick, 1996). Hannan, English, and Silver (1999) contend that change in schools is driven by a number of external and internal forces, including the demands of employers, government policy initiatives and attempts by teachers to meet the changing needs of students and to respond to the changes in subject-matter curriculums. As Goodman (1994) and Taylor (1998) point out, the need for alignment between external demands and internal practices is often an important focus driving the learning process.

In addition to the force exerted by external and internal demands, learning is driven by the vision of a preferred future (Senge et al., 2000). According to this thinking, and also from an ecological perspective, organizational learning is the mechanism through which lasting ecological contextual conditions evolve during the process of change in response to more global environmental changes. Fiol and Lyles (1985) observe that "a commonly expressed belief in the strategic management literature [is] that organizations do learn and adapt and this enhances the organization's ability to survive" (p. 808). As Lorange (1996) puts it, changes stimulate learning. However, stimulation does not necessarily lead to learning that is sustained and embedded. After conducting an analysis of 59 SITES-M2 case reports, Owston (2003) proposed a tentative model of sustainability of classroom innovation involving two sets of conditions. The first set includes five *essential* conditions – teacher support, teacher professional development, student support, perceived value of innovation, and administrative support. The second set includes five *contributive* conditions – innovation champions, supportive plans and policies, funding, support from outside the school, and support from within the school. Essential conditions are conditions that are necessary but not sufficient for innovations to be sustained. Contributive conditions facilitate the sustainability of innovations.

Mindful, however, of the work by Senge et al. (2000), we maintain that organizational learning in schools will only make a lasting impact if it takes place at all three levels of the nested education system, namely the classroom, the school, and the community. These interdependent systems are deeply embedded in interwoven patterns of influence (Senge et al., 2000). The learning classroom includes three prime components – teachers, students, and parents. The learning school provides an organizational infrastructure that sustains classroom activities and involves active players such as superintendents, principals, school leaders, and school board members. The community, at the most complex level, is the learning environment within which the school operates. Its influences and characteristics are drawn from local, regional, and international constituents. Furthermore, every organization is a product of how its members think and interact. As Senge et al. (2000) put it, "… changing the way we think means continually shifting our point of orientation … [and] changing the way we interact means re-designing not just the formal structures of the organization, but the hard-to-see patterns of relationships among people and other aspects of the system, including the systems of knowledge" (p. 20).

Analysis of Four Innovation Schools

The discussion above drew out for us a number of questions that we wanted to explore in some depth. These questions guided our analysis of organizational learning in the four selected innovation case schools.

- What were the drivers for the innovation?
- How was organizational learning led in the innovation schools?
- How did the teachers learn?
- In what ways were the learning experiences of the principal, teachers, students, and other stakeholders connected through the implementation of the pedagogical innovations, and what kind of architecture for learning was available?
- What were the major challenges to organizational learning in the innovation schools?

We chose the four schools on the basis of our Chap. 4 cross-tabulation of the 83 reports of ICT-related pedagogical innovations. This tabulation was based on the extent to which teachers and students played traditional or innovative roles in relation to the innovations. This led to the following categories:

- Group A: both teacher and students played innovative roles (31 cases)
- Group B: the teacher role was innovative but the student role was traditional (12 cases)
- Group C: both teachers and students played traditional roles (28 cases)
- Group D: the teacher role was traditional but the student role was innovative (12 cases)

We selected one case school from each of these categories, as depicted in Fig. 7.1. These cases held distinct features typically found in their respective groups and belonging to different types of pedagogical innovative practice.

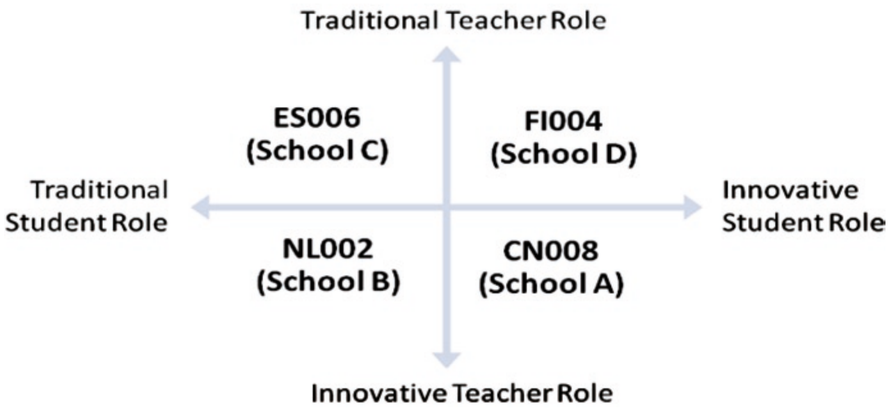

Fig. 7.1 Four case study schools selected for organizational learning analysis

School A

Innovation Background

Innovation CN008, a scientific investigation project (see Chap. 5) named "Problem-Based Learning: Computer-Assisted Scientific Investigations," was pioneered in a secondary girls' school (School A), located in an urban area in Hong Kong. At the time of the case report, the school had 1,002 students and 56 teachers. Most of the school's students come from upper-middle-class families. The school's language of instruction is English.

A total of 280 students from Secondary 4 to 6 (i.e., Grades 10–12) and three science teachers were involved in this project, which was implemented mainly in the physics, biology, and chemistry curricula. The students carried out 30 investigations using data-logging equipment integrated with a computer-based system for data collection and analysis. Each investigation comprised three phases: pre-laboratory discussion, laboratory session, and post-laboratory discussion. The role of the teacher was more that of facilitator than instructor. The students thus took an active role in organizing their learning: they identified problems to research, generated hypotheses, designed laboratory investigations for hypothesis testing, analyzed data, and presented their findings to others.

Innovation Drivers

School A is a well-established school that aims to provide quality education for its students. The innovation aligned well with the school's mission to provide opportunities for each student to strive for academic excellence, to develop her full potential through academic and extra-curricular activities, to acquire cognitive and analytical abilities as well as life, social, and communication skills, and to function as a confident and responsible member of society.

The teachers and principal are all highly committed to and enthusiastic about using ICT as a means of achieving higher order learning. The school, which believes that ICT in education encompasses more than just building up a sophisticated computer system and network within its campus, has developed its own modules for computer-assisted learning across the curriculum. It also encourages students to apply ICT skills when doing assignments and projects and to take part in many ICT-related competitions outside the school in order to "broaden their horizons."

The innovation aligned with the government's ICT in education policy, encapsulated in the document, *Information Technology for Learning in a New Era: A Five Year Strategy* (EMB, 1998), which allowed the school to receive external resourcing and support for ICT implementation and integration in general and the innovation in particular. The appointment of an ICT coordinator and a technical support service provided dedicated ICT-related assistance and troubleshooting. The government also provided the school's teachers with courses covering basic ICT skills, thus ensuring a smooth implementation of ICT in the school. The school was also drawn on the government's Quality Education Fund when resourcing the innovation. (The fund provides support for education developments in schools).

Leadership

The authors of the case report described the principal as a supporter of all kinds of innovations in the school, and as a person who encouraged a collaborative culture among teachers and students. The principal was quoted as saying, "I hope students can bring in new insights and challenges for teachers so that both teachers and students can learn in an interactive manner." The teacher in charge of the innovation said that the principal encouraged him to work with the heads of the groups of teachers forming physics and chemistry "panels" during the project.

Through her promotion of the innovation, the principal created opportunity for the innovation teachers to share their experiences with other teachers in the school. The principal was particularly committed to providing teachers with ICT-related professional development. Realizing that some teachers might feel apprehensive about using IT, she gave teachers more than one opportunity to master the learning objectives covered in the ICT training courses. The report authors said that this opportunity had benefited teachers. Because the teachers could attend the courses on staff development days, which were normal school days, they did not have to use up any of their holiday leave for this purpose.

Teacher Learning

School A organized regular in-house training workshops and seminars for both science and non-science teachers. These sessions focused on developing the teachers' pedagogical understanding of ICT use. The teachers involved with the innovation also received professional development related to it. During these sessions, the teachers were shown how to use data-logging equipment and systems, including systems specific to their area of science. They also had opportunities to share their experiences when using these resources.

Initially, all of the innovation teachers said that they thought the only competence they would need when carrying out the innovation was an understanding of the concept of scientific investigation. As one of the teachers said, "If a teacher can master this concept [scientific investigation], there should not be any great problem in carrying out the same kind of practice." However, their biggest challenge turned out to be a pedagogical one, as another teacher explained: "In this practice, it gave us some room in trying out new pedagogical approaches. […] For me the greatest impact of this practice is on pedagogy. This not only refers to the use of technology but also providing room for students to solve problems."

Over the course of the project, the teachers communicated and collaborated with one another and gained professional development as they learned to use the computer and data-logging technologies. These processes, they said, made their teaching increasingly interactive. The teachers also met regularly to discuss and assess the students' projects. They asked other science teachers for their opinion about the nature and success of the innovation, and had their students complete evaluation questionnaires.

Architecture for Learning

The process that School A was using to implement and support ICT use enhanced the learning of both teachers and students. The school had in place three teams that together provided ICT support. These were the ICT coordination team, the ICT support team, and the ICT student-support team. The school set up the ICT-coordination team in June 1999. It consisted of four computer teachers who were responsible for the day-to-day administration and procurement of computer hardware, the installation and maintenance of the equipment, and the organization of training workshops for the teachers. The ICT support team, composed of 18 departmental ICT representatives nominated by the department heads of the six subject groups, was formed to assist the school to develop and implement ICT use in its teaching and learning. The student support team consisted of 10 Secondary 2–6 students whose main responsibility was to maintain the school intranet and help teachers upload their teaching materials onto their homepages.

The school also set up a team to coordinate implementation of the innovation. The teachers involved said that this approach enhanced collaboration among teachers of the different science subjects. Said one teacher, "Before this practice, the three subject panels worked independently. Thanks to this practice, we now work more closely and collaboratively. We do learn from each other." During the innovation project, the teachers worked and learned alongside their students as the students identified and conducted their investigations. The teachers required the students to develop their hypotheses and conduct the experiments, but provided the equipment the students needed. The whole investigation process was essentially student-centered.

The interviews with both the teachers and students highlighted a change in the roles of both groups. Teachers acted as advisors and facilitators instead of as instructors. One student commented, “He [the teacher] changed and became a guide who led you to think rather than just telling you about the subject matter.”

The case study account showed that School A had in place a sophisticated architecture for learning involving ICT use. This architecture provided solid support for ICT implementation in general and for the innovation in particular. Its structure allowed for connections and collaborations between different groups of teachers and enhanced teachers engagement and collaboration with students.

Challenges

School A clearly went well beyond the adaptation mode of organizational learning while carrying out the innovation. However, the highly innovative roles required of both teachers and students challenged the sustainability of the innovative practice. The innovation teachers said they found it difficult to teach the subject material within the context of the innovation procedures, but said that efforts to meet this challenge had stimulated pedagogical insight and changes in practice. The school considered a major challenge to be integrating the pedagogical practices associated with the innovation into the mainstream curriculum, and staff queried the extent to which the school would, or could, maintain and extend the learning architecture of a multidisciplinary team of teachers after the project had come to an end.

Summary and Conclusions

CN008 was a well-planned innovation that had ready support from the principal, the teachers, and the students. The sophisticated set of professional development and support provisions for ICT implementation was successful in connecting different groups of teachers in various ways and with students. The learning architecture comprised ICT-specific and pedagogical elements, and thus made possible the complex learning required to produce marked changes in role for both the teachers and the students.

The key pedagogical element of the learning architecture was the team of three science-panel heads that came into being only to develop this innovation, which was conducted as an extracurricular activity held on Saturdays and funded as a special project by the Hong Kong Quality Education Fund. This formation of a teaching team dedicated to the innovation along with the school’s collaborative culture created a strong and supportive learning milieu.

A post-study follow up of this case revealed that the innovation was no longer in place. All that remained of it was documentation of the 30 experiments derived from the students’ investigations during the project. These 30 texts had replaced the original set of student experiments included in the science textbooks.

School B

Innovation Background

The set of task-based activities (digi-lessons) comprising the pedagogical design of NL002 (see Chap. 5) took place in a state school for primary education in Apeldoorn, a relatively large city in the center of The Netherlands. The school, situated in a fairly new housing estate and built just over 30 years ago, had a reputation for being an ICT innovation school. As a small public school with 160 students, the school was open to all, irrespective of religious beliefs. It had six classes, with some grades in combined classes. All students and teachers in the school were, and continue to be, involved in the innovation.

The digi-lessons, developed for each grade, include the subject areas of Dutch, arithmetic, history, geography, biology, and music, and all teachers of these subjects have integrated digi-lessons into their daily teaching practice. The digi-lessons featured Word-documents that set out assignments for the students and provide them with internet links so they can find relevant information. The students and their teachers discussed answers to the assignments during the lessons. The lessons were an outcome of the school's commitment to reduce the use of paper by (among other activities) having staff and students use the computer for written work. According to the principal, this aim had led to the hoped-for reduction in paper use, and the aim had been further realized by the digi-lessons replacing textbooks in some subject areas. The role of textbooks in the school curriculum overall had diminished, and the school was debating whether to replace old textbooks with new ones.

Students needed particular ICT-related skills in order to take part in the lessons. They had to be able, for example, to open and save a document (a digi-lesson), change font size or color, access the internet, copy and paste pictures, and enlarge or reduce the size of a picture. The goals of the lessons were twofold: mastery of the content of the subject area (derived from the core objectives of that particular subject area), and mastery of the necessary basic ICT skills. More generally, the school also expected the innovation to contribute to children's ability to work independently and to help facilitate their individualized learning. In line with this philosophy, each student had computer-based access to his or her personal student-file.

When setting up a digi-lesson, teachers selected the one they wanted to use and then copied it into the students' files. Depending on the ability of the student, the teacher could select a lesson appropriate for a lower grade or a higher grade. The teachers could thus individualize the learning trajectory of their students, and give them extra lessons if needed. In some subject areas, such as arithmetic, the school reported that student performances vary considerably. Digi-lessons worked well in these circumstances because the students could work individually, at their own pace, and their teachers could gave them individual instructions and feedback. This change in pedagogical practice was consistent with the school's vision that education had to adapt to students' needs.

Digi-lessons positioned teachers as organizers/planners when they selected the lessons they deemed necessary for their students and as supervisors when their students engaged in the lessons in the computer lab. The nature of the digi-lessons and other ICT-related activities meant that students can also work at places other than the lab when at school. Whole-class instruction had accordingly become less frequent. The principal said, "You do not need to see them all [the students], and they are still at work. That has really changed. The teacher and the students were working at three locations: in their classroom, in the computer lab and in the hallway. You see them sitting in groups and they are working."

Innovation Drivers

School B, convinced of the necessity to use ICT in education, maintains that ICT should replace traditional lessons and not be additional to them. Only then, as the technology coordinator argued, will everybody accept it, albeit gradually: "At first, I thought you need an educational paradigm, and then you look for the hardware and software you need, but gradually I have changed my view. When the hardware and the opportunities are present, you then discover how you can use them in an educational context."

School B's vision for teaching and learning focused on a combination of whole-class instruction, group work, and independent learning. According to the school, education served to contribute to children's happiness, thereby helping them develop a positive attitude towards life. The school acknowledged that parents also influence school goals.

The school adopted the principles of Dalton education,[3] which it aimed to further develop through ICT implementation. At the time of the study, the school had also applied to become a "vanguard" school within the framework of the government project, "Investing in Staying Ahead." As a candidate vanguard school, School B had received a subsidy for the procurement of ICT hardware and other aspects of its schooling. Because a vanguard school acted as a model for other schools, School B had drawn on this external support so that it could meet with various schools in order to describe and discuss the digi-lessons.

Leadership

School B's principal described his leadership style as democratic. He said he welcomed parents' opinions about the goals of education and teachers' comments about their concerns. However, he also said he kept to his principles whenever a conflict arose between him and his colleagues.

[3]The Dalton Plan is an educational concept aiming to achieve a balance between each child's talents and the needs of the growing community, which embraces a three-part plan that continues to be the structural foundation of a Dalton education – the House, the Assignment, and the Laboratory ("Dalton Plan," Wikipedia).

Commensurate with his commitment to modeling IT-use, the principal originated the idea of digi-lessons. He said he used ICT frequently and endeavored to convince the school's teachers of the usefulness of ICT by providing them with the necessary information in a straightforward manner. For example, as part of his efforts to make sure that staff had a sound pedagogical understanding of ICT use, he required them to attend a course on internet access and use at the public library.

Teacher Learning

The school's teachers were reported as needing to have only low-level ICT competence in order to develop and implement the digi-lessons. They had to be able to use a computer, Windows, and the internet; they did not need to know how to use Microsoft Office programs. At the time of the case study, two teachers had attained the European Computer Driving Licence (ECDL). Although teachers were not required to possess the license to conduct the digi-lessons, other teachers in the school were planning to attend this training.

Architecture for Learning

The principal and teachers said that designing and implementing the innovation was time consuming. This work had to be done in addition to the ordinary tasks and activities of the teachers. While the school had received some resources in support of the innovation, much work still had to be done during after-school hours to meet the various innovation implementation deadlines. During the design stage, the computer-based system set up for the innovation encountered the problem of how to set up and distribute the student files containing the digi-lesson while protecting the teachers' domain. Initially, the school decided to use floppy disks for this purpose, but eventually one of the parents provided technical assistance and came up with a solution.

The school reported having invested time and effort to support the teachers who had reservations about the innovation. Extra time slots in the timetable were being used for this purpose. The case study report makes apparent the fact that the principal, as the initiator of the innovation, had proved to be the focal agent within the learning architecture. He took considerable time to discuss the innovation with teachers, was working closely with them to ensure they were successfully involved in it, and he was endeavoring to develop parental engagement in the innovation and support from local organizations for it.

Challenges

Despite the principal being committed and enthusiastic about the use of digi-lessons and despite the widespread use of these lessons throughout the school,

School B, at the time of the case study, had generally "gone it alone" in implementing the innovation. The school had received only minimal support and resourcing from outside sources, although some local organizations were expressing interest in learning from and collaborating in the innovation.

The case study report nonetheless confirmed NL002 as a sustainable innovation. While there was little change in the role of the students, given that they were still following instructions (albeit in digital medium), there was a substantial change in role for the teachers, who were required to move to student-centered, individualized learning – a deep change theoretically requiring related professional development. However, the only kind of professional development that teachers received was technically oriented.

Summary and Conclusions

The case study shows that School B's principal and staff were all committed to using digi-lessons. Students seemed to be at ease with this change, probably in part because it involved little change in their traditional role as students. The teachers experienced change to their roles, but received little, if any, professional development pertinent to this change. We suspect that this kind of oversight occurs when technology-enhanced learning is equated with individualized student-centered learning. Learning for the teachers were primarily associated with technological adaptation, which explains why such a simple learning architecture had proved adequate for sustaining the innovation itself. We query, however, if the change in teacher role to that of facilitator and collaborator in student learning would be sustained in the long-term.

Transferability of the innovation within the school was being readily accomplished, and it was apparent that the whole set of digi-lessons could be easily transferred to other schools. The school had, in fact, already organized meetings with other schools to share their experiences and achievement with the digi-lessons. The innovation requires little training with respect to basic computer skills because anyone who knows how to use a computer, handle Word documents, and surf the internet can use the lessons.

School C

Innovation Background

ES006, titled "The Internet in the Classroom," belongs to the type of pedagogical practice that we refer to as expository lessons (see Chap. 5). It was carried out in a secondary school (School C), which was formerly a vocational school. Because of this historical background, the school staff had close contact with the labor market and were active in the implementation of innovative practices, especially those involving the use of ICT. The school was situated in the centre of Tarragona, a town with about 115,000 inhabitants on the south coast of Catalonia in Spain. At the time of the study, the school had 1,364 students and 91 teachers. The innovation was part of the ARGO[4] project, involving about 40 schools and initiated by the Department of Education of the Generalitat of Catalonia. The Generalitat provided all participating schools with adequate technology equipment.

The Department of Education set up the ARGO project in order to encourage schools to use the internet to develop multimedia teaching and learning materials covering different curriculum areas and produced in the Catalan language. This innovation was being regularly used in School C within the subject areas of technology and physics. Teachers and students of other subjects were also participating to some extent in the innovation, primarily by using the internet as a source of information, or occasionally presenting instructional materials in the ARGO laboratory.

Innovation Drivers

The innovation aligned with School C's policy of making ongoing changes to its pedagogical practice so that it could help its students meet the demands of modern society, especially those associated with the labor market. The school strongly maintained that use of ICT, especially the internet, was an essential component of innovative teaching and learning practice. The Department of Education's support for the innovation, both in terms of policy goals and the provision of an ARGO lab equipped with a projector and a large screen visible to all the students in a class, also provided a strong impetus for the innovation. Through it, the school had become a member of the network of ARGO schools, which meant it could contribute to and benefit from the multimedia materials developed by the network.

At the time of the case study, the innovation also fitted in with the school's concurrent involvement in a number of European-based education innovation projects, some of which necessitated the use of ICT. School C's principal reported that the innovation had increased the amount of information and resources available for both teachers and students, and enhanced the presentation of information. The innovation teachers said that the use of multimedia resources had increased students' motivation and improved the learning process.

Leadership

ICT competency and involvement in international projects was always a priority in School C. The principal saw his role as that of a teaching colleague who could

[4] In Greek mythology, the *Argo* was the ship on which Jason and the Argonauts sailed from Iolcus to retrieve the Golden Fleece.

support staff and facilitate the implementation of new projects and pedagogical approaches, once staff had agreed to their implementation. "The role of a principal," he said, "is a colleague that works harder and is 'rewarded' with more criticisms than the rest of the staff. The managing board is very efficient, and I try to push them. I also try to be available for everybody." The case report, however, made no mention of the principal putting in place any, let alone innovative, ICT-related measures.

Teacher Learning

In order to implement the innovation, School C's teachers had to search the internet to find materials that matched the curriculum of their subject areas. They then had to be adapt these material or create their own. The teachers considered basic ICT training to be adequate (from a technological perspective) for this purpose. However, they also pointed out that teachers participating in the innovation needed to change their methodological approach to teaching, be willing to spend extra time and effort to produce the resources, and have the ability to work in multidisciplinary teams. The case study authors observed that even the teachers not directly involved with the innovation considered ICT a highly important feature of the school, and that they were having to accommodate an increasing use of technology-based resources every year.

Mindful of these concerns, the school set up a working group charged with developing, implementing, and monitoring the innovation. The group included the school technology coordinator (a teacher relieved of 3 hr of teaching per week so that he could accommodate this task), the teacher responsible for multimedia resources, and one teacher from every department in the school. The working group established the general curricular objectives of the innovation, coordinated the use of the technology lab housing the proxy server (i.e., ARGO), and collated information about the various tools and resources used by the teachers in the school's departments. They also determined a general methodology for using the equipment, developed assessment procedures, and created a list of electronic mail users within the school so that teachers could exchange and disseminate information and ideas about the innovation.

The teachers involved in the innovation were also said to have benefited from the learning offered during a 1-day meeting organized by the General Subdepartment of Information Technology (SGTI) of the Department of Education of the Generalitat of Catalonia and offered to everyone participating in the Internet in the Classroom project.

Architecture for Learning

The working group provided an important human resource infrastructure, especially in terms of mediating innovation-related learning – both technical and pedagogical – within the school. The professional communication between this group and similar groups in the other schools participating in this project, as well as support from the project administration team in the Department of Education formed a strong learning architecture.

In addition to the innovation-specific architecture for learning within and outside of the school, School C had in place a long-established and more complex architecture supportive of teacher learning. For many years, School C had provided technology-related training courses for its teachers, many of which were organized by the teachers themselves. Teachers also participated in international workshops and seminars related to innovative practices, including those making use of ICT. The active participation of the School C teachers in the various European educational projects had given them access to local and international professional development opportunities as well as participation in learning communities beyond the school. Taken together, the learning opportunities available for teachers within and beyond the school signaled that the school had in place the factors necessary to scaffold deep, pervasive organizational learning.

Challenges

The project seemed to have progressed smoothly, although the teachers involved in it acknowledged that the challenge associated with implementing and sustaining it would be much greater if it were to involve reluctant teachers. The teachers did report one obstacle, that of competition for use of the laboratory. They said that more resources would be needed if the innovation were to expand to include more teachers and students. The teachers were also unsure if the Department of Education would be able to continue providing the funding necessary to keep the school's ICT infrastructure up to date.

Summary and Conclusions

We categorized ES006 as a case study in which teachers and students played relatively traditional roles. However, the case report was such that we could not gain a clear appreciation of whether the organizational learning taking place in School C was at a level lower than that in School B. Although the teachers in School C were mainly using ICT for expository, instructional purposes, they were trying to find and produce multimedia resources that they considered would make a difference to students' learning.

An important strength of this innovation was the establishment of the working group, which, with its strong focus on curriculum development and pedagogical practice, was able to direct and channel the teachers' attention to the need for changes in their practice, including that associated with assessment. It was also clear from the case report that some teachers were adopting more advanced, student-centered uses of technology while making the entry hurdle to the innovation a very low one. And while some of the teachers involved in the innovation appeared to be engaged in technological adoption only, others were nurturing, under the same project, practices involving deeper changes to their traditional roles, resulting in an ecological mix of pedagogical practices indicative of sustainable emergent changes and development.

School D

Innovation Background

Innovation FI004 was a web-course conducted in an upper secondary school (School D) in Sipoo, Finland. School D is located in Nikkilä at the center of Sipoo, which was a rural commune situated near Helsinki, the capital. School D was a small, non-graded school, with 150 students and 15 teachers. Sipoo is a bilingual commune. Fifty-five percent of its inhabitants speak Finish, and forty-five percent speak Swedish.

The web-course was connected to a project called “Sipoo Institute,” which was endeavoring to build a virtual center for learning in Sipoo. The course consisted of 20 study weeks, during which students learned various ICT, group, and project-work skills. The aim of the course was to provide students with good technical capabilities, the skills needed to work successfully in groups and in customer service, and understanding of business activities. The technical content of the course was quite demanding. It required participants to operate computer systems, such as Linux, to employ database techniques, and to use programming languages such as Java, Perl, and C++. The students participating in the course engaged in activities associated with working in virtual companies. They also had to conduct small-scale projects and undertake practical training in some company. Students worked independently for much of the course work. The rest of the time they worked collaboratively with other students.

Innovation Drivers

School D’s principal maintained that “ICT is a tool, not a value in itself.” The teachers anticipated an ongoing increase in ICT use for teaching and learning. They said that students needed to learn ICT skills in school, as these would be a necessary component of their future lives. However, the extent to which the teachers were using ICT during their teaching varied across subjects. Some teachers, particularly those involved with the Sipoo Institute and who carried out network pedagogy projects used ICT extensively, and reported good experiences of using ICT in their teaching. Other teachers thought that ICT had no place in their subject or did not know how to use ICT when teaching. The most popular use of ICT by teachers in School D was searching for information. While parents considered ICT skills an important lifelong attribute, they too thought that ICT use in schools should not be over-emphasized.

The major driver for this innovation was the enthusiasm of the project initiator, who was also the initiator of the Sipoo Institute. He had been interested in using ICT in teaching for many years and had been active in developing ICT use in the school. School D received ICT resource support and advice from the Sipoo commune, which the school staff considered a highly important success factor not only for the innovation but also for ICT-related pedagogy in general. There were also policy-makers in the commune who supported this innovation.

Leadership

The school principal was one of the initiators of the innovation. He was not involved in the innovation directly, but he understood the value of this project and approved it. The principal did not use ICT in his own teaching, but considered ICT to be a good tool when used as "an addition for teaching." He also approved teachers' requests for professional development. He said that all teachers could participate in any ICT training they wanted, but their participation was voluntary.

According to the principal, the innovation promoted the students' self-confidence because it allowed them to produce something by themselves. This heightened self-confidence, he said, would help students achieve better learning outcomes in other subjects as well. He thought that students who normally did not do well in traditional school subjects would particularly benefit from their achievement in ICT.

Teacher Learning

Teachers could access ICT training inside and outside of the school. Much of this training was organized by the Sipoo Institute. Training included basic skills development (e.g., word-processing, image-processing, using email and web-based environments) and activity related to web-based pedagogy projects. Teachers involved in the innovation generally appeared to find their engagement a pleasant one, and particularly appreciated the emphasis that the initiative accorded to teachers' professionalism. Because the web-course involved fairly advanced ICT skills, many of these were beyond the expertise of School D's teachers. Many of the to teachers directly involved with the course were therefore outside experts, such as graphic designers and employees of technology companies. The students, however, considered that many of these experts lacked pedagogical skills and found their teaching superficial.

Architecture for Learning

The web-course innovation appeared to have provided an activity structure that connected the learning experiences of school teachers, outside experts, and students.

Teacher collaboration varied greatly across individuals, however. According to the teacher interviews, teachers worked alone most of the time and tended not to collaborate with one another. Nonetheless, a considerable amount of collaboration was evident in relation to certain projects, such as the web-course ones. Both teachers and students said that interaction between them was generally spontaneous and direct, and that they worked together like co-workers. Students did the exercises and then discussed them with their teachers and their classmates. Some of the students provided help for other students, and they said that everyone always found something new to learn and discuss. The case study reported that students were usually quite motivated.

Challenges

One of the challenges that the school faced with respect to ICT-related training was the considerable variation among teachers in terms of their ICT skills. Teachers' attitudes towards ICT training and their participation in it were very diverse. Some considered it to be very necessary for carrying out their work, while others found it difficult to find the time to engage in it. Some teachers thought that they because their role was that of experts in pedagogy and instruction, they did not need to know "everything" about ICT, and that it was fine for their students to know more about ICT than they did.

Because the web-course was a special arrangement, the lessons associated with it sometimes clashed with those of other subjects. The teachers of those subjects hoped that this situation would be remedied. The school was planning to develop the course collaboratively with a technical college, and to make the course part of a vocational examination.

At the time of the case study, the web-course had been operational for more than a year, and there appeared to be support for it to be sustained and transferred to other schools. However, because much of the expertise required to teach the web-course depended on external personnel, it was evident that sustainability and transferability for the innovation would rely very much on whether the commune was willing to continue to fund it. Despite this uncertainty, the principal and teachers thought that the course would continue in the school in some form.

Summary and Conclusions

The web-course differed from the previous three case examples in that the school was using ICT to support the learning of advanced ICT skills and not to support teaching and learning in other subject areas. Hence, the course's impact was confined largely to those teachers directly involved in it. The architecture for learning was rather limited in scope, especially given that most of the teachers involved in the innovation were experts from outside of the school. The case study reported students' complaints about the lack of pedagogical skills among these experts, but made no mention of any mechanism to help these people develop those skills. The same could be said with respect to the innovation teachers, given that they usually developed and worked on their courses mainly on their own, with occasional help from the project coordinator.

Summary and Discussion

During our analysis of the four case-study innovations reported in this chapter, we highlighted the contextual differences of each and focused on two key aspects of organizational learning – the teacher learning involved, and the architecture for learning operating in each case. This focus provided us with portraits of the four school ecologies relative to the four profiles of teacher-role and student-role combinations. While we found many similarities among the four cases, we also found differences in their organizational ecologies. We discuss these here.

Innovation Drivers

Leskes, Grogan, Canham, and O'Brien (2003) argue that fundamental and sustainable change is possible given the right combination of vision, compromise, and commitment. These three driving forces of innovation and change were clearly identifiable in the four schools. In all four, a clear educational vision underpinned the innovations. The principals and teachers involved in the innovations showed commitment and enthusiasm. And external resourcing and support for the innovative practices played a notable role in sustaining the innovation.

Teacher Learning

Meaningful and lasting reform in schools can only be accomplished by teachers who consider themselves to be learners (Hendricks-Lee, Soled, & Yinger, 1995). As Fishman, Marx, Blumenfeld, Krajcik, and Soloway (2004) point out, schools and other relevant stakeholders have to realize that teacher learning is a key issue whenever innovations are mooted as potential solutions to problems arising out of systemic reform initiatives. As we discussed earlier in this book, during the development and implementation stages of technology-supported pedagogical innovations, teachers may need to learn new knowledge in seven domains: pedagogical (PK), content (CK) and technological knowledge (TK), as well as their intersections – PCK, PTK, TCK, and PTCK (Mishra & Koehler, 2006).

As our analyses in Chap. 5 made evident, the learning required of teachers differs according to the teacher-role/student-role combination of the innovation. Hence, the above-described innovation in School A was the innovation most demanding on the innovation teachers, as they had to gain new knowledge in all seven domains. Although the learning required of the innovation teachers in Schools C and D was primarily technological (TK), it also included PTK and TCK.

Organizational Learning

If changes are to count as organizational learning, they must challenge the assumptions and values that staff hold about their organization's practices and not just lead to alteration of surface-level practices (Argyris & Schön, 1978). Within the 83 case study schools, transformative and innovative use of ICT relied on "disrupting" established pedagogical practices and thereby creating tension. Behavioral responses to changes in the form of organizational adaptation (i.e., single-loop learning) was evident in all four innovation schools considered in this chapter. A major challenge for schools is knowing how to build on single-loop learning in order to attain a deeper level of organizational learning – a level characterized by changes to values and assumptions (i.e., double-loop learning). In the four innovation schools, including School C, where both the teacher and the student roles remained traditional, double loop-learning took place for the innovation teachers, although the depth of that learning differed. If double-loop learning had not been evident, the innovations would not have taken place.

The biggest challenge facing innovations is their sustainability – whether the new practices can survive and prosper. Often, innovative practices emerge under particularly favorable environmental conditions, such as specially skilled and/or committed leadership and teachers and the presence of external funding and/or support. However, because the emergent new practices are fragile, they are unlikely to survive if any of the special conditions disappear. Sustainability needs organizational learning that is deeper and more pervasive than the organizational learning needed during the initiation and development stages of the innovation. The organizational learning has to be such that it produces long-term changes in institution-wide human resource capacity and in organizational practices. When this happens, the resulting organizational ecology becomes a "habitat" suited to nurturing and sustaining the emergent innovation.

Architecture for Learning

In Chap. 6, we found that schools with a collaborative work culture among staff tended to have higher levels of innovativeness in terms of curriculum goals, teachers' roles, and students' roles. In similar vein, schools that had a collaborative relationship with their communities tended to be highly innovative with respect to ICT sophistication and the connectedness of their classrooms. Connectedness is a critical feature in any architecture for learning in an organizational context, and it appears that differences in this feature have a strong impact on the further development and sustainability of innovations, as was evident in the four case studies described in this chapter.

The innovation teachers in School A successfully met the stringent learning demands necessary to develop and implement the innovative practice (authentic scientific inquiry activities). The architecture for learning was confined to supporting the three innovation teachers during the time they conducted the innovation as an extra-curricular activity. Because the school made no further change to its organizational ecology, the innovation could not take root in the formal school curriculum and so the essence of the innovation did not survive beyond one school year.

The innovation in School B required teachers to convert their traditional lesson delivery into digi-lessons, in order to support students' individualized learning. The teachers had to undergo considerable learning in order to cope with the resultant change to their teaching roles. The principal was fully aware of and committed to providing staff with needed encouragement and professional development support so that the innovation could be implemented school-wide. He spent time convincing teachers who had reservations, and even used slots in the timetable for this purpose. The architecture for learning in this case also included connectedness with parents and local community organizations, both of whom learned about the innovation through the principal's efforts. With increased understanding came additional support from these external agents, which in turn changed the school ecology to one capable of sustaining the innovation in the long term.

As a pedagogical innovation, the case in School C was relatively traditional. It required teachers to use the internet to look for and/or help develop multimedia teaching resources. Although the learning required of the innovation teachers was the least demanding of the four innovations, the architecture for learning that this school developed was the most sophisticated and extensive. A particularly successful component of this architecture was the school's permanently established innovation working group comprising the school technology coordinator, the teacher responsible for multimedia resources, and one teacher from every department in the school. Time was built into the technology coordinator's workload so that he could accommodate this responsibility. The group was tasked with coordinating all the necessary measures to implement and integrate the innovation into the school curriculum. This work therefore included developing curriculum objectives, determining assessment methodologies, setting up administrative arrangements and routines for use of the school's technology laboratory, and collating information about resources, tools, and experiences.

The professional development activities organized by the Ministry of Education allowed School C's teachers to work and collaborate with teachers in other schools participating in the internet in the classroom project. The school was also well connected to a number of European educational projects. These different networks formed an architecture for learning at both individual and institutional levels. It enabled teachers not only to learn new knowledge and skills but also to establish new practices at the curriculum and administrative levels. This situation, in turn, had resulted in a school ecology able to evolve and successfully accommodate new and ongoing innovations.

The architecture for learning in School D was a very simple one in terms of both the scope of learning and its structure. The focus was on identifying people who could teach the sophisticated technical content required in the web-course, either from within the teaching team within the school or from outside expertise. Both the in-house and external teachers had to undertake new learning to cope with the demands, whether technological or pedagogical, of teaching the web-course. However, the school made no explicit provision to support the teachers' learning beyond approving teachers' requests for professional development. Some of the innovation teachers from the school reported increased collaboration among teachers as a satisfying outcome of the innovation, but the collaboration was only a spontaneous outcome of the innovation rather than an orchestrated move. However, despite the weak learning architecture, it was likely that the school was able to sustain the innovation because, as a small course set within the school curriculum, it did not require a changed school ecology for its survival.

Leading Learning

According to Fullan (2001), only principals who are equipped to handle a complex, rapidly changing environment can implement the types of reform that lead to sustained improvement in student achievement. The roles that the principals played during the initiation and implementation stages of the innovations in the four case study schools differed: supporter of change (School A), initiator and champion (School B), facilitator (School C), and initiator (School D). These roles do not focus on the roles the principals play in supporting learning, or establishing a learning architecture. However, leading learning is crucial with respect to the quality of the implementation and the sustainability of the innovation. The learning that an organization needs to sustain an innovation requires the establishment of a learning architecture that connects all stakeholders within and outside of the school. The functions of the learning architecture are to enhance interaction, promote understanding and sharing of ideas, support ongoing learning, establish new curriculum objectives, develop assessment methodologies, and put in place the human and administrative infrastructure necessary to mainstream the emerging innovative practices. In short, the design of the learning architecture has to be led in a manner that allows it to bring about an adaptive evolution of the school ecology compatible with the needs of the innovation. Only then will that innovation be sustainable.

Chapter 8
Pedagogical Innovations as Systemic Change: The Challenge of Sustainability and Scalability[1]

Innovation has become an increasingly important theme in education. Since the last decade of the twentieth century, systematic education reforms have mushroomed in many countries around the world. These reforms have led, in some of these cases, to deep changes in curricula, pedagogical activities, and the roles of teachers and learners. A major challenge associated with these changes has been that of scaling up and sustaining the innovations that they represent.

In the previous two chapters, we explored the kinds of school characteristics most conducive to technology-supported pedagogical innovations (Chap. 6), and portrayed the organizational learning of four schools associated with different combinations of innovativeness with regard to teacher roles and student roles (Chap. 7). These chapters highlighted not only the complexity of educational change but also the importance of establishing an architecture for learning that supports the adaptive evolution of a school's ecology and the sustainability of innovations.

In this present chapter, we argue that systematic, stage-based models of change are inadequate for achieving sustainable educational reform goals. Classrooms and schools are complex systems, hierarchically nested within regional and national education systems. All of these systems are characterized by high interconnectedness, such that changes in one system propagate, through interaction and feedback among the people involved, changes in the other systems. We caution that sustaining and transferring innovations should not be viewed as stages to be considered after a good innovation prototype has been established. Instead, sustainability and transferability have to be built in right from the inception stage of an innovation. And that "building in" requires mechanisms that allow for the opportunistic development of social infrastructures that favor innovation-centered networking. This claim informs the content of this chapter, in which we again draw on the 83 SITES-M2 case studies for illustrative purposes.

[1] This chapter is an edited version of Law, N. (2008). Technology-supported pedagogical innovations: The challenge of sustainability and transferability in the Information Age. In C. H. Ng & P. Renshaw (Eds.), *Reforming learning: Issues, concepts and practices in the Asia-Pacific region* (pp. 319–344). © Springer Science + Business Media B.V. 2008.

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The Need for Systemic Change in Education

A common theme underlying the educational provision of today is the need to bring in, across all levels of education, change of a kind that will equip citizens for life in the knowledge society. This society, according to Riel (1998), is characterized by increasing globalization, rapid changes in and to bodies of knowledge, appreciation of the importance of knowledge creation for sustaining economic and social development, and an understanding that economic competitiveness requires increased collaboration in the workplace (Riel, 1998). This perceived need for major changes in terms of both the goals and the processes of education is shared not only in industrialized countries (see, e.g., the European Round Table of Industrialists, 1997), but also in less developed countries (see, e.g., Gregorio & Byron, 2001; UNESCO, 2003). It is thus no surprise that the term "systemic change" has been embraced by many engaged in instituting and/or researching educational change. Certainly, the term is highly evident in the educational-change literature. This focus purportedly stems from a broad recognition that education is a complex system and that what happens in one component of the system impinges on other components in the system. However, a careful examination of this body of literature reveals that the term systemic change carries very different and sometimes even contradictory meanings.

Reigeluth and Garfinkle (1994) characterize systemic change as a "paradigm shift, which entails replacing the whole thing" (p. 3) rather than making piecemeal changes to or tinkering with that thing. Assuming that wholesale change is necessary, many commentators, such as Hutchins (1994), argue that change will not be successful unless it involves a process coordinated throughout every sector and level of the education system (Hutchins, 1994). Banathy (1994) and Banathy and Jenlink (2004) refer to this process as "system design," which ideally should start with the envisioning of a new society and of the type of educational provision that will create and serve that society. These visions provide the platform from which the required system of education can be designed and developed. This work requires initiation and commitment from the top level downwards and an approach that is well planned and systematic. It also needs to be underpinned by the key processes of change, namely, system-wide, large-scale experimentation, evaluation, and revision.

Although starting from the same point of departure – social organizations as complex systems – Wheatley (1999) focuses on a different set of core features in her consideration of the most important change and management factors of complex systems. Maintaining that complex systems are best understood as a whole rather than as the sum of their parts, she emphasizes the importance of understanding the inter-relations among the various parts of a system. For her, organizational vision and values are the forces (similar to the concept of force fields in physics) that influence human behavior within and across systems. Her view of vision differs from the notion of vision commonly found in the educational-change literature. That notion, evident in the work of, for example, Banathy (1994) and Reigeluth and Grarfinkle (1994), refers to some desired future state. Under this notion of vision, organizational structures emerge as temporary solutions that facilitate the realization of the vision and continue to change as the system evolves; these structures are not part of a blueprint for the implementation of a design. Wheatley (1999) argues that a system should co-evolve with its environment through a process of self-organization, the effectiveness of which depends on a free flow of information. Consistent with Wheatley's model of self-organization is Hargreaves and Giles' (2003) "knowledge society school," which models a process of system thinking, wherein ideas about and implementation of change and innovation move out from the top leadership in the school to key process teams throughout the school and inform interactions between teachers and students in the classrooms.

Changes take place in organizations for many reasons, and may be the product of a reactive rather than a purposive response to a situation (Dill & Friedman, 1979). Systemic changes are purposeful, directed towards the accomplishment of specific goals, and may also be referred to as innovations. The outcome of an innovation may be a tangible product or procedure that is new and intentional, and that aims to lead to benefit (Barnett, 1953; King & Anderson, 1995). Reforms refer to innovations that are typically initiated by individuals at the top of organizations or by agents outside them (Kezar, 2001). Despite the large numbers of reform initiatives that have taken place around the world over the past two decades, many of them have not been particularly successful. Many successful innovations are not the outcome of top-down reform initiatives. For example, an OECD study of 23 innovations in science, mathematics, and technology education collected from 13 OECD countries (Black & Atkin, 1996) identified a range of change agents that included governments (implementing nationwide initiatives) states and provinces, schools, and individual teachers.

Reforms often challenge the survival and "craft norms" of teachers (Olson, 2002). These only succeed if the teachers involved are prepared for and support the deep pedagogical changes that are generally required. Anderson (1998) particularizes this notion by saying that teacher engagement relies on collaborative co-construction of a new social ground. Hargreaves (2003) proposes redesigning school-improvement efforts to incorporate a developmental approach, focused on making available a professional learning community for every teacher. While the difficulties associated with changing pedagogical practices no doubt pose a major hurdle to ensuring the success of systemic changes in education, the greatest challenge is that of sustaining and scaling up innovations (Atkin, 1998; Kozma, 2003).

It is generally recognized that scaling up innovations is even more difficult than developing the first working prototype (Adelman & Taylor, 2003; Taylor, Nelson & Adelman, 1999). Many promising reform prototypes fail during effort to transfer or maintain the innovation over time in ways that retain the initial values of the reform yet allow ongoing productive changes (Tyack & Cuban, 1995). Taking the view that a systemic model of educational change should help us better understand the conditions that favor the scaling up and sustainability of innovations, we attempt, in this chapter, to seek a deeper understanding of the systemicity of pedagogical innovations.

A particular focus in this regard is the place and degree of interconnectedness among the different components of a system.

Exploring Systemicity and Change Through Exemplars of ICT-Supported Emergent Pedagogical Practices

The SITES-M2 study that provides the basis of our various analyses in this book was designed with the firm belief that pedagogical practices are strongly influenced by and can only be appropriately interpreted within the context of school-level and system-level factors and characteristics. Each case report thus contained not only in-depth descriptions of teaching and learning practices based on classroom observations but also rich descriptions of the national, regional, community, and school contexts and factors for the pedagogical innovation concerned. In the previous two chapters, we discussed school-level contexts. In this chapter, we use the cross-national data from the 83 case studies to explore the impact of system-level factors on innovation characteristics and their scalability. Note that we use the term scalability throughout much of this chapter to refer collectively to sustainability and transferability.

One criterion that the SITES-M2 national research coordinators (NRCs) used when selecting case studies from the schools in their respective countries was sustainability and transferability. However, recognizing that some of the cases would be only in their first year of implementation, the international research team acknowledged that these studies might offer little evidence of sustainability and transferability. The team therefore coded each case study according to four binary variables and then asked the NRCs to validate that coding. The variables were as follows:

1. The case authors specifically state that the innovation was sustained over a period of more than a year.
2. The authors provide evidence to support the claim of sustainability.
3. The authors specifically state that innovation was transferred to other classes within the school or other schools.
4. The authors provide evidence to support the claim of transferability.

Table 8.1 provides a cross-tabulation of the sustainability and transferability status of the 83 cases collected in SITES-M2. Sixty-five (78%) cases were sustained

Table 8.1 Sustainability status and transferability status of the 83 SITES-M2 case studies

Sustainability	Transferred	Not transferred	Total
Sustained	36	29	65
Not sustained	5	13	18
Total	41	42	83

and 41 (49%) cases were transferred. These results suggest that the process of transferring an innovation is more difficult than the process of sustaining an innovation.

Scalability and Pedagogical Innovation

Pedagogical innovations as initiatives implemented in order to effect change initiatives are directed at different aspects of the pedagogical process, which include learning goals and/or learning processes (i.e., the activities and roles of teachers and learners). Theorists differ on whether systemic change in education should develop from planned radical overhauls of existing systems (see, e.g., Banathy, 1994) or as the emergent outcome of the evolutionary efforts of participants within those systems pursuing visionary goals (see, e.g., Wheatley, 1999). Questions about whether one can meaningfully compare the extent of innovativeness of pedagogical change, and whether scalability of an innovation is influenced by its extent of innovativeness are ones best answered through use of empirical methodologies.

Law, Chow, and Yuen (2004) discuss two different approaches that can be used when comparing the extent of change evident in the case studies collected in SITES-M2. The first focuses on the extent of pedagogical transformation brought about by ICT use (Mioduser, Nachimias, Tubin, & Forkosh-Baruch, 2003). The second positions ICT as just one comparative dimension (Law et al., 2003). Given our understanding that the primary goal of pedagogical innovation is to prepare learners for life in the twenty-first century and that ICT use is but one feature contributing to change, we consider the second approach the one best suited to the purpose of this chapter.

Key Finding: Innovative Practices are More Difficult to Sustain

In Chap. 3, we used innovation scores to compare the innovativeness of the ICT-supported pedagogical innovations described in the 83 case studies.[2] The innovation scores covered six dimensions: curriculum goals (G_SCORE), teacher's roles (T_SCORE), students' roles (S_SCORE), ICT sophistication (ICT_SCORE), multiplicity of learning outcomes (M_SCORE), and connectedness of the classroom (C_SCORE). Table 8.2 presents the results of an analysis of variance that we conducted in order to determine the extent of difference between the innovative pedagogical practices that had been sustained for a year or more and those that had not.

The most notable feature of Table 8.2 is the pattern showing that all six innovation scores were higher for the not-sustained innovations than for the sustained

[2] These scorings are included in a database set up by the Hong Kong SITES-M2 study team (http://sitesdatabase.cite.hku.hk/).

Table 8.2 Comparisons of innovation-dimension scores for sustained and not-sustained innovations

	Sustained ($N=65$)		Not sustained ($N=18$)		ANOVA
Innovation dimension	Mean	SD	Mean	SD	F
Curriculum goals	4.09	1.26	4.50	1.42	1.40
Teacher's roles	4.17	1.34	4.94	1.21	4.90[a]
Students' roles	4.17	1.61	4.83	1.58	2.43
ICT sophistication	5.69	0.73	5.78	0.81	0.19
Multiplicity of learning outcomes	4.05	1.73	4.44	1.38	0.81
Classroom connectedness	4.05	2.06	4.56	2.04	0.86

[a] Significant at $p<0.05$

Table 8.3 Distribution of T_SCORES across the two groups of sustainability status

	T-scores						
Sustainability	2	3	4	5	6	7	Total
Number of sustained	10	8	21	15	9	2	65 (78%)
Number of not sustained	0	2	5	5	4	2	18 (22%)
Total	10	10	26	20	13	4	83 (100%)

innovations. The largest differences were those for teacher's roles and students' roles. However, the only difference that was statistically significant was that the teacher's roles. These results provide strong evidence that the more innovative an educational change is, the more difficult it is to sustain it.

This finding is also evident in the results presented in Table 8.3. Here, we can see that only 65% of the high-T_SCORE (scores of 6 or 7) cases were sustained (i.e., 11 out of 17), whereas 90% of the low-T_SCORE (scores of 2 or 3) cases were sustained (i.e., 18 out of 20).

The biggest differences between the innovation scores in the sustained and not-sustained case studies were those for teacher's roles and students' roles, the two most pedagogically important dimensions. Thus, within the sample of SITES-M2 innovation case studies collected from around the world, an innovation was significantly less likely to be sustained if it involved major changes in the teacher's role away from a traditional instructional and didactic one towards one of facilitating collaborative inquiry. The following examples provide some qualitative details to illustrate this finding.

Examples of Less Innovative Practice

Chinese Punctuation (CN010), a case study from Hong Kong, provides an example of an innovative pedagogical practice that was sustained for more than a year. The innovation, implemented in a Primary 6 classroom as part of the Chinese language curriculum, saw teachers using a suite of customizable learning software developed at the University of Hong Kong in order to create presentations as well as drill-and-practice exercises directed at helping students learn Chinese punctuation. The three teachers involved in this work received professional support from a consultant involved in designing the learning software.

The curriculum goals associated with the innovation were actually very traditional: students were expected to master a good understanding of Chinese punctuation and then show that they could use it appropriately. The software that the teachers used simply supported and extended their traditional role of presenting information and exercises and then letting students know if their work was correct or not. The most innovative dimension of the practice was the sophistication of the technology involved: the software had been designed on the basis of findings from rich research on cognitive aspects of Chinese language learning.

Because of the lack of real change in the roles played by both teachers and students, we can assume that sustaining the pedagogical practice would have been relatively easy. Indeed, the teachers reported no difficulties in sustaining the practice, which at the time of the case study was in its third year of implementation. The one difficulty that the teachers did report was the time and effort needed to develop the learning materials for other grade levels in the school. By develop, we mean customizing the learning materials by inputting the appropriate content into the software template.

In another example, that of an ICT-based geography laboratory (TW006), implemented in a junior high school in Taiwan, the teacher concerned used ICT when developing her classroom presentations. However, her pedagogical orientation, although enhanced by ICT use, was essentially teacher centered and instruction driven. She presented and explained information, set instructional tasks, monitored and assessed student learning. TW006 is a typical example of the innovation profile *technologizing the pedagogical process* that we discussed in Chap. 3. In line with the situation in CN010, sustaining the pedagogical practices associated with this kind of profile is not particularly challenging. However, as the authors of the TW006 case report observed, it does represent a "more expensive model." As such, the only sustainability-related difficulty is that of securing and funding ongoing technological support.

Examples of More Innovative Practice

One of the case studies conducted in Hong Kong involved major changes to the relevant curriculum goals as well as to the roles of the students and teachers involved. We described this innovation, titled Problem-Based Learning: Computer Assisted Scientific Investigations (CN008), in detail in Chap. 7, under the heading, School A. At the time of the case study, the innovation was only in its first year of implementation, and the students engaged in the investigations were doing so on a voluntary and an extracurricular basis. We learned that although the school continued using data-loggers in relation to conducting science experiments, students were no longer involved in the open-ended scientific inquiries.

Another example from Hong Kong is innovation titled Project-Based Model Building in Physics (CN012). Implemented in a secondary school and involving the collaboration of two physics teachers and a laboratory technician, the innovation required students to use highly specialized tools when conducting scientific investigations. The tools included Modellus,[3] digital video-cameras and video-editing/image-processing equipment (to capture and analyze visual images taken during experiments on motion), and data-loggers and graphing software. The aim of this innovation was to help students develop a better understanding of scientific theories as models by having them design experiments aimed at verifying the scientific principles or laws they were learning about in their advanced physics lessons. These learning experiences would not have been possible without the use of the sophisticated technology tools. In Chap. 3, we classified this type of innovation profile as *innovative pedagogical roles in isolated classrooms*. CN012 gained high scores on all innovation dimensions except classroom connectedness (C_SCORE). The innovation required both teachers and students to change their roles considerably. As was the situation with CN008, the CN012 report gave no clear information on the sustainability of the innovation.

Transferability of Innovations

Table 8.4 presents the results of the analysis of variance that we conducted to find out if there was any significant difference between the innovative pedagogical practices that had been transferred to at least one other classroom (whether within the same or in another school) and those that had not.

The results of this ANOVA were very different from the results that emerged from the sustainability analysis. First, none of the observed differences between the transferred and the not-transferred cases was statistically significant. Second, although the teacher's role scores, the students' role scores, and the outcome scores were still higher with respect to the not-transferred cases, the connectedness scores and the

Table 8.4 Comparisons of innovation-dimension scores for transferred and not-transferred innovations

	Transferred (N=41)		Not transferred (N=42)		ANOVA
Innovation dimension	Mean	SD	Mean	SD	F
Curriculum goals	4.17	1.30	4.19	1.31	0.00
Teacher's roles	4.24	1.39	4.43	1.31	0.39
Students' roles	4.17	1.63	4.45	1.61	0.63
ICT sophistication	5.80	0.75	5.62	0.73	1.31
Multiplicity of learning outcomes	3.95	1.67	4.31	1.65	0.97
Classroom connectedness	4.34	2.19	3.98	1.93	0.65

[3] A software for building scientific models (see http://modellus.fct.unl.pt/).

ICT-sophistication scores were higher with respect to the transferred innovations. These findings indicate that the mechanisms and/or factors required for sustainability and for transfer may not be the same.

The findings of Law, Kankaanranta, and Chow's (2005) in-depth comparison of the SITES-M2 case studies collected in Finland and Hong Kong provide possible explanations for these findings. Starting from their observation that the Asian case studies had the lowest connectedness scores and the Western European ones had the highest such scores, Law and her colleagues looked for and found major differences in the roles that ICT played in the cases collected from these two education systems. In Finland, ICT played the core role in providing a scaffold upon which to build connectedness. This scaffold was an essential part of the success of the Finnish innovations. In Hong Kong, ICT was being used mainly as a learning and productivity tool. Even though all of the Hong Kong innovation schools had access to Internet, use of this facility was confined mainly to information searching, emailing, and discussion forums.

The authors of all of the Finnish cases reported ICT-related collaborations with individuals and organizations outside the school. They also reported the establishment of networks that provided those involved in the innovations with technological and learning-resource support as well as subject-matter and pedagogical expertise. Most of the innovations had also extended beyond the respective schools to become a networked project at the local, regional, and/or national levels. For the innovation initiators, these change processes had not only helped reduce the resourcing and expertise challenges associated with implementing innovations, but also helped to establish a technological and socio-institutional infrastructure that (importantly) could help sustain and transfer innovations. In the nine Hong Kong cases, and with the exception of one innovation that was part of a university-based project, the innovation teachers had to build up the requisite infrastructure and teacher competence by themselves. Support and collaborations were confined to the innovation schools. Although the teachers involved acquired considerable expertise during the change processes, they were not able, for whatever reason, to establish support infrastructures beyond the school. The sustainability of the Hong Kong innovations therefore depended largely on the extent of ongoing support from the teachers and the school heads concerned, while the transferability of the innovations was limited to transfer within the same school.

Key Finding: Internet-Based Innovations are Inherently Adapted for Easy Transfer Across Schools

One innovation profile commonly observed in the case studies discussed in Chap. 3 was that of *sophisticated ICT use, high connectedness, and traditional pedagogical roles*. The innovations holding this profile were mostly virtual schools or online courses. The United States-based case study titled the Online High School (US020) provides a typical example of this type of innovative practice, which took advantage of the connectivity provided by Internet to break down classroom walls. At the time the case study was conducted – academic year 1999/2000 – the Online High School (OHS) was catering for 2,516 students from 87 schools located across 29 states. The aim of this innovation was to widen the educational opportunities available to the students. All of the school's teachers attended a graduate-level online professional development program focusing on how to create and teach a net-course for high school students. Although the teachers were encouraged to use a variety of innovative pedagogical approaches, students rarely interacted with one another during any of the OHS courses, and generally did their assignments independently. Many high schools were interested in participating in the project. According to the principals and district superintendents, the high number of secondary schools interested in joining the OHS project was a product of two particular features of it. First, schools could quickly expand course offerings beyond what was feasible for them if acting on their own. Second, computer and network technologies could be used in ways that seemed to offer important benefits to students and teachers. Several principals and school superintendents also said that because the OHS was an extremely appealing proposition for their school boards, procuring necessary board approvals and the money needed to buy requisite technology was generally straightforward. In short, there was clear evidence in US020 of innovation transfer.

Key Finding: Highly Innovative Cases Can be Scaled Up if the Ecological Conditions Are Favorable

The few (rare) cases that were highly innovative on all six innovation dimensions, and so labeled *balanced, highly innovative cases* (refer Chap. 3), were considerably more challenging than the less-innovative ones to scale up. However, scalability could still be achieved if the contextual conditions provided an ecology conducive to further development of the innovation. In of these rare cases – an innovation from Germany titled Economy and Schools (DE014), the Grade 12 students involved in it participated, over a 10-month period, in a business education program that taught them about large and small enterprises and how to develop their own business ideas. Throughout, the students had the support of a business consulting company. The teachers assumed the role of co-learners, facilitated group-dynamic processes, and monitored the progress of the project. ICT played a significant role in supporting information searches. As indicated in the case report, the conditions needed to successfully sustain and transfer this innovation included teacher commitment, sufficient equipment, Internet access, and the collaboration of local business companies. Thoughtfully designed communication and solicitation efforts conducted alongside the development of the innovation allowed these conditions to be realized. According to the German SITES-M2 NRC, the active support of the school's administration team and parents' committee as well as of the local business sector were particularly important factors influencing the successful sustainability and transfer of DE014.

Scalability and Leadership

The extent to which innovations are sustained and transferred is highly dependent on school-level policies and support. Much of the educational change literature emphasizes the role of the principal in leading or hampering change and innovation (Fullan, 2001), which is why we coded each of the 83 cases for the presence or otherwise of a range of features (17 in all; refer PL1–PL17 in Table 4 of Chap. 6) associated with the following aspects of a principal work:

- *The principal's general role in the school*: whether he or she tended to be an initiator of school reforms, a supporter of school reforms, and/or a modeler of ICT use (PL5–PL7).
- *The principal's specific role in relation to the innovative pedagogical practice reported in the particular case study*: whether he or she initiated the innovation supported the innovation case, and/or championed it (i.e., promoted and/or actually implemented it) (PL8–PL10).
- *The specific actions taken by the principal to support the innovation*: communicating with parents about the innovation, encouraging teamwork among staff, and listening to the views of staff (PL14–PL16).

We conducted a chi-square test to determine if any features of the principal's roles were significantly associated with innovation sustainability. Only two features were marginally significant (exact 1-tailed significance at $p = 0.052$): the principal as an *initiator of the innovation* (PL8) and the principal *maintaining good communication with parents* about the innovation (PL14).

The results presented in both parts of Table 8.5 (i.e., A and B) are identical. Of the total number of innovations, the minority (22%) initiated by the principals themselves stood the best chance (17 out of 18) of being sustained beyond 1 year. The same pattern was evident for innovations where the principals maintained good communication with the parents. The reason behind the identical pattern in both parts of the table may be that principals were highly motivated to communicate with

Table 8.5 Statistically significant relationships emerging from chi-square analysis of innovation cases sustained beyond 1 year and various principal roles

Sustainability	No	Yes	Total
A: Principal as an initiator of the innovation			
Number sustained	48	17	65
Number not sustained	17	1	18
Total	65	18	83
B: Principal maintaining good communication with parents about the innovation			
Number sustained	48	17	65
Number not sustained	17	1	18
Total	65	18	83

$\chi^2 = 3.522$ (1, 83); $p = 0.052$

parents about the innovation if they were involved in initiating it. This observation has important implications for the sustainability of the majority of the innovations – those that were *not* initiated by the principals.

We found no statistically significant relationships when we used chi-square tests to assess the extent of association between the various principal roles and transferability. Theoretically, school leadership factors determine whether innovation transfer occurs among classrooms within the same school or beyond, although the impact of school-level factors on transfer beyond the same school would be much smaller.

We note here that statistical analyses of data derived from SITES-M2, which is essentially a qualitative study, are limited and useful mainly for exploratory purposes. In order to provide a better understanding of the interplay of scalability and school-level leadership, we now turn to an in-depth examination of the qualitative details of one the most innovative *and* sustained innovations evident among the SITES-M2 case studies.

Key Finding: Effective Leadership is that which Supports Team Building and Pedagogical Bricolage

My Pocket Money (CN001), a 4-month cross-curricular project conducted in a Hong Kong primary school, covered the subjects of general studies, mathematics, and Chinese. In this project, a class of students designed and conducted a survey designed to collect information from schoolmates on how much pocket money they received, how they spent that money, and whether there were gender and age differences in the amount and use of pocket money received. The project also incorporated a service component, during which the school organized what it called a "fund-raising bazaar, with the aim of encouraging students to donate part of their pocket money towards organizing a service day for the residents of a nearby home for the elderly. In order to carry out this project, Teacher B rearranged the normal timetable so that he could spend a lesson each week discussing project progress with the class and giving advice and support as necessary. The goals of the project went beyond learning subject-based knowledge. Students were expected to develop appropriate values and attitudes, organizational skills, cooperation skills, and the skills needed to search for, organize, analyze, and present information.

Although this case study was conducted during academic year 2000/2001, it began in 1998 when the school experimented with project-based learning in extra-curricular activity groups. During the following year, one of the teachers (Teacher A) piloted project-based learning in the formal school curriculum in two of the classes she taught. My Pocket Money was one of the projects she developed for use with her Primary 5 students. After Teacher A shared her experience with other teachers in the school, two of them, Teachers B and C, modified Teacher A's two project plans and used them in their teaching during 2000/2001. As noted above, Teacher B was the teacher who featured in the My Pocket Money case study.

The sustainability and transfer of the pedagogical innovation evident in this case study was not the outcome of serendipity but of successful leadership. The principal of this school, described in the case study as a visionary leader, was committed to changing the pedagogical culture of the school towards a more facilitative and empowering one. He firmly believed that the priority with respect to introducing ICT into teaching and learning was that of supporting pedagogical change. In order to promote ICT-facilitated change and to equip teachers with the necessary skills and knowledge, he held staff development sessions twice a month, during which teachers shared their ideas and experiences with one another. The principal did not mandate how the project-based learning should be designed and implemented. Nor did he require teachers to adopt this new approach until they felt ready for the challenge. The principal's approach was to provide teachers with the support they needed to surmount or minimize hurdled associated with implementing an innovation. In short, the principal set up an architecture for learning that led to the establishment of a community of practice able to pioneer innovations.

According to Teacher C (who was quoted in the case study), implementing the ICT-based project-learning innovation involved these challenges:

> Firstly, it is the understanding of the teachers. The teachers have to recognize and appreciate the impact of project work on students' learning. Secondly, teachers have to possess pedagogical competencies to facilitate project work … In terms of ICT resources, the schools have to consider the number of computers in school, time and space. Moreover, the ICT competence of students is very important too. We do not need to spend much time on teaching students IT skills [for the project work], as they have been having computer lessons since Primary 1 and they are quite competent in using the computer.

The author of the case study reported that the school put considerable effort into addressing these challenges. The bi-monthly staff development sessions and the establishment of a collaborative culture in the school were particularly important in this respect, as was the practice, among teachers, of sharing curriculum design and teaching resources. The latter reduced the pedagogical hurdle for teachers who lacked the confidence and/or expertise to develop project-based learning on their own.

The principal was also instrumental in ensuring that the school's ICT infrastructure and technical support were sufficiently robust to facilitate the use of ICT for project-based learning. In 1998, when the IT literacy curriculum was first introduced in the school, a mechanism was put in place that allowed subject teachers to liaise with the IT literacy teacher. The main focus of this liaison was on ensuring that students not only had mastered the particular IT skills they needed to engage in project-based work but had mastered them before this work began. So, although Teacher B's practice built on the work of Teacher A, that practice was *not* a case of prototype replication. Teacher A's earlier work provided Teacher B with curriculum ideas, teaching resources and experiences relevant to conducting the innovation, and Teacher B certainly found this support valuable when she first implemented project-based learning. However, Teacher B's intention was not to replicate the manner in which Teacher A had conducted My Pocket Money but to take the project forward through a second round of innovation, which she carried out after discussions about and reviews of project-based learning conducted during the staff development sessions.

The technology-supported project-based learning innovations were not conducted according to a tightly planned, staged change model. Instead, the principal and teachers involved held in common a clear educational vision and goal, and the change mechanism focused on building a learning community supported by a learning architecture. The change strategy was to build a school ecology conducive to the emergence of different varieties of technology-supported project-based learning in the school curriculum. Change happened when individual teachers felt ready to take on the challenge. There was room for bricolage and action learning (Kramer, 2007; Marsick & O'Neil, 1999), and the process was always one of continual innovation. The change strategies and mechanism were thus conducive not only to continuous alignment of vision and goals among staff but also to the evolution of a curricular assessment and administrative system. Because the system evolved as more and more teachers adopted this innovative mode of teaching and learning as a pedagogical approach, it ensured a simultaneous evolution of the school ecology.

Scalability and Government Support

Each of the SITES-M2 case reports documented the national and regional contexts relevant to the innovations described. This documentation included detail about supporting factors at the systems level, which could refer to the national, state, and/or district level, depending on the extent of centralization of the education policies in the countries concerned. We coded each of the 83 case study reports for the presence or otherwise of the following government support features (see, in particular, SU1–SU11 in Table 9 of Chap. 6):

- The innovation aligned with the government's general education policy
- The innovation aligned with the government's policy specific to ICT in education
- The government provided the necessary ICT infrastructure
- The government provided necessary technical support
- The government provided funding for ICT infrastructure
- The government provided funding for the innovation beyond ICT infrastructure
- The government provided general funding for schools
- The government provided support beyond resourcing
- The government provided professional development courses for teachers
- The government provided courses for teachers directly specifically at the innovation
- The government organized sharing of experiences and knowledge among schools

Key Finding: The Influence of Government Support on Innovation Sustainability and Transferability Needs to be Considered Within The Context of Schools' Ecologies and Policy Trajectories

The chi-square test that we conducted (see Table 8.6) to determine the extent of association between these government-support factors and innovation sustainability (i.e., beyond a year) revealed two statistically significant relationships: provision of technical support (SU4) and professional development courses for teachers (SU9).

The cross-tabulation results in the two parts of Table 8.6 are, at first sight, counter-intuitive. The innovations that had received government-resourced technical support and teacher professional development were significantly less likely than those that had received no such support to have been sustained beyond a year. A probable interpretation of these results is that schools identified as not receiving specific government-support measures already had such support fully integrated into their regular funding and supporting mechanisms. As such, the case study authors might not have seen these measures as specific support mechanisms and therefore not reported them in the case reports. Nonetheless, the findings presented in Table 8.6 provide further evidence that innovation-specific government support is an interim measure for schools. As such, if schools are to sustain an innovation, they need to build a school ecology suited to it. Given that educational change is complex and dynamic, it is not possible to specify the exact composition of the various contextual factors for sustaining an innovation. Instead, establishing mechanisms that enable adaption and co-evolution of the contextual factors is the route to sustainable innovation and change.

The chi-square test that we conducted to determine associations between the various government-support factors and transferability (i.e., the innovation had been transferred to at least one other class) produced only one significant result. An innovation was significantly more likely to be transferred if the thinking behind the innovation was *not* aligned with the government's general education policy (SU1) (see Table 8.7 for details).

Table 8.6 Statistically significant relationships emerging from chi-square analysis of innovation cases sustained beyond 1 year and government-support factors

Sustainability	No	Yes	Total
A: Government provided necessary technical support			
Number sustained	53	12	65
Number not sustained	10	8	18
Total	63	20	83
B: Government provided professional development courses for teachers			
Number sustained	52	13	65
Number not sustained	6	12	18
Total	58	25	83

Part A: $\chi^2 = 5.203$ (1, 83); $p < 0.05$
Part B: $\chi^2 = 14.585$ (1, 83); $p < 0.001$

Table 8.7 Statistically significant relationships emerging from chi-square analysis of innovation cases transferred to at least one other classroom and government-support factors

	Innovation aligns with government's general education policy?		
Transferability	*No*	*Yes*	Total
Transferred	27	14	41
Not transferred	16	26	42
Total	43	40	83

$\chi^2 = 6.403$ (1, 83); $p < 0.05$

This outcome was just as counter-intuitive as the significant relationships between government factors and sustainability: an innovation was less likely to be transferred if the case study report specifically mentioned that it aligned with the government's general education policy. Common sense predicts that an innovation will be much more difficult to transfer if it does not align with the prevailing government policy. However, the results of our analysis make sense if we interpret them as indicators of the state of policy implementation over time. When a policy is newly implemented, the educators operating within the system are likely to be highly aware of it. Also, innovations developed in response to reform initiatives are less likely to be transferred during the initial than the later stages of the reform. But when a reform has been in place for some time and a good number of transfers have taken place, the policy goals driving them have probably become part of the daily milieu. This possibility may explain why these policy goals were neither mentioned nor highlighted when the SITES-M2 researchers interviewed the informants.

Summary and Conclusions: The Need for Re-culturing

One popular, systematic approach to scaling up reforms is to follow a stepwise model of replication that kicks in after establishment of a good working prototype. One such model is that proposed by Taylor, Nelson, and Adelman (1999). The model that they offer has four phases: creating readiness, initial implementation, institutionalization, and ongoing evolution. Unfortunately, pedagogical innovation is a complex systemic change that requires not only restructuring (with respect to the structure, roles, and related formal elements of the organization, which, in itself, can be accomplished as a systematic change process), but also reculturing (Fullan, 2000). Reculturing is the process whereby the school changes "from a situation of limited attention to assessment and pedagogy to a situation in which the teachers and others routinely focus on these matters and make associated improvements" (Fullan, 2000, p. 582).

However, the findings from our in-depth analysis of the SITES-M2 case studies indicate that the more pedagogically innovative a practice is, the more difficult it is to sustain. Taylor et al. (1999) suggest that failures to sustain reform are often an outcome of top–down implementation and that reformers should therefore help teachers improve instruction from the inside out. And they caution that the process must be conducted in a democratic manner. But, as the SITES-M2 case study titled problem-based learning: computer assisted scientific investigations (CN008) revealed, even when the innovation is an outcome of a bottom–up initiative from the teachers themselves and even when both the school leadership and the teachers involved stay the same over an extended period of time, innovation sustainability is not assured. Although, the new technology (computers with data-logging equipment) that the teachers in CN008 brought in stayed in place, the main point of the innovation – getting students to engage in creative scientific problem-solving – did not.

The challenges associated with sustaining innovations are thus no different whether they are driven from the bottom–up or the top–down. Because school-based education is a complex system, institutionalizing a fundamentally different set of goals, values, and relationships requires change at all levels of the system. The innovation CN008 is similar to the "inside story" in Fullan's (2000) three-story analogy: it involved a change driven from within, its focus was on improving student learning, and it led to changes in pedagogical practice and the formation of a professional learning community. Reculturing within the context of schooling requires school staffs to move from a situation of limited attention to assessment and pedagogy to a situation in which they routinely focus on these matters and make associated improvements. Structures can facilitate this process or they can block it, but the latter can be overcome as long as the development of a professional community is the key driver of improvement. This approach brings about deeper changes in both culture and structure. Moreover, for an innovation to be sustained, the requisite reculturing and restructuring processes have to evolve dynamically, in tandem: the innovation will not be sustained unless two particular "stories" are "narrated" in parallel. One story is the *inside−out* "story," in which the school is actively connected to the outside. The other is the *outside−in* "story," in which the school seeks support from external infrastructures. It is only when these three facets of innovation development act in collaboration that the innovation can be both challenged and sustained by an external infrastructure.

The counter-intuitive results that we obtained from our analyses of the relationships between support factors and scalability and between government policy and scalability highlight the importance that system-level changes hold for the scaling up of innovations. The results indicate that support factors need to be institutionalized into a school's infrastructure, such that these resources are no longer a concern for the stakeholders in the system. The results also indicate that the impacts of government policies take time to become an integrated and accepted part of the school system's infrastructure. Drawing on their experience of projects designed to support reform in science education, Blumenfeld, Fishman, Krajcik, Marx, and Soloway (2000) likewise concluded that a successful process of systemic reform is one in which the stakeholders anticipate difficulties arising from different contextual settings and identify potential solutions in collaboration with different communities of practice, including those containing teachers, school administrators, and district boards.

Our analyses of the 83 SITES-M2 case studies furthermore indicated that those practices which lead to marked changes in the roles of the teachers and students can only be scaled up, without loss of the core pedagogical innovativeness, if mechanisms for scalability are built in at the start of the innovation. We could find no report among the case studies of innovations that had gone through a clear two-stage development from prototype to scaled up. The case study most akin to this situation was that of CN001 (technology-supported project work), where scaling-up had occurred, but had taken a fairly circuitous, albeit ultimately effective, path. The school principal featured in CN001 intended from the time that the innovation was first mooted that it would be adopted across the school's curriculum. During the 3 years that preceded the case study, the innovation had undergone continuous improvement and extension in terms of its curricular and pedagogical design, and it had embraced a growing number of teachers and classes, while professional development directed at supporting pedagogical and curriculum bricolage by the teachers and building up a collaborative community of teachers remained a core feature of the school principal's strategies relative to the innovation. The school had also made adjustments to its timetable and other administrative units in order to support scaling up of the innovation.

Our comparison of the occurrence of transfer in the innovations reported in the Hong Kong and Finnish SITES-M2 case studies also showed the importance of supportive structures and mechanisms. When structures and mechanisms capable of supporting the implementation of an innovation in multiple schools are in place, there is a much higher chance that the innovation will flourish in all of those schools. All except one of the innovations reported in the seven Finnish SITES-M2 cases had transferred to at least one other classroom. In an earlier study of the SITES-M2 case studies, Law et al. (2005) found that all of the Finnish case-study schools had identified collaborators beyond their gates and, from there, established a network able to provide the technological, learning resources, and/or expertise (subject matter and pedagogical) needed to sustain innovations. Most of these innovations had also extended beyond a single school to become a collaborative project supported by an online collaboration networked across local, regional, and/or national levels.

The Finnish cases provide examples of systemic rather than piecemeal reform, during which effort is made not only to reduce the burden of innovation on the initiators but also to establish a technological and socio-institutional infrastructure that contributes to the sustainability and transferability of the innovations. In these situations, ICT played the core role of providing a scaffold upon which stakeholders could build up the connectedness necessary for scaling up innovations and producing sustained systemic change. As Anderson and Plomp (2008) observe in one of the reports arising out of the SITES 2006 study:

> Policy statements on twenty-first century skills consistently mention the need for active learning and student-centered learning, as well as the need for training in decision-making, and collaborative work. Thus the outgrowth of trends toward curricula and classroom experiences designed for the learning of twenty-first century skills inevitably leads toward even more pedagogical reforms. (p. 66)

Our analyses support this claim. The findings emerging from them indicate that everyone involved in and with schooling needs to develop a sound understanding of reform trajectories by systematically examining the highly interconnected components of classroom ecologies and their corresponding school ecologies. This understanding is crucial if we are to lead system-wide changes, including those driven or supported by ICT, that are needed to provide our students with twenty-first century skills.

Chapter 9
Research into Practice: Using Case Studies in Professional Development

Professional development of teachers involves working with individuals, understanding their needs, experiences, hopes, and goals, sharing, exchanging, and exploring practices, trialing new ways of doing things, and critically reflecting on models, factors, and practices that influence what happens in different education environments. In this chapter, we explore how the SITES-M2 case studies are being used to support professional development – to act as a catalyst to advance and change educational practices. We describe the roles that case studies in general have played in education, before documenting how the SITES-M2 case studies are being used to inform educational practices in Hong Kong and elsewhere. The model underpinning this use of the studies is not one of "farming," that is, of trying to replicate innovations as good practices in different regions, countries, schools, and classrooms. Rather, it is one that encompasses observation, interpretation, and analysis. It also involves, where appropriate, adapting, with reference to a model of evolving development and change, ideas taken from the case studies so that they suit different environments. We also consider, in this chapter, how the SITES-M2 studies can be used to stimulate change in thinking about innovation and the role that technology can play in different contexts. We describe how this use has played out so far during workshops held in different countries for teachers and educational administrators and during professional development courses for teachers.

The principle behind using case studies to support professional development is based on the premise that although each innovation is unique and cannot be replicated, we can nonetheless learn from it, as we can from all the other cases. The ecological metaphor helps us understand this uniqueness. If we compare gardens, we soon see that none is or can be exactly the same. Two or more gardens may have many similarities – shared plants, similar soils, the same macroclimate. However, each garden has, at the very least, subtle differences in its conditions, caused by, for example, its position relative to the sun, the extent of shaded areas, changes in elevation, and variations in soil type. Nearby buildings are likely to impact on wind within the garden; this, in turn influences what will grow well in different parts of the garden. The topsoil itself has variations of acid and alkaline pH levels, affecting what will grow best where. When planning a garden, we need to know how to observe and interpret these differences in the macro- and micro-environments so

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that we can make the garden the best it can be. Likewise, when educational systems, institutions, and individual teachers want to develop sustainable change and introduce innovations, they need to consider many factors unique to each level. The case studies offer us that glimpse into unique situations. Studying them gives us insights into and ideas about innovations and how we can adapt them to suit different environments. Professional development also requires broader considerations. Here, we need to focus not just on individual teachers but also on the entire environment in which they work.

Case Studies: Different Types and How They Are Used

When used to support teachers' pre-service and in-service professional development, cases typically form the basis of problem-solving discussions directed toward encouraging collaborative learning and critical thinking (McDade, 1995). The different types of case studies used to support professional development include illustrative, exploratory, critical incident, and cumulative cases (Stake, 1995; Yin, 2003). *Illustrative case studies* are descriptive; one or two instances or "slices of life" are used to illustrate a situation. Illustrative cases aim to make the unfamiliar familiar and to provide a shared understanding of and language about a topic or event. These case studies generally require much in-depth descriptive detail and careful selection of instances to ensure accurate representation of the situation under study. *Exploratory case studies* are generally condensed instances, normally completed as a pilot before the carrying out of a large-scale study. These cases aim to identify questions and topics for further investigation. *Critical incident studies* focus on very specific instances and are not intended to be used for generalization. These studies are often used to address particular cause and effect questions. *Cumulative case studies* include aggregated information from different sites collected at different times. They also comprise collections of cases that follow a format and structure and so afford comparison between them. Cumulative studies can be created by using retrospective data collections, a practice that allows us to make broader generalizations. The SITES-M2 case studies match this final grouping because the cases were collected from multiple sites.

In business, case study use was championed by both Harvard and Northwestern Universities, where businesspeople were invited into faculties to explain actual business problems or dilemmas that students subsequently analyzed and attempted to solve (Schlossman, Gleeson, Sedlak, & Grayson, 1994). These illustrative cases were often supplemented by lengthy documents that students had to analyze prior to class discussions. Over time, these supplementary documents changed. They were often simplified and shortened (Sudzina, 1997) for practical reasons. Guidelines and critical questions were provided to help students identify key points more efficiently and to ensure students stayed focused on important issues by having to address critical questions (Seperich, Woolverton, Beierlein, & Hahn, 1996).

In business settings, the case study is often used as a key tool for learning not only about the subject itself but also about how to think in analytical, critical, problem-solving ways within the discipline. The use of case study is thus inextricably linked to the process and the product of learning (Sudzina, 1997).

In law, legal decisions and new laws are built on precedents and critical incident cases. Learning about the law involves reading such cases and using this data to stimulate judicial reasoning, decision-making, and insight into the process of creating new laws. By studying legal cases, law students learn about legal precedents while simultaneously acquiring new ways of thinking and reasoning (Black, 1979).

In medicine, case studies are often used to encourage medical students to problem solve as they learn about the complexity of medical practice. The cases are often based on real stories with real people in trouble. Students have to work out what is wrong and how to fix the problem(s) identified (Herried, 2004). Case studies in medicine are chosen because they serve to illustrate principles, practices, and problems and ways of thinking analytically about those problems. Seeking solutions and providing solutions reflect the real-life process of following false leads, serendipitously stumbling onto correct ideas, having brilliant insights, and making mistakes in a safe environment, without actually harming anyone (Edwards, Fox, & Phillips, 1997).

Merseth (1991) argues, with respect to education, that practitioners need to consider subjective, interpersonal factors. The success or failure of a proposed solution to a case study may rely on the personal and contextual variables of the individuals involved. In this sense, explains Merseth, educational situations are in a state of flux, with conditions always changing and individuals and groups likely to have different understandings of what is going on (see also Wassermann, 1994). Case studies are used in many ways in education, but especially in a manner that reveals the human condition. This is because cases tend to emphasize the complexities of contexts and situations. Richardson (1994) maintains that working with case studies in education often creates more ambiguity and fewer certainties for the individuals concerned, but this very factor offers users a more realistic view of what happens in educational environments. Strategies for using case studies in education are often less deductive, less top–down, and less hierarchical (and thus more inductive, participative, and emergent) than the strategies for using case studies in, say, law or medicine.

Teacher educators' current interest in using case studies is due, in part, to a growing interest in the development of teacher knowledge and cognition and an acknowledgement of the changing complexities of the education system and teaching in schools (Sudzina, 1997). The interest also denotes acceptance that sustainable educational change happens when multiple and coordinated changes occur (Zhao & Frank, 2003). As Evans (1995) argues, one of the strengths of using case studies in teacher education is that the cases document complex real-life school situations that feature multiple perspectives and truths. Discussion of these, Evans says, generates new understandings and awareness of education at the country, school, and individual-classroom levels.

Case Study Examples in ICT Leadership and Professional Development

Case studies lend themselves well to professional development in ICT application and e-leadership. Various ICT-related professional development projects around the world have adopted the case study approach. Among them are Strategic Leadership of ICT (SLICT) in the UK, NETS National Educational Technology Standards (NETS) in the USA, the improving capability programs in New Zealand, the professional development activities surrounding the master plans for IT in Education I and II (1997–2007) in Singapore, UNESCO cases of innovative practices, Microsoft Education's international programs, and the IEA SITES-M2 studies. Each of these projects has aimed to identify, encourage, and exploit the use of ICT to improve teaching and learning, and each has used multiple strategies to achieve its goals.[1]

The UK-based SLICT project focused on improving learning through ICT by garnering the support and perspective of school leaders and those in positions of influence in schools. Its particular aim was to build, through a series of courses, leaders' knowledge and understanding of key issues associated with using ICT to enhance and extend pedagogy in schools so that those leaders could spearhead a clear strategic vision for ICT use in those schools. The project included case studies of individual schools in the UK, identified as exemplary in using ICT to support student learning. These case studies, produced in the form of a CD-Rom and supplemented by information uploaded to a website, included a documentary-style introduction to each school and videoed interviews with key staff. This material was complemented by text data elaborating details of each school. Designed to support the SLICT courses, the case studies provided leaders with models of how ICT integration could be adopted in their own schools. School leaders taking SLICT courses were also encouraged to develop descriptive case studies of their own schools for upload to the online site. These studies provided examples of ICT integration that other course participants could share and discuss. Although these cases followed a broadly similar structure, they differed in length, detail, and focus and were not seen as a central component of the SLICT project. Since the development of the CD-Rom, additional cases have been developed and uploaded into the website.

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[1] For detailed information on and examples of these case study approaches, as well as information on the CD -Rom mentioned in the next paragraph, see:

- *UK*: http://www.nationalcollege.org.uk/ and http://www.xma4education.co.uk/successstories.aspx
- *USA*: http://edtechcases.info/ubiq_home.htm and http://www.iste.org/
- *New Zealand*: http://www.techlink.org.nz/Case-studies/Classroom-practice/ICT/index.htm
- *Singapore*: http://wiki.nus.edu.sg/display/ICTSGedu/Case+Study+-+Anderson+Junior+College
- *IEA*: http://www.iea.nl/sites-m2.html
- *UNESCO*: http://www.unescobkk.org/education/ict/ict-in-education-projects/innovative-practices/

In order to facilitate school improvement and to guide school leaders in recognizing and addressing the essential conditions for using ICT effectively in school education, the NETS project (USA) developed national standards for educational uses of technology. The case studies produced as part of this work were simplified, illustrative examples of school-based ICT-implementation practices that incorporated the national standards. NETS encouraged schools and their leaders to work through these cases in order to find out how they could implement the standards in their own schools.

The New Zealand programs for improving capability created a number of initiatives designed to support longer-term professional development for teachers using ICT and to promote effective use of ICT in and across schools. Strategies employed included developing and using cases of good practices to stimulate discussion and sharing of ideas among teachers. An e-learning teacher fellowship was also established to further enhance effective integration of ICT in schools. The fellowship scheme used case studies to enhance teachers' ability to use e-learning strategies in classroom. The studies served as tools to prompt stimulating discussion among teachers and to encourage them to share and exchange practices with one another.

The government of Singapore has, over time, developed multiple strategies to improve effective use of ICT in schools. The policies that the country put forward in a series of educational master plans provided a staged and sustained development of ICT-related implementation strategies over several years (Plomp, Anderson, Law, & Quale, 2003). Case studies in the form of videos of principals talking to a camera were part of this program of development. However, because the stories presented in each study did not provide a standardized approach to implementation, they were seen and used as a supplementary resource.

In 2007, UNESCO initiated an "ICT in Education Innovative Practices" project which aimed to identify and reward innovative use of ICT in education. The project called for cases, where applicants needed to complete a standard proforma. Selected cases were summarized and uploaded to the UNESCO website. UNESCO then organized training workshops, where selected innovative cases were used to illustrate practices in educational settings and extend participant understandings of introducing innovation.

Microsoft Education's broad international program focused on working with educators, educational organizations, and industry partners to expand the world of learning through technology. The program had several aims. One was to help educators connect with one another to share and learn from their respective experiences of using technology to support teaching and learning. Another was to increase teachers' and students' access to technology. And a third was to help prepare students for the digital age. The program promoted, through awards and grants, exemplary ICT-related practice in ICT in education and then presented these practices in the form of case studies that online communities of interested educators could access. These exemplary cases were also used in face-to-face development sessions for leaders in education.

The IEA SITES-M2 case studies were designed to provide policy-makers with a database of information on ICT and its role in advancing educational goals and addressing educational needs and problems. The database was also developed to provide teachers and other educational practitioners with ideas on how to use ICT to improve classroom practices and identify factors that contribute to successful use of innovative ICT-based practices. A panel of specialists and experts in each of the SITES participating countries identified studies in the database that they considered were authentic cases of innovation within the schools. Further secondary analysis and development work with respect to this material led to the establishment of two separate and distinctly different website resources. These are the Exemplary Technology-Supported School Cases in the USA and the Hong Kong-developed SITES-M2 database.[2] In the next section, we outline the key differences between the two website databases.

Comparison of the Content of The Two Databases

The two databases, which were completed around the same time, are based on additional research beyond that documented in the initial international IEA SITES-M2 study report (Kozma, 2003). Both databases focus on the characteristics of innovative pedagogical practices using technology, and both allow exploration, from the perspectives of teachers and principals, of how schools might successfully adapt the innovative practices illustrated in the case studies. Each website database includes, in addition to the case studies, links to the original IEA SITES and related studies, reports, and papers on professional development and leadership. Beyond these similarities, the two websites are very different in nature. The USA database includes 11 cases from schools in the USA, whereas the Hong Kong SITES-M2 database includes 130 cases from 28 countries.

The USA expert panel spent considerable time carefully identifying schools exhibiting exemplary best practice. This rigorous selection process involved discussions between researchers from two organizations involved in cross-national studies of education (i.e., IEA and OECD). Selection also included a nationwide competition sponsored by the federal government's secretary of education and judged by a panel of experts in educational technology. The 125 "exceptional schools" selected comprised both elementary and secondary schools from 35 states. Each of these schools met the following criteria, which were additional to those required by IEA SITES. To qualify for selection, each school needed to be not only a public school but also to have:

- A majority of its teachers engaged in school-wide reform or school improvement
- A majority of its teachers engaged in an innovation using technology
- A demonstrated commitment to meeting high content standards in core subjects
- Students drawn from diverse backgrounds, including low income
- Reform effort and innovation that appeared sustainable and transferable
- Compelling evidence that both reform and innovation had resulted in educationally significant outcomes or gains for the students involved

[2] To access the USA website, go to http://edtechcases.info/exemp_home.htm; to access the Hong Kong website go to http://sitesdatabase.cite.hku.hk/online/index.asp.

A further extensive round of investigation and consideration resulted in the number of selected schools being reduced to around 20. In order to include a representative sample of excellent schools from the two levels of the education system, the panel reduced the final selected number of schools down to 11, each of which provided demonstrated exemplary innovative practices across the entire school. These 11 schools were thus judged to be the "best of the best."

The manner in which the cases were produced and presented was also of a very high standard. During the production work, two researchers visited each of the 11 schools, where they spent five days conducting interviews and observing classes. The researchers also chose two classes from each selected school and then called in an audio-visual production team and directed them to capture key elements of each lesson. The audio-visual team included professional camera operators and sound and lighting engineers. After sections of classes had been recorded, the two researchers interviewed the teachers and selected students from these classes in order to highlight those features that best characterized the innovation.

After completing the recordings, the production team and the researchers edited and polished each recording to ensure the best and most succinct representation of the interview content. The team also produced a scripted documentary about each school that gave viewers all background information necessary to identify school type, setting, and context. This material was then uploaded to the website. Supplementary materials accompanying each exemplary school case study were also posted on the website. The care given to all aspects of the post-production work resulted in a package of brief but extremely clearly presented best-practice cases of innovative uses of technology in elementary and secondary schools across the USA. This valuable resource is available to schools nationwide.

In contrast to the small number of nation-specific cases selected by the USA team, the Hong Kong database contains 130 case studies, selected from the 174 cases worldwide that featured in the original IEA SITES-M2 database. (The 44 cases excluded from the Hong Kong study lacked the amount and type of data required for the secondary analysis.) The Hong Kong case-study database is very different from the USA one not only in terms of number of cases but also in terms of content. The Hong Kong cases do not feature specially scripted video or audio interviews with staff or students from the schools. Any such material that is included was self-produced by in-country researchers or classroom teachers or students. The videos that are present are direct recordings of classroom activities as they occurred. As such, they are neither scripted, nor rehearsed, and they are not professionally produced and edited. The cameras used were handheld and shots were therefore rather unsteady. The sound, mostly recorded from the in-built microphone in the camera, is generally of poor quality. Despite these "flaws," the videos provide us with a "slice of real life" look at classroom events. Whereas the USA case studies were produced as "broadcast-standard" documentary examples of exemplary practice, the Hong Kong SITES cases were compiled as a research resource. Users are given direct access to the raw data and encouraged to carry out secondary analysis and research. Users can also utilize a broad range of flexible search facilities to conduct and share their own investigations of innovative practices.

In summary, both case study databases support professional development, but through different approaches. The 11 USA case studies serve to illustrate exemplary practices and thereby help educational administrators and practitioners understand, adopt, and adapt these innovations in their own schools. The Hong Kong team, however, set up their database in order to invite researchers and practitioners to undertake ongoing investigation, compare cases, identify differences, and share the outcomes of their work.

A Closer Look at The Utility of The Hong Kong Database

So that the in-depth analyses reported in the previous chapters could be used to support an ecological model of ICT-related professional development, the Hong Kong SITES research team added summaries of analyses of selected SITES-M2 cases to the database. They structured the database in a way that would encourage exploration, interaction, and reflection on what constitutes good innovative pedagogical practice. The database's authentic examples also guide visioning, planning, and the implementation of good practice. Users can easily access the database material because of the many cross-references between the cases and the analyses. While this linking facility offers additional interpretation and restructuring of the data, it still leaves the studies and analyses fully available and open for further investigation and research. The target groups for this bilingual website (English and Chinese) include educational leaders, policy-makers, curriculum and resource planners, classroom teachers, researchers, and students. The database thus provides a resource for those with e-leadership roles, practitioners seeking professional development in teaching and learning, and individuals engaged in research and analysis.

The Hong Kong team decided to provide the case-study analyses in database format so that users could personally interpret the cases rather than be "constrained" by models of innovation or showcase-type practices. Each analysis is displayed in a way that invites interpretation, questioning, and comparison. The provision of various online strategies enables users to think about and "trial" their comparisons of cases. Rather than encouraging replication of innovative practices, the database allows users to challenge received as well as personal views and standard ways of thinking about teaching creatively with and through technology. In short, the database encourages users to be "less reliant on ascribed authority and more open to alternative interpretations," reflections, and analysis (Walker, 2002, p. 115).

The database design furthermore facilitates interactive and dynamic use of the case studies because it blurs the boundaries between writers and readers of research. Both are encouraged to submit commentary on the case reports to the database, and both can contribute their own case reports of innovation through a separate but similarly structured database. The database users are thus not just consumers of knowledge; they are also knowledge producers (Walker, 2002).

The rationale behind the research team's decision to construct the database with these features rested on two premises. First, theories and models for technology implementation and use would emerge from analyses of the innovative practices. Second, practitioners could use these theories and models to plan and integrate technology use in their own schools. This rationale is particularly evident in the multiple entry points that the database affords users. This multiplicity accommodates users' different needs and preferences and allows them to compare systems, schools, and classrooms within and across countries. It also allows users to review, reflect, and comment on individual cases and clusters of case studies.

A particularly useful feature of the database is that it provides visual comparison, via radar diagrams, of the cases according to the six dimensions of innovation presented in the earlier chapters of this book. The radar diagrams appear on the entry page to the database, thereby highlighting the notion that the innovations are ecological in nature. Each emerges in the form of an authentic classroom practice that may or may not be innovative on all six dimensions. The diagrams also emphasize the message that innovations are progressive efforts, and that it may not be necessary or feasible to aim for maximum change on all six dimensions. That said, the diagrams provide a framework within which innovators can examine their own practice and identify directions for further improvement. Users are thus provided with a way of analyzing degrees of innovation and a framework that allows them to reflect on and write up their own cases of innovation.

Another intended use of the database is to support exploration of the notion of distributed leadership (Spillane, Halverson, & Diamond, 2004). Such exploration calls into consideration the importance of and methods for ensuring that the innovation-related efforts of educational stakeholders at the macro, meso, and micro levels of individual countries align with the educational reform agendas of those countries. This alignment needs to be apparent even at the initiation stage of a practice to ensure its sustainability and transferability. Sustainable innovation, as we have argued in the previous chapters, cannot be imposed, but must emerge from within a community, unified through an architecture for learning that builds a shared vision and mission and in which expertise at every level is acknowledged and valued. This community-based perspective extends well beyond the traditional view of single leadership from the top (i.e., the school principal as leader). Instead, it encompasses the concept of partnership through multilevel leadership.

Such thinking promotes the idea that national and/or regional government must work with and support principals in their efforts to institute change in collaboration with key teaching staff in their schools. As Elmore (2004, p. 29) stresses, "… the task of transforming schools is too complex to expect one person to accomplish [it] single-handedly. Accordingly, leadership needs to be distributed … rather than vested in one position." The Hong Kong database supports distributed e-leadership development because it offers policy-makers, schools, and teachers opportunities to explore how innovations are being implemented, the effect of those implementations, and the extent to which they are sustained over time and transferred across classroom, school, and national boundaries.

An important principle guiding construction of the database was that the interests of e-leadership would be best served by a design that offered users, whether government, school, or individual, a multilevel, collaborative approach to examining the case studies. Just as importantly, this design aligned with an ecological model of educational change. Educational change involves a journey undertaken by a community, not just one person. And that journey is one which moves forward through collaborative discussion and reflection on policy and practice. The reference point for the journey with respect to the database is the cases. During actual professional-development activities centered on the case studies, practitioners can access another database linked to the case studies database. This second repository serves as a communal resource. Practitioners worldwide can write up their experiences as further case studies and upload them to the database. They and their colleagues can then use this supplemental material to inform and generate further research. Through the two databases, a community of co-researchers can come together to contribute to the development, sustainability, and transference of innovative classroom practices.

In the next section of this chapter, we outline the main components of the secondary analysis database developed by the Hong Kong SITES team. We look at how the database can be used to stimulate discussion, challenge ways of thinking, and develop awareness of complexity, multiple perspectives, and multiple truths. We also look at how it can be used to guide practitioners and leaders undertaking professional development to envision future innovations and future ways of working and to develop an understanding of the importance of distributed leadership and alignment between classrooms, schools, and national-level stakeholders.

Using The Web-Based Case Studies in Professional Development

The examples that we present and discuss here relate to a postgraduate Master's teacher education program at the University of Hong Kong. The students who attend this program are mainly primary and secondary school teachers, IT coordinators, and teacher librarians (85%). The remaining 15% are teachers and administrators from vocational training or tertiary institutions, government education department staff, educational software developers and publishers, and staff involved in the IT training industry. (In Chap. 10, we provide examples of the extensive use that has been made, primarily in Hong Kong, Thailand, and the Philippines, of the database for e-leadership purposes.) The professional development activities below, based on the Hong Kong SITES-M2 database, relate to five areas: innovative practice, types of practices, changing roles, planning and vision building, and multilevel leadership.

Activity 1: Exploring Innovative Practices

Exploring the nature of innovation is fundamental to effective professional development and e-leadership programs. Although the country expert panels that selected the SITES-M2 cases used the same framework of understanding to accomplish this task, what constitutes innovation remains open to interpretation and discussion. Generating discussion is central to establishing shared understandings about the complexity of sustainable, transferable innovations and about the contextual factors at all levels of the education system that contribute to the emergence of innovation in schools. Analyses of existing innovation in the Hong Kong database provide a way of helping determine which of these contextual factors contribute most to the emergence of technology innovation. Understandings emerging from the analyses may then provide a springboard for the development of new innovations.

The following task was designed so that course participants could explore their understandings of innovative practices and develop a heightened awareness of the various dimensions of innovation. Those involved in this activity formed small groups and were asked to consider what innovation meant to them. Group members exchanged ideas before examining one or two SITES-M2 case studies. The groups then came together to compare and analyze the selected studies. Participants' own examples of emergent innovation were also discussed, compared, and then mapped out on the "six dimensions of innovation" radar diagram detailed in Chap. 3. Individuals were also encouraged to upload their own cases into the parallel database of case studies described earlier in this present chapter.

The teachers and IT coordinators in the class were particularly interested in exploring the six dimensions of innovation depicted on the radar diagram. They were especially struck by how the shape formed by the lines drawn in the radar diagram depicted, for each case study example of innovative practice, the degrees of innovation across the six dimensions for that practice. Each member of the class also had opportunity to map an innovation of their own or with which they were familiar onto the radar diagram.

In preparation for this activity, each member of the class was asked to prepare a brief case study of their own experiences of an innovation, which they shared with other members of their respective groups. Individuals were asked to:

- Describe why they thought their example was innovative
- Compare their example with the examples of other group members
- Consider how the practices within their example had transformed learning and teaching
- Outline the contextual factors associated with their innovative practice

Having done this, each person completed their radar diagrams and then, again in their groups, compared and discussed their case studies with those provided in the SITES database.

Several common issues raised within the groups stimulated discussion and reflection on the complexity associated with effectively introducing an innovation. For example, group members noted that their own case studies, when mapped onto the radar diagram, tended not to compare well in terms of degrees of innovation with the SITES case studies. The exercise also encouraged participants to closely examine the six dimensions and to explore possible substitute and additional dimensions. Some participants, for example, strongly opposed setting the "out of class" connectedness dimension as important. One participant said, "This is not a new idea. We've been doing this a long time before the introduction of information technology, so why include it?" Others considered that defining a practice's degree of innovation was better determined by the dimensions in combination than by the individual dimensions on their own.

The analysis of the case studies using the six dimensions of innovation provided a platform for open discussion. The comparison of innovations, the resultant discussions, and the expression of different opinions led inductively to a greater awareness of the complexities inherent in innovation. It also led, at the same time, to a greater understanding of the nature of innovation itself. Initially, participants were unsure exactly what innovation meant or is or how an innovation can be identified. However, by analyzing and comparing their own examples with those in the SITES-M2 case studies, each group was able to suggest "traits" common to both sets that they thought merited further exploration. One important idea that emerged was that innovations need to continually evolve or change if they are to remain innovative. Innovations that do not change become "normal practice."

While individuals were happy to discuss examples of innovative practices they were familiar with, few were prepared, at first, to write and then upload their own examples to the parallel case-study database. The six-dimensions framework helped them in this respect because it allowed them to debate considerations relating to implementing innovations in schools and the importance of innovations in the workplace. Participants concluded that, regardless of a clear definition of innovative practice, exploring cases, whether their own or the SITES ones, increased their awareness and understanding of issues. Moreover, trying out new ideas, taking risks, and sharing practices came to be seen as an important and meaningful professional experience. The participants also noted that problems, particularly those concerning sustainability, are likely to arise when the innovation occurs in isolation and that "lone rangers" (Bates, 2000) – teachers who work in isolation – need support from their organization if their innovations are to be sustainable and transferable.

The use of the SITES-M2 case studies and the research analysis in the above activity also stimulated considerable debate and reflection on central issues concerning the meaning of innovative practice, its role in institutional and individual development, and its importance for ongoing professional development and change. Participants exchanged stories about the "tragedy" of early adopters (Spratt, Palmer, & Coldwell, 2000) – individual teachers who developed and trialed innovations but were not supported by their organizations. Either their innovations were short-lived or the teachers left their organizations, having become exhausted and disillusioned. The course participants concluded that unless teachers receive broader departmental and institutional support and recognition, innovating in the classroom is very hard to maintain and very difficult to transfer to other classrooms. This led participants to discuss the importance of leadership at various levels, notably government, school (principals, department and panel heads), and classroom (IT coordinators and teachers) that is necessary to support innovative practices and then ensure they are sustained and transferred.

Activity 2: Exploring Types of Practices

The analysis of the case studies revealed that each case could be sorted into several categories according to the way in which the teaching and learning associated with it was organized. The categories were project work, scientific investigations, media production, virtual schools/online courses, task-based learning, and expository lessons. Of these six categories, the most popular was project work, followed by media production, task-based learning, virtual schools/online courses, scientific investigations, and expository lessons. Although the SITES-M2 case study research found that the type of pedagogical practice was not useful with respect to discriminating among innovations, it did provide a useful category for raising questions and stimulating discussion within professional development and e-leadership contexts, as the next activity shows. Our description of this activity also shows how it helped participants rationalize and then suggest solutions to problems that several participants had encountered during their school's implementation of discipline-based concurrent projects.

This activity began with the teachers in the Master's class forming small groups. Each group member was then asked to select a SITES-M2 case study and to compare and contrast the types of practices in it with those of the case studies selected by the other group members. Each group member was asked to provide a rationale for selecting the case.

One group of teachers from the same school was interested in identifying and analyzing case studies of project work from the database. The principal of this particular school had responded to encouragement from the government to introduce more project work in classrooms, but the school was experiencing problems with implementing and sustaining this development. Before recounting this experience, the teachers had noted that the more innovative SITES case studies tended to be those involving the investigative, inquiry-based, problem-solving tasks typically associated with project-oriented work.

The teachers were not surprised by this observation. In their experience, well-designed projects run over a prolonged period of time, offer students new opportunities to work on authentic tasks anchored to real situations and contexts, and lead to meaningful learning outcomes. The teachers further noted that good problem-solving projects provide both teachers and students with multiple new roles. They also offer students new possibilities to engage with parents and the community.

The problem with all of this in their own school, said the teachers, was twofold. First was the number of multiple projects initiated and second was the type of project conducted. The projects were very time consuming for both teachers and students alike, and because the projects were mainly discipline-based initiatives, a teacher of one subject was often unaware of what their teaching colleagues were doing even though they were working with the same year group of students. Parents had complained that their children were so busy doing the various project work activities that they were not doing what they (the parents) considered to be "real" homework related directly to the prescribed curriculum.

The teachers then went on to observe that the SITES-M2 case studies providing examples of project work well coordinated across different disciplines seemed to report the best results. The group agreed that this degree of coordination was clearly what was needed in their school to help resolve the problems generated by having disconnected, multiple projects. Analysis of the SITES-M2 case studies projects helped these teachers not only to identify but also to begin to address a problem in their school. The activity also helped them to think about exactly how they could offer coordinated and connected project work across the disciplines.

Activity 3: Exploring Changing Roles

As we noted in the previous section, the SITES-M2 case study research found that type of pedagogical practice is not a useful index for discriminating among innovations. The six key dimensions of classroom practices that we explored in Chap. 3 were far more useful in developing understandings about the nature of innovations, what constitutes innovation, and what is necessary to effect change in various environments. An assumption here is that what happens in the classroom is central to understanding innovation and reform.

The participants involved in the Master's class were particularly interested in exploring the case studies for examples of innovative teacher roles. They wanted to compare these with their own experiences. They also wanted to evaluate how feasible it would be to adopt new roles or combinations of roles in certain contexts and to try out and adapt ideas from the case studies in their own practices. During the class, the participants again formed groups, each of which was introduced to the 13 teacher roles that the Hong Kong research team had identified in the case studies (see Chap. 4 for details). Most of the individual teachers in the groups noted that they had, over time, adopted most of the 13 teacher roles. However, they were all interested to see how these roles played out in the case studies, and the impacts that these roles had with respect to innovation.

After the groups had discussed these roles and compared them to their own experiences, they were directed back to the database so that, between them, they could review cases showing different combinations of roles in different contexts. During their explorations, the groups noted the Hong Kong research team's analysis of teacher roles in each case, and they also examined what was interesting, different, or impressive about the roles played. The groups then shared their findings. In general, the groups were impressed by the multiple roles teachers took in the various cases. They also noted that certain groups of roles were more likely to be taken by teachers involved in particular types of practices.

During the next stage of the activity, participants were introduced to the research team's "percentage of roles table" for the different cases. They were also introduced to the associated cluster analysis, with its categories of "more traditional teacher roles," "emerging teacher roles," and "types of practices" (see Chap. 4 for details).

Participants examined the distributions of teachers' roles and clusters of innovative practices across different regions. They noted that the types of role and practice combinations adopted in some regions, for example, Western Europe, were those relating to scientific investigations, project work, and media production – the three typologies most associated with the more emergent practices (see Chaps. 4 and 5 for details).

In general, the participants noted that South-East Asia had more task-based learning practices along with more teacher-centered activities. The participants also observed that the case study authors in the countries of this region obviously considered these innovations very innovative, despite the fact that teachers were still playing primarily traditional roles. This observation led to discussion about the impact that teacher role has on technology innovation, which in turn led participants to conclude that although the roles teachers adopt are important with respect to innovation, teacher role is just one of many factors involved in developing, sustaining, and transferring innovation.

The participants engaged in this activity were particularly interested by one of the findings that emerged from it. This was the aforementioned finding that certain types of practices, such as scientific inquiry, project work, and media production, are the practices most conducive to the adoption of emergent pedagogic roles. This same finding emerged from the Hong Kong research team's earlier analysis of the SITES-M2 case studies (see Chap. 5).

When they considered features associated with the changing roles of teachers, as identified in the case studies, the groups noted a number of commonalities. For example, teachers taking up the more emergent pedagogic roles tended to act less as the sole knowledge provider and more as an advisor to students. These teachers were also concerned with establishing environments that facilitated student-centered activities. These teachers were more likely than other teachers to monitor and provide ongoing feedback to students, and they were also more likely to collaborate with fellow teachers. They furthermore seemed to spend a good chunk of time organizing classroom environments suited to project-type work. The groups also observed that students using ICT worked differently from students not using ICT. Their work was more creation-oriented, collaborative, and independent in nature. They provided peer feedback and assessment, and they put pressure on teachers to facilitate this process. What became particularly clear to the groups was that no matter how innovative a teacher's role was, any involvement in an innovation usually required the teacher to acquire new pedagogic as well as technology skills.

Other issues raised by the groups that were also in line with the Hong Kong team's research findings included the following:

- The extent of innovation along the six dimensions was very different on a case by case basis
- Even though teachers' roles may not be particularly innovative, teachers played a crucial role in orchestrating the other dimensions
- Teachers' roles may not need to be particularly innovative to facilitate very innovative roles for students

- Where teachers' roles remained traditional, innovation on the other dimensions generated new demands on teachers
- Whether or not there were substantial changes in pedagogic roles played by teachers, teachers had to innovate at a professional level to meet new challenges and thus realize classroom innovations
- Teachers needed to engage in continuous learning and work collaboratively with other teachers, given that pedagogic innovation is the means whereby the teaching profession renews and recreates itself

It was also evident from this activity that enabling teachers and other educational practitioners to explore teachers' roles relative to innovative ICT-related pedagogic practices stimulates not only reflection and debate on, but also a re-evaluation of, these practices. Participants noted that ICT use can encourage networking between teachers and the sharing of pedagogy within and across schools. A particularly noticeable area of debate during this activity related to consideration of whether ICT is simply a resource to support pedagogy or whether its use is much more a part of a teacher's pedagogic repertoire. Participants concluded that ICT use certainly enriches the teaching resources available, and that it is an important lever for change. They also concluded that the effectiveness of ICT use in facilitating learning depends more on pedagogic beliefs about teaching and learning processes than on the resources it can deliver.

Activity 4: Planning and Vision Building

The SITES-M2 researchers noted that what happens in innovative classrooms rarely happens in isolation and that classroom practice is influenced by school culture and leadership (Pelgrum & Law, 2003). Building visions and planning forward directions for the school is therefore fundamental to the change process (Law, 2004). Because ICT means both a major opportunity and a major expense for schools, its implementation requires careful planning.

Studies on managing school change and innovations show that the process of change is a complex one, involving not only changes in physical and organizational infrastructures and curriculum materials, but also, and more fundamentally, in beliefs and practices (see, for example, Fullan, 2001; Law, 2003; Law et al., 2000). These last – and much deeper – changes can only take place if the innovation is led by dynamic and visionary leadership capable of developing and implementing a collective plan to bring about changes in organizational culture, beliefs, and practices (Law et al., 2000). A clear and shared vision that addresses all contextual needs is therefore paramount. The potential benefits, implications, and challenges of introducing ICT into schools can be very different depending on the vision and understanding of the nature of change, as well as the strategies to manage it adopted by the leadership at the school level and beyond, which is why this next activity focused attention on exploring the extent of importance attached to vision building and planning in the SITES-M2 case study schools.

The class members, again in small groups, selected two SITES-M2 case studies per group, and endeavored to answer these two questions: Did each school have a clear vision and, if so, what was the relationship between the case study innovation and the vision? Did the school have a plan for ICT integration and, if so, to what extent did this planning align with the school vision? Over the course of several weeks, the individuals in each group built a vision statement for ICT integration in their own school, and articulated it to align with the strategic plans of their respective schools. Group members exchanged their visions and plans and discussed differences.

This vision-building exercise raised awareness of the importance of developing a school vision that clearly conveys where the school wants to go and how it intends to get there. The SITES case studies provided the class members with concrete examples of what other schools had done with regard to visioning and planning. Although most of the activity participants said their particular schools did have a vision, few were able to see the connection between the vision and the school plans for change, or what role the technology would play in helping the school achieve its vision. This activity was particularly useful for participants in schools that had just started integrating ICT across the curriculum.

Activity 5: Multilevel Leadership

Successful implementation of ICT is a key concern for leaders at all levels of the education system, that is, national government and ministry through district education boards and on to school principals, departmental heads in schools, and individual teachers. The greatest challenges with respect to this concern for the leaders of these different levels is that of establishing a common vision of ICT as a pedagogical tool and that of bringing in effective implementation strategies that will work in tandem and can be dynamically adjusted.

The activity that we outline in this section calls into reference the SITES-M2 research conceptual framework that we discussed in Chap. 2. This framework provided the participants of the Master's class with a point from which they could begin discussing, in small groups, the importance of a shared vision and coordinated effort across the three main levels of the education system (country, school, and classroom). Each group then used the case studies to explore how various schools had adopted different leadership strategies and approaches. The groups were also asked to identify the types of leadership within their case study schools and then to compare their findings and consider the strengths and weaknesses of the schools in terms of multilevel leadership. To guide the discussions about leadership, groups were asked to articulate their definitions of good leadership, to state who should be involved in leadership roles, and to outline what leadership should focus on.

The aim of this activity, which was to focus participants' attention on the importance of multilevel leadership for sustainable and transferable innovation and change in schools using ICT, was successfully met. The guiding questions stimulated useful discussion on issues concerning ICT implementation in schools and the important part that leadership at the various levels of the education system plays in supporting innovation and change.

Usefulness of The Case Studies with Respect to Professional Development

The feedback that we have received to date from practitioners who have participated in courses using the case studies to support professional development activities confirmed that this approach stimulates:

- A more sophisticated understanding of innovations and the contextual factors that support innovative practice
- New ways of thinking about ICT roles that go beyond supporting existing practices
- An awareness of the complexity and importance of the interrelationships between the country, school, and individual levels of the education system in ensuring sustainable innovation
- Reflection on the importance of multilevel leadership
- A review of education planning in general and the role ICT can play
- Realization that a holistic and coordinated approach across all levels of the education system to planning and activities increases the chance of positive development, sustainability, and transferability of innovative practices in the longer term

The ecological model of understanding educational change at country, school, and classroom levels offers those providing professional development and those undertaking it with a lens through which to view classrooms of the future. Studying the SITES-M2 case studies through this lens helps educational leaders, practitioners, and administrators envisage future classroom practices and develop their own plans for developing and implementing such practices. Discussing strengths and weaknesses of particular cases draws attention to how ICT can be employed to provide new learning opportunities and approaches. This type of discussion also helps participants understand that planning and integrating technology use in schools has the added advantage of effecting major changes to how schools are organized and run.

The individuals who have participated in the professional development activities using the SITES-M2 case studies also express appreciation for having the classroom level as their starting point. They tell us that they and their schools receive considerable benefit from the opportunity to examine innovative pedagogical practices and to review what these mean in terms of changes to teacher, student, and technology roles. They say the same with respect to opportunity to view the classroom nested within the context of country/government- and school-level factors and to gain a considerably deeper understanding of the importance that interrelationships between and close collaboration across the three levels holds for innovation sustainability and transference.

Summary and Conclusions

In this chapter, we described and discussed how case studies of ICT-related pedagogical innovations in schools can be used as a professional development tool in pre- and in-service courses for educational practitioners, leaders, and administrators. Consistent with the principles and practice underlying technology-supported pedagogical innovations, we developed an online database of 130 selected case studies from the SITES-M2 cases and integrated these into the classroom-level and school-level analyses frameworks reported in the earlier chapters of this book. We designed the database so that it would support an ecological model of professional development. When discussing this model, we used the metaphor of a garden ecology to emphasize the complexity of introducing innovation into a site of practice and the challenges associated with sustaining and transferring innovations. The case-study model of innovations that we developed thus offers a way of understanding and making use of innovations that differs from existing models, which typically present only exemplary cases of innovation.

The ecological model emphasizes a need to understand innovations as a process of emergence that is intimately linked to multiple levels of context beyond the classroom, and where sustainability and transfer rely on establishing an architecture for learning that involves the many stakeholders across the various levels of education connected with the site of innovation. Within such a model, adoption of an innovation as replication is not possible; any successful and sustainable adoption of innovation has to be an innovation in itself. For this reason, we also constructed a parallel case-study website database where teachers can upload their own examples of innovation. This database offers teachers an analytical framework similar to that used for the SITES-M2 case-study database. The two databases therefore provide teachers and other stakeholders with a robust professional development tool that allows them not only to consider the practice and experience of others but also to document and discuss their own experiences of innovative practice. The responses of those who have used the databases as a means of professional development thus far indicate the viability of this model, although substantive follow-up on the impact of this approach to professional development on schools is not yet available.

Chapter 10
Changing Leadership Roles in Changing Times

Leadership in its various forms is recognized as a key factor in any reform process. Building on the work presented in the previous chapters, we consider, in this chapter, leadership as an essential component of successful technology-supported curriculum and pedagogical innovation. We pay particular attention to a concept of leadership that goes beyond the traditional roles and responsibilities of the principal and the senior management team to encompass multilevel conceptions of leadership.

In Chap. 9, we described how the SITES-M2 case study database can be used to stimulate practitioners' examination of and engagement with innovative pedagogical practices in the classroom. In this present chapter, we again draw on the database, but this time consider how it can be used to explore multiple roles of leadership, particularly with respect to how leaders influence the scaling up of change and sustaining innovative practices in education. Our exploration thus focuses on how leaders contribute to taking the innovation *beyond* the single classroom in order to support more sustainable and transferable practices. As we show in this chapter, effective leaders are able to do this in two main ways:

1. They facilitate the establishment of broader, more systemic communication and networking among the various stakeholders in an education system
2. They aid formation of the multiple initiatives that engage these stakeholders in supporting innovation and the reform process

We also, in this chapter, draw on three such initiatives in order to clarify and discuss the networks between multilevel initiatives and their impact on scaling up innovation and change in schools.

Networks as Architecture for Learning and Educational Transformation

One again, we begin this chapter by turning to our ecology metaphor, especially that of the garden. Gardeners can focus on sections of the garden, or they can take a broader view of it. New concepts of gardening emphasize sustainability and of

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gardeners taking into account the totality of the garden and its environment and settings before they undertake planting or make other changes to the garden. The key to this analogy is recognition that everything in the garden, including its immediate environment, is affected by broader ecological factors: in other words, everything matters.

When exploring change in schools, we, too, need to recognize the importance of the total educational ecology and to take into account all factors that need to be considered when planning for continuous change and innovation. Over the years, investigation of change in schools has generally focused on changes carried out by individual schools working independently and on teachers within each school working, often in isolation, to implement the changes at the classroom level. This "isolationist" approach is no longer appropriate in the face of the major and multiple changes and reforms taking place in society as a whole and in education in particular. As Gronn (2002, p. 18) points out, "Schools now operate in complex, data-rich task environments as never before," a situation that calls for interdependence and reliance on new ways of cooperative working. Many educational commentators and researchers claim that capacity building for successful change has to occur beyond schools if societies are to achieve the type of change within the broader educational ecological environment that is necessary for sustainability (Banathy, 1991; Engeström, 2005; Fullan, 2007; Fullan, Cuttress, & Kilcher, 2005; Hargreaves & Fink, 2004). These commentators also maintain that, within the context of reform, learning is crucial to the process of establishing alignment in terms of goals, vision, and strategy across the different levels and sectors of an education system. They also argue that learning which takes place as individual acts isolated from practice will not lead to changes in practice in the workplace.

Socio-cultural theories situate learning as a process that takes place when individuals engage in socio-cultural practices within relevant communities. According to the community of practice theory, learning is a product of social interaction between people in micro-communities of practice (Lave & Wenger, 1991; Wenger, 1998). These communities sit mid-way between formal organizational structures and individuals, and their presence highlights the informal relationships that often play an important role in creating opportunities for learning. Alignment of learning across these levels requires opportunities for *boundary spanning*, that is, the interactions and the negotiation of meaning that takes place among individuals from different communities. Boundary spanning takes place through *boundary practices* (activities such as regular meetings that provide a forum for mutual engagement and negotiation of meaning), and it often involves the use of *boundary objects* (artifacts that embody a set of ideas or processes). *Brokers* (individuals belonging to multiple communities) play an important role in coordinating meanings arising out of boundary spanning. Organizational environments, such as these, that foster teachers' opportunities to learn new ideas and to try out new practices, are referred to as "architectures for learning" (Wenger, 1998).

Hargreaves (2003) argues for bridging the artificial divides between policy and practice and between governments and schools. Hopkins and Levin (2000) propose the establishment of networks between government, schools, and the community. These two authors also propose that schools and their teachers establish networked communities with schools with similar interests and challenges so that they can help one another work through the necessary ongoing changes. Hargreaves (2003) stresses the strong role that these networks play in helping address the growing imperative for ongoing reform and transformation of the entire education system. Fullan (2005), who describes this networked process as lateral capacity building, explains that it involves practices such as establishing special interest groups across schools. This type of networking is particularly important, Fullan argues, because change nearly always requires teachers to learn new ways of teaching that are outside their own experiences. Such learning can be emotionally and intellectually demanding of teachers, especially if they have to do it on their own. Networks diminish this isolation; they form the architecture for scaffolding learning at the different levels of the education system, and so are critical to successful and sustainable change. So, too, is the role played by leadership at the multiple levels within this architecture for learning.

Leaders and the Changing Concept of Leadership

Leadership has been identified as playing a key role in enabling successful school development and change (see, for example, Jackson & Kelley, 2002; Louis, 2006; Wallace, 2002; West, 2000). While the quality of teaching has a powerful influence on student motivation and achievement, quality leadership is a deciding factor in motivating teachers and in the quality of teaching in the classroom (Fullan, 2001; Sergiovanni, 2001). However, the term "leadership" does not necessarily equate with one person in the school, even though the principal is clearly a key factor in leadership, as identified and analyzed in Chap. 6. The complexities of rolling out school improvement and change cannot be seen as the direct and sole responsibility of the principal. This premise warrants even more attention during integration of technology into teaching and learning. The reason why, is that this process adds layers of complexity to school change that require additional considerations (Yuen, Fox, & Law, 2004).

A prominent model of educational leadership within the literature focuses on the skills, talents, and capabilities of one person. Fullan (2001, 2005) argues, however, that this model of leadership severely limits enabling, scaling up, and sustaining school- and class-level change. This situation highlights, he says, the need to redefine leadership so that it moves beyond its traditional conception of a formal role vested in an individual to a conception in which leadership is taken by many in order to effect school improvement and change. Hallinger and Heck (1988) likewise argue for the need to redefine the term leadership away from role-based conceptions in favor of multi-stakeholder involvement. Elmore (2004, p. 87) encapsulates these ideas when he writes:

> Schools and school systems need to learn not just different ways of doing things, but very different ways of thinking about the purposes of their work, and the skills and knowledge that go with those purposes. This shift requires … a redefinition of leadership, away from

> role-based conceptions and toward a distributive view … Distributed leadership … derives from the fact that large-scale improvement requires concerted action among people with different expertise and a mutual respect that stems from an appreciation of the knowledge and skill requirements of different roles.

This commentary does not imply that any less importance should be accorded to the role of the school principal. However, in order to implement changes, leadership support is needed from stakeholders within and across many levels (Hopkins, 2001).

These considerations of who holds, or should hold, leadership does not adequately answer the question of what leadership is. Various terms denoting different understandings are evident in the literature on leadership. One term that has increasingly been used in recent literature, and which we discuss in the following paragraphs, is *distributed leadership*. There is no single agreed understanding of this term, although it is generally characterized according to the concept of collective leadership, where principals, administrators, teachers, and others work collaboratively to develop and implement decisions (Spillane, Halverson, & Diamond, 2004). Distributed leadership "decenters" the concept of leader because it involves dissemination of leadership between formal and informal leaders in the school and because it results in changes to the roles and activities of both staff and students. As Gronn (2002) argues, leadership can, and should, reside in all stakeholders at all levels of the school and beyond.

Although there is no commonly agreed definition of distributed leadership, there is broad agreement in the literature on it that increased demands for change in education require a sharing of leadership responsibilities within and across schools in conjunction with a flatter, less hierarchical leadership structure. Across time, the literature accordingly has moved away from the "command and control" view of leadership to a "cultivate and coordinate" perspective (see, for example, MIT Sloan Management, 2004). Most commentators in the more recent literature also argue that distributed leadership works best in conjunction with strong leadership (e.g., Graetz, 2000; Spillane, 2006). This thinking positions the members of a strong principal and senior management team as individuals who have a clear vision of what they want their school to achieve and how they want it to get there, and who are able to disseminate this vision across the school. Importantly, they are also able to involve others in the school at all levels, engaging them in the leadership roles necessary to ensure successful implementation of the changes required. Those contributing to this body of literature (e.g., Harris & Chapman, 2002) also tend to suggest that distributed leadership vested in a senior management team is the type of leadership most likely to support a school and its stakeholders as they strive to achieve their goals.

Hargreaves and Goodson (2006) concluded from their longitudinal case study research, carried out over a 30-year period in eight schools, that the key issue to consider when effecting change through leadership is *sustainability*. Hargreaves and Goodson state that exemplary or excellent leaders in the form of a single principal and a senior management team do not, in themselves, bring about sustainable success: they only create temporary improvements and change. Using as their basis the interim findings of this research, Hargreaves and Fink (2004) concluded that sustainable leadership requires sharing responsibility in the form of distributed leadership. Only then, they argue, can an organization such as a school ensure improvements and changes that last and spread *over time*. Other crucial factors associated with sustainable leadership, according to Hargreaves and Fink, are the following:

- Judicious use of human and financial resources
- Care of the educational and community environment
- Avoidance of negativity and damage
- Active and continuous engagement with the community
- Promotion of diversity
- Sharing and exchanging good ideas and successful practices

In line with these factors, Hargreaves and Fink (2004) define seven role-related principles that they consider essential for ensuring sustainable leadership:

1. Preserving and sustaining learning
2. Planning, coaching, mentoring, grooming, and securing successors to the leadership of the school
3. Sharing leadership responsibilities throughout the school community, thereby softening "the blow of principal succession" (p. 6)
4. Ensuring that the benefits for individual students and teachers are not at the expense of others
5. Developing judicial husbanding of resources and establishing networks between leaders to increase the leadership resources
6. Developing environmental diversity and increasing capacity for continuous improvement
7. Undertaking and promoting an activist role in the community

Hargreaves and Fink (2004, p. 10) summarize their conclusions thus:

> … leaders develop sustainability by how they approach, commit to and protect deep learning in their schools; by how they sustain themselves and others around them to promote and support that learning; by how they are able and encouraged to sustain themselves in doing so, so that they can persist with their vision and avoid burning out; by how they try to ensure the improvements they bring about last over time, especially after they have gone; by how they consider the impact of their leadership on schools around them; by how they promote and perpetuate ecological diversity rather than standardized prescription in teaching and learning within their schools; and by how they pursue activist engagements with their environments.

Vesting leadership in others in a school, especially the teachers, reinforces sustainable leadership and the central role of the principal in enabling this sustainability (Davis, 2008). Bringing others outside the school into the leadership sphere – namely, parents, the community, government and non-government organizations, industry partners – is equally important. A term that is often used to encompass this broadened notion of leadership is *multilevel leadership*. It is the type of leadership that Yuen et al. (2004) have in mind when they contend that the main challenge for rapid change in education requires the “different levels of leadership in a nation – from national government, through local education agencies, through school principals, department heads in schools, to individual teachers – to establish a common vision as well as effective implementation strategies” (p. 11). The authors argue for the need to align the vision at all levels and to adjust strategies as required to address the changing conditions faced. They also call for a more fluid, dynamic, coordinated education sector – a sector that, through its multiple interconnections and networks, can sustain change and innovation.

Using SITES-M2 Case Studies to Support Multilevel Leadership Development

Multilevel leadership occurs in many ways, depending on the type of task at hand and the history, culture, and support mechanisms of individual organizations. Because multilevel leadership is an emergent property of a network of interacting individuals, it presents a strong contrast to the traditional notion of leadership as a role and responsibility held by an individual and/or senior management team within an institution. In this section of the chapter, we report on and examine examples of professional development projects designed to foster multilevel leadership. Each used the SITES-M2 case studies as a stimulus resource.

When analyzing the studies, project participants were asked to identify the following:

- Conditions that offer opportunities for new pedagogical practices to be nurtured and sustained
- Environmental impact of the new practices on the educational ecology
- Conditions, patterns, and critical environmental factors that influence sustainable and scalable change
- Development plans for pedagogical innovation appropriate to the participants’ own contexts

The APEC Regional e-Leadership Project

In Chap. 1, we identified a broad imperative: international calls for system-wide changes in school education across countries. This imperative, shaped in part by developing knowledge-based economies, has led to the need for fundamental reform in education, including curriculum goals and pedagogical processes. Many education reforms around the world link ICT to documents setting out change policies (Plomp, Anderson, Law, & Quale, 2003, 2009). Responding to these calls for reform, the Asia-Pacific Economic Cooperation (APEC) established the APEC Cyber

Education Cooperation (ACEC). Set up under the auspices of the APEC Education Foundation (AEF), ACEC undertakes projects that aim to improve the use of ICT in education and to develop ways of narrowing the digital divide in APEC member economies. One of the earliest ACEC projects was Bridging the Digital Divide through e-Educational Leadership in ICT, led by the Centre for IT in Education (CITE) at the University of Hong Kong.[1]

The main focus of the CITE-led Bridging the Digital Divide initiative was to provide APEC member economies with the knowledge and working methods they would need to support e-leadership in ICT development. This support, it was envisaged, would assist these economies scale up sustainable reform. The project, ambitious and broad in scope, also aimed to jump-start quality partnerships across economies by facilitating collaborations focused on developing e-leadership capacity at multiple levels and thereby bridging within-country and cross-country digital divides. In order to support leadership development of a kind facilitative of changes at regional, school, and classroom levels, the Digital Divide designers made the concept of partnership through shared and multilevel leadership a central component of the initiative.

As described earlier in this chapter, the concept of multilevel leadership assumes that national and regional governments as well as international organizations such as ACEC and AEF will work with and support all stakeholders in education as they work to institute ongoing change. In order to help foster mutual understanding and collaboration across the APEC region, Bridging the Digital Divide included e-leadership development activities centered on examination of the SITES-M2 innovative practices. These activities were offered during two CITE-organized regional workshops designed to initiate and promote intra- and inter-economy e-leadership development. While both workshops drew on the SITES-M2 database, each had a different focus, which meant the activity work resulted in different outcomes.

The first workshop was held in Bangkok, Thailand, in March 2002. When planning this workshop, the CITE team contacted the country and regional coordinators of the SITES project to help them identify key educational stakeholders in 20 APEC economies. The CITE team sent these people a survey designed to gather information that would provide insights into economy priorities and contexts. The stakeholders were also asked to identify key people (across all levels) to participate in the first workshop. CITE invited the nominees to participate in the workshop and, if they were willing to do so, to provide further information on their areas of interest and what they felt was important to cover in the workshop sessions. The CITE team then worked in partnership with the local Thailand host, the Institute for the Promotion of Teaching Sciences and Technology (IPST), to develop the workshop structure and content, a process that included taking into account the data collected from the surveys.

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[1] For more information on these interrelated initiatives, see http://www.apecef.org/; http://www.apecef.org/aboutAEF/activities_01.asp; and http://acec.cite.hku.hk/.

This first workshop was attended by 40 people from 11 APEC economies. As a group, these people represented a broad range of educational stakeholders. They included government officials, inspectors, staff from non-government organizations, teachers, principals, teacher educators, and researchers. During the 3 days of the workshop, participants engaged in activities focused on developing within-country and inter-country multilevel leadership. The activities covered three main areas:

- Developing and building visions on what full integration of ICT in the education system might and should look like
- Approaches and strategies for implementing ICT
- Developing ICT implementation plans to assist achievement of educational goals and longer-term targets

The workshop content referred to and drew on policy documents and research from the participating economies, SITES-M2 case studies, and studies of country ICT-implementation strategies and school and classroom integration of ICT. Workshop activities involved a mix of delegate, plenary, and small-group presentations as well as formal and informal occasions to exchange ideas and reflections. Opportunities to examine and compare innovative pedagogical practices using ICT from the SITES-M2 case-study database and the associated management and change strategies at institutional, regional, and national levels were a mainstay of the workshop.

During the first 2 days of the workshop, participants worked in groups comprising members from different countries. Installation of broadband internet-connected laptops and desktop computers enabled groups of five or six participants to work on networked computers on various activities. This process also helped establish stronger ties between individual participants. The online resources were configured in a way that allowed individuals and groups to place their work and reflections in relevant online folders and, later, to present their ideas on how ICT could be used in their localities to support changed pedagogical practices. The participants and their colleagues were also able to continue cross-national discussions and communications after the workshop because access to the online workshop resources remained open.

As we have already indicated, the key resource used throughout the 3-day event was the SITES-M2 case studies. Prior to the workshop, the CITE and IPST teams worked together to identify and then summarize cases from six countries with different levels of economic development. The six cases allowed the workshop participants to reflect on the content of each and to compare its descriptions with their own ideas of what constitutes innovative ICT-related practice in education. The cases also helped participants to think not only about technology use in general in education but also to take the examples of innovation and compare them to their knowledge of best innovative practices in their own economies. The workshop concluded with participants grouped with colleagues from their own country in order to develop plans for ICT implementation across the curriculum. Each group then presented its strategic plan so that all workshop participants could compare the various plans and use the information gained to develop additional ways of collaborating with and supporting one another across levels and between economies.[2]

During the feedback session following the workshop, participants commented that what impressed them the most was the opportunity to engage with a multilevel group. The workshop had been the first opportunity any of them had to meet, work, and network intensively with a cross-section of stakeholders. The participants all expressed the desire to conduct echo training sessions and related events within their own economies. They wanted, they said, to encourage broader and deeper thinking and planning of ICT integration, innovation, and change throughout their educational systems in general and their schools in particular. Participants also voiced interest in making further use of the SITES database because it had stimulated them, they said, to:

- Review and reconsider the ICT-development planning processes in their own economies
- Reflect on issues related to e-leadership and educational change
- Realize the importance of multilevel leadership and coherent planning (national/regional, school, classroom, and individual)
- Identify and clarify their own ideas about innovations in education relative to the innovations provided in the database

The participants also said they would like ongoing access to the database because it would enable them to request and engage in further collaborative activities on e-leadership in the APEC region.

After the workshop, delegates representing the different economies met to discuss ideas for the second workshop and where it would be held. They also talked about strategies to keep the project active between the workshops. This hoped-for ongoing activity became evident when the next workshop began. Participants quickly saw that the workshop content and approach had built on the outcomes arising out of the first workshop and on the increase in multilevel interactions. Thirty-seven participants, representing ten APEC economies as well as a broad range of roles and responsibilities, attended the second 3-day workshop, held in Cebu, the Philippines, in February 2003.

As with the first workshop, the workshop conveners collected details from participants prior to the workshop. All participants were asked to prepare a presentation documenting their experiences of ICT implementation and integration and outlining the factors influencing change and innovation in their economies. A mixture of plenary, exhibition, and small-group presentations and discussions stimulated considerable debate on these matters. These discussions continued well after the workshop finished. The exchanges between members led to firmer proposals for follow-up projects between economies and between schools across economies.[3]

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[2] Details of the workshop activities are provided in the ACEC final report (http://acec.cite.hku.hk/).

[3] These are summarized in the ACEC final report (http://acec.cite.hku.hk/).

During the 3-day workshop, the debates on innovation and change were advanced with the presentation of a secondary analysis of 25 of the SITES-M2 case studies. This was conducted by the Hong Kong research team, who used the same analytical approaches and methods described in previous chapters of this book. The workshop participants, in groups, also reviewed and analyzed the 25 cases. Between them, the groups highlighted a range of success factors with respect to supporting sustainability and innovation. They also identified different models and processes for implementing change, but they offered no single model for moving forward. Instead, they suggested multiple pathways, each dependent on a different configuration of multiple factors. During the workshop, participants again had access to an extensive online database of resources database. Here, they could not only reference existing posted material but also upload their work and communicate within and across groups.

Participant feedback following the workshop reiterated the importance of the unique opportunity to work collaboratively across multilevels. Opportunity to draw on the SITES-M2 secondary analysis provided added stimulus for proposing new collaborative projects across the APEC region. Participants highlighted, to use the words of one of them, "collegiality and relationship building and the relatively informal and good-natured balance of humor and work encouraged during the workshop." They also said that the facet of the workshop they most appreciated was the "interaction with other participants, learning from each other's experiences, and trying to see what is applicable in local situations."

Overall, the feedback from the participants identified which of the workshop experiences were most effective in terms of lasting impact. The group or team approach emerged as the most significant. Throughout both workshops, participants worked in various teams, the composition of which changed in line with the activity to be completed. At times, participants worked across levels. Thus, each team included a government official, inspector, principal, teacher, etc. At other times, groups comprised the same or similar roles and responsibilities: for example, teachers in one group, government officials in another group, and so on. As the participants themselves said, this was their first experience of working across such broadly varied levels and roles. The outcomes of this approach, as reported by the participants, was a deeper and broader understanding of the complexities involved in effecting lasting change and reform and the importance of including stakeholders from across the levels of a system when planning for and implementing (hoped-for) lasting changes. The participants identified as an important outcome, an understanding that sustainable change requires two types of impetus: all levels within a system working together, and development of networking infrastructures and practices that enable regular ongoing communication between and across the levels (see also Hargreaves, 2003).

The strength of this APEC project was the links that the individuals from the various economies in the region established as they worked together to focus on issues of reform and change, in general, and on those relating to the role that ICT plays in supporting and sustaining innovation and in facilitating multilevel leadership interactions, in particular. Gronn's (2002) concept of the importance of "concertive action" – of people working together across areas of roles and responsibilities, pooling their experiences and expertise – was mirrored in the workshop.

The project achieved the overall objectives of the ACEC consortium: to stimulate multilateral cooperation in the APEC region, enable the sharing of experiences and resources, and (through exchange of information) avoid making mistakes. The original ACEC consortium of four economies (Hong Kong China, Korea, New Zealand, and the United States) in 2001 quickly expanded to eight economies in 2002. By 2004, 15 economies had become ACEC members, each intent on "encouraging multilateral collaboration activities" and developing human capacity across the region (APEC Education Foundation, 2009, p. 44).

ACEC's original undertaking led to various new projects. For example, by 2008, 112 schools in 12 economies had joined the APEC ICT Model School Network. All together, more than 40,000 teachers and students are involved in this network (APEC Education Foundation, 2009, p. 52). In 2009, the APEC Education Foundation (2009, p. 48) reported that the e-Educational Leadership project, along with other original ACEC consortium activities, had established a new tradition of international cooperation in education across APEC. The consortium has thus encouraged not only an interest in sharing experiences and built up a climate of trust through the contacts made; it has also produced a willingness among educational stakeholders to participate in ACEC-led initiatives in order to better understand how to overcome challenges such as the digital divide.

The model established in the CITE-led workshops and the use of SITES-M2 case studies acted as a catalyst for some mirror training in APEC economies and helped establish the importance of multilevel involvement during reform processes in the various education systems. The SITES-M2 case studies proved to be an important means of stimulating exploration of innovation and identifying regional similarities and differences in practices. However, lack of funding and post-project support for the many new initiatives that the 70 or so project members wanted to engage in meant that the e-leadership project could not be sustained beyond its original dates. Nevertheless, the project was seen as a start with respect to raising awareness, identifying the crucial role of distributed and multilevel leadership, and establishing ongoing communication and discussion networks across all levels of the respective education systems.

Good Practices Initiative in Hong Kong

This second program, based in a single economy, Hong Kong, is titled Good Practices for IT in Education (Good Practices, for short). The Hong Kong government, as part of its strong commitment to leveraging the potential of ICT to produce the kinds of curricular and pedagogical changes called for by the government's program of curriculum reform (Education and Manpower Bureau, 2004), initiated and funded the program. Good Practices thus reflected the government's strategic goal, "empowering teachers with IT." More specifically, Good Practices provided teachers with the professional development and technology support they would need to develop their own case studies of ICT-supported innovation and good pedagogical practice. During this activity, the teachers used SITES-M2 case studies as a reference resource and framework, and they eventually uploaded their own cases to a website so that other teachers could share them. In addition to providing funding and encouragement for this initiative, the government also helped identify schools and teachers engaged in innovations that would provide interesting case examples.

The Good Practices project grew out of the recognition that adopting and implementing innovation has to be an innovation process in itself. It also grew out of the understanding that establishing communities of practice in curriculum innovation is necessary to develop the effective and coordinated support structures and mechanisms that teachers need if this goal is to be achieved. The government accordingly commissioned CITE to establish an online database and a professional web-based network to support the development and sharing of case studies of good ICT-based pedagogical practices in schools. The government brief stipulated that the online database should highlight the key dimensions of innovation as well as the features and contextual factors involved in each of the examples given. The Good Practices website[4] was thus seen as a means of creating a networked innovation community wherein teachers could explore, share, and reflect on their own pedagogic uses of ICT with one another. It was also seen as a means of supporting the formation of communities of practitioners among teachers sharing common professional interests and contexts, such as teaching the same subject areas at similar grade levels or using mobile learning devices.

The Good Practices website was not intended as a database for accessing information on ready-to-use packaged cases but rather as an interactive and constructive professional development environment that would encourage teachers to learn about and share the tacit aspects associated with the complexities of implementing innovative pedagogical practices in schools. The Good Practices website was therefore not primarily designed by and for researchers but was designed and co-constructed *with* the teachers involved in developing and reviewing case studies of good practices. During the design and production stages, the CITE team invited teachers to share their ideas and comments on structure, content, and activities, to ask and answer questions, and to raise and address technical issues.

This culture of experience sharing and collaboration not only formed a strong framework for the program but also became an integral part of the teachers' ongoing practice. This culture furthermore facilitated sustainability and transferability of change and innovation, given that these two processes are primarily concerned with converting tacit knowledge to explicit knowledge, a state that is achieved through active collaboration with other members in a community of practice.

[4] See http://goodpractices.cite.hku.hk/ and http://gp.edb.hkedcity.net/home.

Building the Communities of Practice: Website and Support Mechanisms

Twenty pilot schools in Hong Kong were identified as centers of excellence – schools that had led the way in integrating technology into the curriculum. These schools received extra funding and other support from the government. In return, the government required them to take a primary role in inter-school activities and to lead and participate in seminars and workshops on technology integration.

As part of the Good Practices initiative, two or three teachers from each school of excellence were relieved of normal school duties for 1 day/week for 1 year. During this time, they worked on technology-related matters associated with the project. They also participated in professional development activities and collected information on cases of good practices using technology from their own and other schools. The seconded teachers furthermore attended CITE-led workshops, where they learned how to identify examples of good practices and how to collect the data that would inform development of the case studies for the Good Practices website. While in the workshops, the teachers also critically discussed the international SITES-M2 cases of innovative practices, the SITES analyses of these cases, and one another's case studies. When developing their own cases, the teachers engaged in a process of review, discussion, reflection, development, and re-development. The CITE team explained to the teachers that they did not need to see these cases as examples of excellence or exemplary practice but as authentic examples of good practices designed to stimulate discussion and thought and, where appropriate, adaptation by other teachers to different teaching and learning environments.

When they had completed the workshops, the seconded teachers visited schools to introduce and discuss the cases uploaded to the website. They encouraged teachers and other relevant staff in the schools to debate the cases face to face in school, online, and in seminars. The seconded teachers also helped the visited schools identify their own examples of good practice for submission to the website. Throughout this period, the government continued to encourage schools to participate in the Good Practices initiative. It did this through various means, including teacher professional development seminars and partnership events with the private sector, such as the technology and e-leadership short courses organized by Microsoft. The government also offered human resource support in the form of teaching assistants to help the seconded teachers develop and write up the cases. Along with the University of Hong Kong's CITE, other teacher training institutions took part in the project. Their participation included engaging in discussions about initial and continuous teacher training opportunities as well as running a series of related e-leadership courses for principals, during which the Good Practices initiative was discussed and reviewed. This widespread support for the project produced a substantial increase in the number of schools involved in the project (Fullan, Hill, & Crévola, 2006).

The following two examples, taken from the Good Practices website, illustrate the kind of cases collected during the program.

- *The teddy bear project*: The focus of this project, cultural exchange among students, was facilitated through writing and sharing diary entries. A school in Hong Kong contacted a primary school in Sydney, Australia. The two schools agreed to establish the project so that students from classes in both schools could learn about each other's culture and everyday habits, and so that both could practice or improve their English skills in an authentic context. The two classes of students initially involved in this project were 9–10 years of age.

  Each class of students posted a "teddy bear" to the other class. The Hong Kong school sent a panda; the Australian school sent a koala. The students in each participating class took turns to take the guest teddy bear home overnight. The next day, these students wrote a diary entry of what they had done with the teddy bear the night before and sent their entry, along with a photo of themselves with the teddy bear, to the other school. The "host" students also read their diary entry to their classmates. All students could also ask their overseas peers questions. The teddy bear activity helped the students not only engage in cultural exchange and perfect their English, but also improve their typing skills and their ability to use emails and send attachments.

  This project, popular with the primary school children involved, has been repeated with other schools in other countries. These schools were stimulated to take part in the project after seeing it described on the Good Practices website. Some of these schools chose to use cultural items and artifacts other than teddy bears to stimulate cross-national communication and discussion.
- *Learning with mobile technology*: This second case involved a secondary school in Hong Kong, which used mobile handheld technology to support student learning. The school's vision was to make handheld connected mobile computing fully available to all students and teachers, for use in every class. All 60 Form 6 (Grade 12) students in the school received a pocket computer (pocket PC) with a wireless LAN card. (Other groups of students also received these computers at a later date.) After 2 years of experimentation across subjects, the school was confident that the pocket PC gave students easy access to online resources, enabled more interaction and collaboration in class, promoted self-study, and reduced dependency on textbooks. When used during field trips and outdoor activities, the pocket PC allowed students to complete work in the field that they normally would have done after returning to school. The students used the PCs to complete calculations, key in and exchange data between PCs, and draw initial conclusions from the data collected and analyzed on site. Once back in their classrooms, the students were able to extend their learning of relevant topics by building on the work completed during the field trip.

  Teachers were generally positive about the use of the pocket PCs, agreeing that students found these devices a less bulky alternative to laptops for field work. Other advantages besides the light weight included low cost and mobility. The teachers agreed that these features would guarantee ongoing demand for these tools as a pedagogical resource. However, they, along with us, considered that the full impact of pocket PCs on practices would not be realized for some years because time, continuous encouragement, and broad-based support are needed for this to happen.

The teachers and students who took part in the pocket PC project demonstrated and presented their work in various workshops and conferences organized by local government agencies and CITE and open to local teachers and principals. Other schools have since adopted pocket PCs for use across the curriculum. They have also adapted the various pedagogical practices described in the case study on the Good Practices website to other curriculum settings. This process has allowed schools to talk to one another about the use of pocket PCs in teaching and learning, stimulated adaptation and adoption across schools in various settings, and helped establish cross-school communities of practice for education professionals.

The Good Practices project has facilitated not only a more sharing culture in and across schools but also a greater willingness among teachers and other involved individuals to share examples of practice and to participate in discussions about how best to adapt a particular case to each school's setting and needs. Teachers have voiced appreciation for this peer-to-peer approach to establishing learning communities, the members of which are keen to exchange and trial new ideas. What became particularly clear to the seconded teacher-researchers involved in the project is that straight replication of cases is not a satisfactory way of scaling up innovations. As Fullan (2000) points out, pedagogical innovation is complex. It requires schools not only to make the major structural changes needed to support that innovation but also to undertake re-culturing. During this process, schools change "from a situation of limited attention to assessment and pedagogy to a situation in which teachers and others routinely focus on these matters and make associated improvements" (Fullan, 2000, p. 582).[5]

The ongoing challenge for a project such as Good Practices is how to scale up and sustain the work. Those involved in this project agreed that all stakeholders involved in it needed to maintain a culture of concerted effort and energy. These people include school principals, management teams, heads of subject-based departments, teachers, teacher educators, university researchers and teachers, government personnel, and community representatives and members of commerce. This multilevel involvement and the establishment of community networks of interested educators were identified as essential for this type of initiative to succeed in the longer term. In short, the restructuring and reculturing process has to be ongoing, and if it is to be ongoing, it requires support and attention.

Hargreaves (2003) argues that such communities need to be permanently bedded in if this aim is to be realized. Without the total commitment of all parties, individual innovations are unlikely to have a lasting impact across the education system. One serious limitation of the Good Practices project was that the government saw it as an initiative that needed to be completed within a timeframe, rather

[5] For a more in-depth consideration of restructuring and re-culturing, see Chap. 8 of this present book.

than as an initiative that required continuous support. Although many teachers and schools took part during the 2 years of the project, engagement in activities began to diminish once the government directed funding and attention to other projects. Nevertheless, Good Practices has made a difference to the ecology of education in Hong Kong. Comparisons of the data obtained for the two SITES surveys provide examples of the transformations that have occurred over time, especially in relation to the extent of ICT adoption by teachers and in terms of how the technology is being used to support innovation (Law, Pelgrum, & Plomp, 2008).

The government's primary focus when it initiated the Good Practices project was on a measureable product – the number and quality of case studies developed and uploaded to the website. However, another useful focus would have been that of examining the processes behind successful scaling up of innovation-based changes and transfers in and across schools. Identifying examples of innovative practices that can be easily transferred and focusing on encouraging discussion about how this can be done would have been a worthy activity. As Hargreaves (2003, p. 48) reminds us, "… in truth teachers willingly accept new practices that are teacher-friendly, that make their lives better or easier in some way."

Although the Good Practices website amassed hundreds of cases, little was learned about the numbers of cases that were transferred to other schools and other environments, let alone how this happened. As Hargreaves (2003, p. 15) proposes, gaining this understanding requires us to pay attention to identifying, supporting, and sustaining multilevel networks. He says we also need to know how best to transfer the resultant knowledge on a large scale. We furthermore need to determine which educational priorities are most likely to focus people's efforts on innovating and creating leverage for change, what strategies policy-makers setting out agendas for cultural change can add to support innovation, and what type of ongoing and lasting support is needed. Finally, we need to know which processes we need to undertake when endeavoring to evaluate and spread innovation across systems of education. All of this, according to Stein and Coburn (2008), requires a new focus on establishing and sustaining networks into a learning architecture that embraces all levels of those systems.

The eLeadership Stories Project

The first of the two projects that we have just described – that is, the APEC project – was a multi-system initiative focused on within- and cross-system levels. The second project, the Good Practices initiative, focused on change at the classroom level. This third example highlights change at the school level. In particular, it shows how schools manage and support innovation and how schools can learn from one another.

Another program funded by the Hong Kong government and conducted by CITE – the eLeadership Stories project – developed out of an e-leadership course for school principals. Its primary objective was to build principals' e-confidence. The program therefore focused on giving principals a hands-on understanding of how ICT could be used to support and improve education in their schools. It also sought to facilitate, among these leaders, ICT-related vision building and knowledge of how to plan for change brought about and associated with ICT implementation and integration. Another objective was to help school leaders and key educational stakeholders build the types of links with one another that facilitate improvements in teaching and learning across schools.

With support from the Strategic Leadership of ICT (SLICT) of the UK-based National College for School Leadership, CITE organized 3-day workshops for principals, with the sessions held during a period encompassing just over 1 month. Around 30 principals attended each 3-day workshop, during which a range of resources were used to stimulate their e-confidence. The resources included SLICT materials (including case studies of exemplary practices in using technology in the UK) and the SITES-M2 local and international case studies. The CITE team encouraged the principals to identify, from the various applications of technology in different school settings presented, the educational goals that motivated each innovation and the contextual conditions necessary for success in each case. The CITE team then asked participants to develop ideas for using technology to address a goal related to teaching and learning that their respective schools considered important.

Workshop activities included visits to schools and technology centers involved in innovation development and debriefing sessions following the visits. In order to extend, beyond the workshops, principals' opportunities to reflect on and develop ideas related to "hot topics," CITE facilitated the establishment of an online discussion forum. As part of this initiative, CITE also invited senior government officials at deputy secretary level, teacher education experts, and experienced teachers from the UK and Sweden to act as resource persons on a "hot seat." These people uploaded a stimulus piece of writing on the selected topic to the online forum and then responded to participants' comments and discussions. Experienced school principals who had already set up innovative uses of technology were invited to participate as moderators during the online discussions. Approximately 200 principals took part in the workshops and support activities.

Ten of the principals involved in the workshops volunteered their schools as sites for more intensive and systemic e-leadership development. After completion of this work, CITE research staff collected data on what each school had been able to do. A website (http://elep.cite.hku.hk/casestories) was created so that schools could share their experiences. This resource was also established as a means of stimulating networking and further discussions among principals, teachers, and other stakeholders. Four key dimensions of e-leadership were identified from these school case stories:

1. All ten schools developed broad visions for technology-supported learning and teaching. During the initiation stage of the innovations, some schools set out goals and objectives in line with the broad visions they had formulated. The other schools did not go beyond stating goals; they simply encouraged teachers

to develop ideas and innovations under the broad direction identified. The follow-up evaluations conducted by the CITE team showed that the former group of schools had a more positive impact than the latter on practice in the school.

2. Nearly all of the ten schools established a distributed leadership team. However, the composition of the teams varied. Some schools had single disciplinary teams, supported by members of the school's ICT coordination team, who helped teachers try out new ideas. Other schools had an interdisciplinary team that included members from both the ICT team and heads of the curriculum-subject departments involved in the innovation. A third approach was to establish two teams, one of which (the ICT coordination team) supported the other (comprising the heads of departments). Evaluation data showed that the format of having one interdisciplinary team with members from various teacher groups facilitated better formulation of a common vision and a smoother, more effective change process.
3. Principals had many possible roles to play in initiating, implementing, and evaluating the innovation. Principals visualized their roles differently in relation to the innovations in their schools. Some were very active in steering the direction, setting targets, leading innovation teams, and so on. Others provided a broad general directive, gave teachers freedom to decide when and what initiatives they wanted to focus on, and offered support as necessary. However, all principals mentioned that they acted as a facilitator. Teachers stated that principal participation was a critical success factor for the innovation. The evaluation data also confirmed that unless the principal was actively involved in the project and aware of issues arising during it, the overall initiative was considerably less effective and transformative than it would have been otherwise. The same can be said with respect to changing teaching and learning across the school.
4. Although the kinds of technology used in the innovations differed greatly, most of the cases used technology as collaborative learning tools to aid student learning. The choice of technology differed depending on what each school considered most appropriate for achieving its desired curriculum/pedagogical changes. Analysis of the evaluation data revealed that the type of technology used was not associated with the impact the innovation had on teaching and learning.

In order to extend the experiences and share findings from these ten case stories, the CITE team organized a symposium that was held in one of the project schools. The symposium attracted 200 principals, teachers, students, and other stakeholders, and it focused on the following: sharing leadership experiences; establishing communication networks; identifying critical themes in the leadership stories; discussing successful uses of technology to support curriculum reform; and facilitating interactions between a broad spectrum of stakeholders, including principals and teachers, students and parents, government agents, and research and industrial partners.

One of the main findings to emerge from the e-leadership stories was that ICT adoption supported and facilitated new pedagogical practices in Hong Kong schools. However, these changes were unlikely to be sustained in the absence of strong leadership and multilevel support. This support, moreover, needed to be of a kind that ensured ongoing changes to the educational environment of each school.

Summary and Conclusion

In this chapter, we looked at leadership and its role in sustaining and transferring innovation and change in schools. While much of the educational leadership literature focuses on the role of the principal, there is ample evidence that factors associated with the external environment strongly influence the changes within schools. For example, education reform goals will only succeed if the change strategy includes efforts designed to secure parent and community buy-in to the change agenda. As Hargreaves and Fink (2004) found, if an individual school uses means of raising its students' achievement that harm the wellbeing of other schools around it (e.g., poaching the best teachers and/or students from those schools), change will not be sustained. Change strategies that bring about fast results in the short term also tend not to be sustainable in the longer term.

These findings, along with the findings of analyses of the SITES-M2 case studies, are consistent with a model of change that interprets pedagogical practice as teachers' adaptive behavior within schools positioned as interacting complex adaptive systems (Bar-Yam, 2002) nested within the broader education system (Davis, 2008). Mindful of the numerous reform and innovation efforts that fail to reach sustainability, researchers and commentators published in recent educational-change literature advocate a systems perspective that (1) recognizes the complexity of school change arising from the dynamic interactions between and across different levels of units (individual, school, community, district), and (2) highlights the importance of learning and capacity building for successful change (Banathy, 1991; Engeström, 2005; Fullan, 2005, 2007; Hargreaves & Fink, 2004).

Bransford, Slowinski, Vye, and Mosborg (2008) argue that schools intent on providing their students with the skills and knowledge they need to function well in the twenty-first century require what the authors term "adaptive expertise." Schools thus need, according to these authors, teachers who are themselves adaptive individuals. And teachers who are adaptive people need support from adaptive organizations, which, in turn, thrive only if the community they are in evolves to become adaptive with a similar orientation. Hence, leadership for sustainable innovation needs to comprise a leader who cannot only support learning for those directly involved in the innovation but also facilitate the building of a learning architecture for the wider community.

The three programs reported in this chapter focused on building leadership capacity within connected and/or nested communities. They were inspired by a broader conceptual understanding of leadership extending beyond principals and encompassing stakeholders situated within the multiple levels of education systems. Fundamental to the design of these projects was recognition of the importance of maintaining diversity within schools and education systems, of building on success through sharing and exchanging ideas and practices, and of building a mutually supportive environment able to sustain ongoing change.

The SITES-M2 case studies provided leaders and other relevant stakeholders with a key stimulus for discussing the features and strengths of innovations and the conditions needed to support their sustainability. These discussions helped these people acknowledge that rather than trying to duplicate innovations in their own settings, they would be better to identify what they could realistically adapt and redevelop to suit the niche needs and contexts of those settings. Hargreaves and Fink (2004) focus on the principles of sustainable leadership. However, the focus during the three projects (and, indeed, our entire study) was on the mechanisms and practices involved in building the type of capacity at all levels of the education system that is needed to implement sustainable and transferable innovations and change.

The programs also represented efforts to build architectures for learning that connect the communities at different levels of the education system in different ways. The first program, the APEC initiative, looked across economies and explored ways different countries could learn from and help one another develop and grow. The processes employed to achieve this aim included sharing information and knowledge, developing e-leadership programs, and initiating multilateral multi-country collaborative activities directed at building and developing greater human capacity in the APEC region. The program activities emphasized the nested nature of classrooms in schools and school districts through to entire education systems. In so doing, the activities also demonstrated how efforts to build capacity for multilevel leadership form strong connections within, between, and across education systems.

The second project, the Good Practices case studies, focused on the classroom level. The case studies, whether existing or developed by the teachers participating in the project, acted as a "stimulus" resource because the teachers used them as means of sharing and exchanging their experiences and practices. This process led to formation of connections between teachers and schools with similar pedagogical goals at the classroom level. It also encouraged teachers to learn from one another about aspects beyond classroom practice. In particular, the process encouraged teachers to examine the school-level conditions necessary to sustain and transfer innovations.

The third example, the e-leadership stories, was an initiative designed to foster coordinated school-based development. It focused on scalable and sustainable change, supported by technology within individual schools.

The three programs all used the SITES-M2 case studies to stimulate reflection and interaction on innovation and transfer. All three projects led to multiple other initiatives involving ICT innovation. The three projects thus met the core need, as identified by Stein and Coburn (2008), of opportunity to examine the full "architecture for learning" and to gain a working appreciation of the roles of all stakeholders in bringing about sustainable change in their respective educational ecologies.

While we strongly advocate for multilevel leadership in this chapter, we do not claim that this will happen immediately, given the complexity of education systems.

However, we maintain that multilevel understandings and activities that take into account cross-level responsibilities do have a positive impact on the total educational ecology. While we agree that fundamental change depends on local leadership, as described by Hargreaves and Fink (2004), we argue that there is also the need for a broader, cross-level approach. If innovation is to be sustained, then broad collaborations and networking within and across schools and communities and across and between teachers, schools, government, and society are essential. Change of this nature may be slow, but it has a good chance of changing the total ecology, especially if its starting point is that of reflecting on and planning out changes in the cultures existing across the multiple levels of the education system.

The key to sustainable success is for all those involved in the education system to recognize that they are all part of a larger ecology and so must engage in multiple ways of interacting and networking. They must also take on connected multilevel leadership roles and work together within and across levels on small and large tasks. All must see themselves as part of the living organism that is the education system. The mantra for a healthy educational environment, then, is one which encapsulates the need to build the type of capacity which secures the multilevel improvement that comes from ongoing pedagogical innovation and transformation.

Chapter 11
Education Innovations Beyond Technology

The advent of the twenty-first century has been accompanied by increasing rates of change in social, economic, and cultural practices, brought about by sophisticated advances in information and communication technologies (ICT). Worldwide, since the 1990s, these global changes have continued to provide the contextual backdrop for the strong impetus to change education systems. Part of this pressure comes from the need for countries to attain or retain economic competitiveness in the face of accelerating globalization that is, in part, attributable to the changes brought about by the technological advances.

There is also a heightened awareness that education must prepare individuals with the necessary competence to face the many new challenges of the future. Policies to promote technology-enhanced learning are integral to the education reform initiatives in many countries, which consider technology-related skills an important component of life in the twenty-first century. Technology, it is maintained, needs to play a critical role in the curriculum and pedagogical reforms considered necessary for the development of those competences. Around the globe, many national and international projects are fostering the development of ICT-supported pedagogical innovations.[1] Our purpose, in writing this book, was to explore the nature of the changes that have taken place thus far in classrooms and schools where technology is being given a prominent role. The school settings that we focus on are those in which technology has been identified as a key part of pedagogical innovation. Our particular goal, in this respect, has been to identify and explore the conditions that contribute to the scalability, sustainability, and transfer of these innovations.

Two important ideas underpinned our work. First, if ICT use is to bring about desired transformative changes to education, its role has to be one of disruption. What we mean here is that the technology should not be a tool used to sustain or improve traditional and popular pedagogical practices, which are largely teacher- and

[1] See, for example, the Assessment and Teaching of Twenty-First Century Skills project (http://www.atc21s.org/home/) and the Innovative Teaching and Learning (ITL) Research project (http://ctl.sri.com/projects/displayProject.jsp?Nick=ITL).

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knowledge-centered. Instead, technology should be used as a tool for changing those practices in fundamental and long-term ways. Disruptive technology in the context of studies of technology development refers to new (or new uses of) technology that is not necessarily more advanced than that existing in the market but which serves a different market niche and focuses on a different user purpose.

The core "disruption" with respect to ICT-supported pedagogical transformation is that of changing the role of the teacher and the learner in the pedagogical setting – change that goes far beyond the mere introduction of technology. The acquisition of technical skills by teachers and learners is only a small part of the challenge involved in changing education toward more student-centered, inquiry-oriented, collaborative practices. For the innovation to endure and thrive, the pedagogical innovation has to be accompanied by changes in values, practices, and infrastructure at the institutional level and beyond, such as those relating to assessment practices and university admission requirements.

The second key idea informing this book is the idea that classrooms and schools are nested ecologies within local and national education systems. These, in turn, are connected to other nested educational ecologies within the broader global ecologies. As such, pedagogical innovations should be viewed as emerging practices that evolve within specific contextual situations at classroom and school levels, which, in turn, are influenced by wider environmental factors. An ecological perspective on innovations means taking on board the assumption that there is no context-independent best or optimum practice. It also means that understanding the context and the interactions of the key elements involved in the innovation is more important than understanding the characteristics of the individual elements. Innovations are, by definition, rare and a challenge to sustain within the given context from which they emerge. Efforts to scale up and sustain innovations can therefore easily fail unless the focus on isolated classrooms and/or schools is changed to one that encompasses building, in tandem with careful implementation and integration of the innovations, the mechanisms that foster adaptive changes in the wider educational environment.

In order to achieve the goal of seeking a better understanding of ICT-supported pedagogical innovations and their sustainability, we embarked on an ecological study of the emergent characteristics of ICT-supported pedagogical innovations and the key environmental characteristics of the educational ecology that interact significantly with those characteristics. Our exploration involved secondary analysis of the IEA case studies of ICT-supported pedagogical innovations produced during the course of IEA's Second Information Technology in Education Study 2006 (SITES-M2). We also brought into our account considerations of professional development and networking projects that have built on the SITES-M2 findings in general, and on our secondary analysis, in particular. In this chapter, we summarize what we learned during this analytical journey. We end with a reflective note about that journey and what we hope will lie beyond.

Ecological Niches and Context Dependence of the Innovations

We began our analysis, in Chap. 3, by examining the case studies in terms of their "innovativeness." Our particular aim here was to determine the extent to which the niches accommodating these innovations compared to those associated with traditional pedagogical practices. We identified six innovation dimensions for comparison: the role of the teacher, the role of the student, the kinds of learning outcome observed, the curriculum goals, the ICT used, and the connectedness of the classrooms with the outside world. We found considerable variation in terms of innovativeness across the cases on the six dimensions; only a handful of cases emerged as highly innovative on all six. We were not surprised by this outcome, given that highly innovative cases require niche conditions very different from those commonly found in classrooms, where conditions at the traditional end of the spectrum prevail.

We were able, nonetheless, to identify some typical patterns (or profiles) of classroom ecologies that were innovative across some but not other dimensions. For example, a number of the cases focused on using technology to enhance teacher presentations. Because the pedagogy adopted in these instances was essentially teacher-centered, the only dimension on which we could rate them as innovative was the use of ICT to empower the teacher. Other innovations showed a high degree of sophistication in ICT use and high connectedness with outside communities, but the pedagogies adopted remained relatively traditional – primarily content-focused curriculum goals and teacher-centered approaches to teaching and learning. In general, these innovations focused on leveraging the communication potential of ICT. Most of the case studies featuring virtual schools and online courses shared this profile. Another typical profile comprised cases where teachers and students played highly innovative roles in isolated classrooms. Here the focus was on using the technology in collaborative, inquiry-oriented practices, such as scientific investigations and project work. These practices had, as an inherent aim, fostering the development of twenty-first-century skills. These isolated innovative classrooms were generally sited in the education systems of the Asia-Pacific region.

Our analyses allowed us to see a clear pattern of emergence: in each of the innovations, the classroom ecology deviated from the traditional with respect to some of the six dimensions. This deviation was a result of the specific curriculum focus of the local agents (e.g., principals, teachers) and the interactions of those agents with the local conditions. When we undertook correlation analyses of the mean innovation score ratings of the case studies, teacher's role score emerged as the only score significantly correlated with the scores of all five other innovation scores. This outcome indicates the importance of the teacher's role in influencing the presence of more innovative features in the other dimensions.

From the perspective of the ecological analogy, we can see that teacher's role is a keystone species within classroom ecologies. In ecology, a keystone species is one whose impact on the structure of the ecological community is greater than would be expected based on its relative abundance. Keystone species help to support the entire community of life in an ecosystem. Should this species become extinct, so, too, will the other forms of life. Hence, when developing strategies designed to foster, sustain, and scale up technology-supported innovations, stakeholders must pay primary attention to the teachers' role and the changes needed. Another finding relevant to these considerations was that multiplicity of learning outcomes had the lowest mean dimensional score. This finding indicates that new varieties of this "species" emerging from the innovations is the most ecologically fragile and that innovations associated with this dimension are unlikely unless innovations along the other dimensions are present.

Of the six innovation dimensions, only one was associated with ICT, and that was ICT sophistication. The score for this dimension correlated significantly, albeit on the relatively low side, with two other scores, teacher's role and connectedness. ICT sophistication is also the dimension that had the highest mean score for all geographical regions, a finding which suggests that while ICT availability and sophistication are relatively easy to achieve, level of ICT sophistication has a fairly weak ecological influence on the other innovation characteristics, except connectedness.

When we looked at the innovation scores for the cases collected from the different geographical groupings of SITES-M2, we found sizeable regional differences with respect to the mean profiles of innovation. Western Europe had the highest mean innovation score for all dimensions, except for ICT sophistication, which was topped by cases from America. The mean innovation scores for Asia, however, were below four (i.e., towards the traditional end) for all dimensions except ICT sophistication, a finding which indicates that pedagogy in Asian classrooms still tended toward the traditional even for practices selected as the most innovative within the countries of this region. An ecological interpretation of this phenomenon is that regional differences in innovation characteristics reflect differences in pedagogical practice that are pervasive across education systems. This interpretation is consistent with literature reporting the prevalence of the Confucian heritage culture in East Asian countries, where the teacher is a figure of respect and authority (Watkins & Biggs, 1996, 2001).

The Crop and Keystone Species: Students' Roles and Teachers' Roles

Students' roles link directly with the kinds of learning experience students have. Learning experiences determine, to a large extent, learning outcomes. Because our interest in the technology-supported innovations was premised on the need for school education to deliver new curriculum goals directed at helping students develop twenty-first-century skills, such as problem-solving, inquiry, collaboration, and communication, students' role was another dimension of marked interest for us. If we turn again to our ecological metaphor, we can position students' role as the crop species within the classroom ecology. We were interested in determining if the emergence of newer varieties of this crop species had produced, or would be likely to produce, seeds (learning outcomes) with the desired properties.

In Chap. 4, we categorized students' roles into five main categories based on a *K*-means cluster analysis of the student learning activities reported in the analyzed case studies. The roles were follow instructions, search and present information, create digital products, conduct inquiry, and conduct online inquiry. In addition to the differences in students' role scores across case studies highlighted by differences in students' role scores in the innovations analyzed, qualitatively different kinds of students' learning-activity patterns also emerged from the cluster analysis results. In the "follow instructions" cluster, the learning activities that students carried out were the same as traditional practices, even though technology was used. However, the remaining four clusters revealed changes in the nature of students' learning activities, which differed in terms of the variety and extent of autonomous agency required of the students.

When we undertook further analysis, we found that innovations belonging to different student role clusters differed statistically significantly from one another on four of the innovation scores: teacher's role, students' role, curriculum goals, and multiplicity of learning outcomes. Because the cluster analysis results were independent of the innovativeness ratings, this difference provided good triangulated evidence of the student role clusters most likely to help students develop twenty-first-century skills. However, the lack of difference among the clusters in terms of the ICT sophistication and connectedness scores suggest that these two dimensions per se were having little impact on the roles played by students.

We can interpret these five student role clusters as five varieties of a flowering crop species of interest to gardeners emerging in response to climatic and other environmental changes in the gardens. These varieties differ from one another in terms of the quality of their seeds, particularly with respect to the ability to germinate and propagate in the changed general environment (multiplicity of learning outcomes score). Also, the gardens supporting these varieties have butterflies (pedagogical practices) that can use a new environmental condition – ICT. One of the crop varieties – the "follow instructions" cluster – differ little from the predominant species that has long existed in these gardens.

We conducted a similar cluster analysis on the teaching activities reported in the case studies. The five teacher role clusters that we identified were instructing, developing learning resources, coordinating student learning, facilitating exploratory learning, and guiding collaborative inquiry. The cluster analysis results indicated the emergence of new varieties of the plant that the caterpillars in the garden fed on (the keystone species). With the exception of instructing, the other four roles (species) involved new activities and new behavior on the part of the teacher. As was the case with respect to the students' role clusters, we found statistically significant differences across the teacher's role clusters on the same four innovation scores: teacher's role, students' role, curriculum goals, and multiplicity of learning outcomes. No significant differences emerged relative to ICT sophistication and connectedness. The crop species *follow instructions* and *search/present information* were most closely associated with the keystone species *instructing* and *developing* *learning resources*. The crop species *learning through digital production*, *learning through inquiry*, and *learning through online inquiry* were more closely associated with the other three emerging varieties of the keystone species (i.e., more innovative roles), namely, *guiding collaborative inquiry*, *facilitating exploratory learning*, and *coordinating student learning*. These patterns indicate co-evolution of the crop species and the keystone species.

Types of Innovative Pedagogical Practices as a Species in the Classroom Ecology and Relative to Teacher Competence

Just as a crop species has to be pollinated by insects, such as bees and butterflies, before it can bear fruit and yield seeds, students' learning has to be facilitated through the pedagogical practices orchestrated by their teachers. Our focus in Chap. 5 was on the organizational features and nature of the activities associated with the pedagogical practices reported in the SITES-M2 case studies. Pedagogical practices – often referred to as "methods of teaching" – encompass the full sets of teaching activities a teacher engages in when supporting student learning. Within our ecological metaphor, we can equate the butterfly with these highly complex activities.

Close consideration of the most prominent teaching and learning activities described in the case studies allowed us to identify six major means (formats) of organizing these various pedagogical practices. These were expository lessons, virtual schools or online courses, task-based learning, scientific investigations, media productions, and projects. Because the nature of the teaching and learning activities differed across these pedagogical practices, the kinds of ICT tools commonly used in them also differed. More importantly, it was evident to us that different types of pedagogical practice were associated with different mean levels of students' and teacher's role scores, indicating that different types of practice were more likely to mediate different teacher- and student- related role clusters.

By again referring to the ecological metaphor, we can note that different varieties of the butterfly (pedagogical practice) feeding on different varieties of plants (teacher's roles) are more able to pollinate different flowers (student's roles), and thereby fulfill a critical process for fruiting. The more innovative pedagogical practices (scientific investigations, media productions, and projects) were thus the ones most likely to be adopted by teachers playing more innovative roles, such as guiding collaborative inquiry. These roles, as emerging varieties of the keystone species, needed in turn particular nutrients (competences) in order to prosper.

In support of this claim, the analyses that we reported in Chap. 5 showed that the more innovative teachers' roles and pedagogical practices required new competences not found in traditional teacher roles and pedagogical practices. Mishra and Koehler (2006) suggest that teachers need four types of teacher knowledge additional to the three types of teacher knowledge originally proposed by Shulman (1986) – pedagogical knowledge (PK), content knowledge (CK), and pedagogical-content knowledge (PCK). The four additional types that Mishra and Koehler include in their framework are technological knowledge (TK), technological-content knowledge (TCK), technological-pedagogical knowledge (TPK), and technological-pedagogical-content knowledge (TPCK).

When we used this expanded framework to analyze the types of teacher knowledge required by the different types of pedagogical practice evident in the case studies, we found that practices involving significant changes in teachers' and students' roles were more demanding on teachers' mastery of new knowledge beyond the technological. In the case of collaborative inquiry projects involving exploration of authentic, real-life problems, such as HIV/AIDS, teachers needed to have mastered the knowledge and skills related to the four technology-related areas. But because these practices involved new content and new pedagogy, teachers also needed to have strong mastery of the three non-technology-related forms of knowledge.

This finding helps explain why teachers' and students' roles had remained somewhat traditional in the innovations involving virtual schools and online courses. For teachers, the significant effort spent acquiring the technology-related competency required to plan, organize, and conduct these courses tended to leave them with little capacity for undertaking additional learning in the other domains. Media productions, however, by their nature, encourage students to take on the more active role needed to create useful products. It was evident to us that teachers only needed to master the new TK and the TCK to implement this type of pedagogical practice in order to allow their students to take on innovative roles. In a few instances, when the students' productions needed to be digitized, other professionals in the school, such as an ICT coordinator, took on this assistance, which meant that the teachers did not even have to master the technology-related knowledge in order for their students to benefit from the use of the new media.

These findings are consistent with a complexity model of educational change, which posits that pedagogical practice differing markedly from the predominant practice requires teachers to acquire so many new kinds of knowledge (nutrients) that the practice is not only rare but also difficult to sustain. Teachers thus need to acquire the new learning if they are to move into more innovative roles (become a new keystone variety). An important implication of all this is that learning is the basic means of facilitating co-evolution of the various elements in the classroom ecology.

Characteristics of Innovation Schools and Level of Innovativeness at the Classroom Level

Classrooms are embedded inside schools. Schools, in turn, are embedded in larger, contextual units such as school districts all the way through to entire education systems. The ecological analogy is that of groups of co-located plants nested within gardens, and gardens nested within larger localities and geographical and climatic regions. The important problem of how best to foster, sustain, and scale up ICT-supported pedagogical innovations cannot be addressed without consideration of the complex interactions of the focal ecological elements (pedagogical practice, the roles of the teacher, and the roles of students) with other factors within a particular ecological environment. We began Chap. 6 with an environmental scan of the 82 schools that, taken together, featured the 83 pedagogical practices analyzed in Chaps. 3–5. We systematically coded the school-level descriptions in these case reports against 64 school-level contextual factors. One-way ANOVA exploration of the interactions between the school-level factors and the case innovation scores revealed the following factors at school, community, and system levels as positive predictors of innovativeness:

- The school's vision and goals include any of the following – promotion of lifelong learning, promotion of active learning, development of positive values, using ICT as a tool to empower students' learning
- Experience, within the school, of carrying out ICT innovations
- A collaborative work culture within the school
- The principal as an initiator and/or supporter of the innovation
- The school providing staff and students with access to the internet and technical support, and/or providing students with access to ICT beyond scheduled class time
- Government education policies, including ICT-specific directions
- Local community involved as a collaborator/partner in the innovation

These findings are consistent with the literature on school change, which identifies school vision, principal leadership, school culture (including innovation experience), government policy, and community support as important factors contributing to and supporting the emergence of ICT-supported pedagogical practices.

ICT-specific infrastructure and technical support are likewise often identified in the literature as factors crucial to the success of ICT integration. However, our analysis revealed one very surprising finding. This was that government provision of ICT infrastructure to schools acted as a significant negative predictor of the level of innovativeness of the case studies analyzed. This is an intriguing finding because access to ICT infrastructure has long been considered an important positive condition for ICT-supported innovation. This finding, moreover, illustrates well the complex interaction among the different environmental conditions in the education ecology. We suspect that the reason behind this finding may be that while the presence of this type of government policy probably encourages schools to adopt ICT, that adoption takes place in the absence of an understanding of the pedagogical implications of use of these tools, let alone an encompassing school-wide/educational vision of the outcomes of that adoption.

Organizational Learning and Pedagogical Innovations

As we reported in Chap. 5, pedagogical practices that are relatively innovative in nature demand a range of knowledge and skills far beyond those needed to use ICT. Our comparison of the levels of innovativeness of sustained SITES-M2 cases and not-yet-sustained cases showed a significantly lower mean level of innovativeness for the former cases than the latter (see Chap. 8). But the relationship between sustainability and innovativeness of the cases is not as simple as this finding might suggest. The close examination of the organizational learning associated with pedagogical innovations in four schools with very different innovation profiles that we reported in Chap. 7 sheds light on how the different kinds of learning and learning architecture available in each case influenced the interactions among different elements in the school ecology and hence the different resultant change trajectories.

In all four innovations, including the case in which the roles of both teacher and students remained traditional, the teachers experienced double-loop learning, involving changes in assumptions and values. Although the depth of that learning differed across the four cases, its presence was essential in ensuring the innovations took place. But implementation is one thing, sustainability is another. Emergent new practices, even the least innovative, are fragile and unlikely to survive unless deeper and more pervasive organizational learning beyond that needed to initiate and develop the innovation takes place. Sustainable innovation requires longer-term, institution-wide changes in human resource capacity and in organizational practices, such that the resulting organizational ecology becomes a "habitat" able to nurture the emergent innovation.

These findings again point to the complexity of educational change and the importance of establishing an architecture for learning that supports and sustains emerging innovative practices. The functions of this type of learning architecture are to enhance interaction, promote understanding and sharing of ideas, support learning, and establish new curriculum objectives, assessment methodology, and human and administrative infrastructure. In short, the learning architecture has to be designed in a manner that allows it to bring about adaptive evolution of the school ecology compatible with the needs of the innovation and thus its sustainability.

Sustaining and Scaling Pedagogical Innovations

Although we identified only 18 of the 83 cases analyzed as not sustained, we could find no clear pattern of sustainability/non-sustainability across the participating countries. For example, all of the Finnish cases had been sustained for over a year while most of the Hong Kong cases had yet to be sustained beyond a year. In-depth examination of the cases from these two countries revealed that this difference was not simply due to differences in the schools' history of ICT adoption.

Law, Kankaanranta, and Chow (2005) found several major additional differences between these two systems. First, ICT played the core role in providing a scaffold able to build up connectedness in the Finnish cases to a point where ICT had become an integral part of the architecture for learning. In the Hong Kong cases, ICT was being used mainly as a learning and productivity tool. Second, all of the Finnish cases found collaborators outside the school and established networks for technological, learning resources, and/or expertise (subject matter and pedagogical) support for the innovations. Not only was the burden of innovation on the initiators considerably lessened but the technological and socio-institutional infrastructure needed to support sustainability and transferability was constructed as an integral part of the innovation at its very beginning. In all but one of the nine Hong Kong cases analyzed, the innovation teachers had to build the requisite infrastructure and teacher competence by themselves.

Analyses of the SITES-M2 case studies further revealed that the challenges to sustaining change and institutionalizing innovations were no different whether the change was bottom–up or top–down. In order to be sustained, each case must be able to develop three "stories" (Fullan, 2000), running in parallel and occurring irrespective of where the person initiating the change sits within the organization's hierarchy. There must be an "*inside story*," that is, a shared focus on improving student learning. This story is the one that drives changes in pedagogical practice and the formation of a professional learning community within the school. Changes in pedagogical practice lead to a reculturing process; the professional learning community impels the restructuring needed to facilitate change within the school. But even then, these changes are difficult to sustain unless changes in policies and practices and structural alignment outside of the school takes place. This consideration explains the need for the two other stories – the *inside–out* story, in which a school is actively connected to the outside, and the *outside–in* story, in which the school seeks institutionalized support available through external infrastructures. It is only when these three facets of innovation development act in collaboration that the innovation is both challenged and sustained by an external infrastructure.

One popular, systematic approach to scaling up reforms is to follow, once a good working prototype has been established, a stepwise model of replication. Taylor, Nelson, and Adelman (1999) proposed a four-phase model to scale up reform prototypes: creating readiness, initial implementation, institutionalization, and ongoing evolution. We could find, in the SITES-M2 cases, no instances of innovations that had gone through a clearly staged development from prototype to scaling up. In fact, the individuals involved with the practices that had led to significant role changes for teachers and students and that had scaled up without loss of the core pedagogical innovativeness had built in scalability right from the start of the innovation. Our comparison of the occurrence of transfer in the Hong Kong and Finnish SITES-M2 case studies also revealed that having in place structures and mechanisms designed to support the initiation of an innovation in multiple schools favored transferablity through the strong supportive networks created. Certainly, the technological and socio-institutional infrastructures that the Finnish schools built in at the earliest stage of their innovations contributed importantly to their sustainability and transferability.

The analyses presented in this book accordingly indicate that stage-based models of change are an inadequate means on which to base achievement of sustainable educational reform goals. Classrooms and schools are complex systems, hierarchically nested within regional and national education systems. A high degree of interconnectedness, involving interaction and feedback within and across these components, is therefore needed to ensure that changes instigated in one part of the system will propagate to the other parts. We consider that architectures for learning in the form of purposefully established ICT-enhanced professional networks are those most conducive to sustaining and scaling up innovations. The reason why is that they facilitate the reculturing and restructuring processes that need to evolve dynamically and simultaneously at different levels of the education system.

Research into Practice: Ecologically Inspired Case-Study-Based Professional Development for Innovation

Case studies of innovations are typically used in professional development in education as models of exemplary practices that can be replicated in different educational settings. Critical conditions for success are identified and strategies for implementation seek to establish the prerequisite conditions for success. The approach inherent in these prevalent models of change, underpinned as they are by a staged model of sustainability and transfer, is analogous to "farming." Superior strains of a species are selected and the best conditions for their growth identified. The best strains are then planted in as many farms as possible to produce a high yield of the best crops. However, inspired by our findings from the analyses of the SITES-M2 case studies, we have elected to offer a different approach to the use of case studies. A farming model of change may seem efficient, yet it may not be feasible because of the ecological context of the innovation. If the social, economic, cultural, and/or technological contexts of the innovation are too different from those of the target site, the cost of replication may be too high, too difficult to sustain, or both. Our different way of understanding and making use of innovations emphasizes their emergent nature and ecological context.

An ecological model of professional development for change and innovation emphasizes the need to understand innovations as a process of emergence that is intimately linked to multiple levels of context beyond the classroom. Under this model, sustainability and transfer are achieved only through the establishment of an architecture for learning that involves the multiple levels of stakeholders connected with the site of innovation. In addition, adoption of an innovation as replication is not possible with respect to this model; any successful and sustainable adoption of innovation has to be an innovation in itself. Learning that incorporates reflection *on* and *through* practice is key to the process of successful change because it facilitates self-organized alignment across the nested levels of the education system, interconnected with the many sectors of the wider community. Hence, instead of packaging selected case studies as exemplars to model upon, we developed and drew on a database of reports and analyses relating to 130 case studies from the 174 collected during SITES-M2. Throughout this process, we used the metaphor of sustainable gardening to guide and make sense of our work. Both database and analogy are designed to emphasize not only the complexity of introducing innovation into a site of practice but also the need to examine and understand the interactions among various factors. Only then, can one truly appreciate the challenges of sustaining and transferring an innovation.

Our thinking in this respect was evident in Chap. 9, where we described a number of professional development activities based on use of the SITES-M2 case studies database. These activities were designed to promote discussion and reflection, while the case studies provided participants with reference points for their own experiences. For example, the participants found that comparing, along the six dimensions of innovation, the ICT-support practices that they themselves had experienced with the practices in the case studies engendered considerable debate and discussion on the nature of pedagogical innovations. This work also made clear to them the relative importance of the dimensions and their relationships, methods of identifying innovations, and the role of innovations in institutional and individual development. This type of activity also stimulates reflection on the need for innovations to be evolving if they are to remain innovative and to be successful in terms of impact on the institution and beyond. Reflection, in turn, heightens participants' awareness of the importance of e-leadership and its multilevel nature.

We also described, in Chap. 9, the benefits, for teachers engaging in a professional development workshop, of comparing different case studies belonging to the same type of pedagogical practice. This work helped participants realize that the activity per se does not determine the nature and quality of students' learning experience and the importance of the teachers' role with respect to pedagogical practice. It also enabled them to identify some of the organizational features conducive to helping students develop twenty-first-century skills, such as the relative advantage of multidisciplinary authentic-inquiry projects over multiple single-subject, curriculum-bound projects. It became evident to us that investigations such as these also help teachers develop a better understanding of the relationship between types of pedagogical practice and the roles teachers play. Another useful activity is to ask groups of participants to compare, for two selected case studies, the visions of the respective schools and whether they can detect a clear link between the vision and the pedagogical innovation. We found this activity was particularly useful in prompting the workshop participants to realize the role and importance of a clear educational vision when developing a plan to integrate ICT-supported pedagogy in their schools.

Using the SITES-M2 Case Studies to Build Professional Development Networks for Innovation and E-Leadership

While individual professional development activities may stimulate innovation and change, their real impact is only realized when ensuing initiatives or innovation ideas are taken *beyond* the single classroom to support more sustainable and transferable practices. An important principle in sustainable gardening is that any planting or plans to make changes in the garden must take into account the totality of the garden and its environment and settings. Educational innovations are more likely to be sustained and transferred if professional development activities are organized in conjunction with the provision of an architecture for learning. Essentially, what is needed to garner stakeholder support for the innovation and ensuing reform process is broader, more systemic communication and networking. In Chap. 10, we described three professional-development networks designed as architectures for learning that used the SITES-M2 database-related activities described in Chap. 9. All three projects focused on building leadership capacity within connected and/or nested communities at different levels of the education system.

The first project explored in Chap. 10 was a project funded by the APEC Education Foundation (AEC) called Bridging the Digital Divide through e-Educational Leadership in ICT. This international project, which was facilitated by a team from the Centre for IT in Education (CITE) at the University of Hong Kong, was designed to help scale up sustainable reform and change through multilevel ICT-development networks established by educational leaders from more than ten APEC economies. The CITE team organized two regional workshops for participants working at different levels of the education systems within these countries. These people included national and regional education policy-makers, inspectors, non-government organizations, teachers, principals, teacher educators, and researchers.

The workshop activities examined issues relating to the role ICT plays in supporting the achievement of educational goals at different levels of the education system. The activities also enabled participants to focus on e-leadership development policy and strategies. The various activities were organized around examination of the SITES-M2 innovative practices. Participants found that access to case studies from very diverse cultural, economic, and political contexts was a valuable experience with respect to fostering mutual understanding and collaboration across the countries represented at the workshops. Participants also rated the practice of working in different cross-role, within-country, and cross-country teams to examine different problems related to ICT integration in education another very helpful feature of the workshops. A team that included a government official and an inspector along with a principal, a teacher, and other stakeholders was considered good for consideration of a country-level policy, while a group composed of the same or similar roles and responsibilities was deemed good for development of specific strategic measures.

The project helped participants understand the nested nature of classrooms in schools and school districts through to entire education systems. It also enabled connections within and across the education systems represented both during and after the workshops. These connections not only stimulated and helped sustain countries' efforts to build capacity for multilevel leadership after the workshops but also fostered the development of multilevel, multi-country collaborative activities for human-capacity development in the APEC region. We note, however, that the many regional collaborative projects to support transformative uses of ICT education launched in the APEC region after completion of the project mainly occurred because of persistent support for this type of strategic development from AEF and the regional governments. This CITE-led APEC e-leadership project was able to make an impact because of the suitable ecological conditions existing at the time. The project, in turn, helped further enhance the ecological conditions conducive to regional collaboration in e-leadership.

The Good Practices for IT in Education project in Hong Kong focused on identifying and writing up case studies of good practices in ICT integration across the curriculum at the classroom level. The SITES-M2 case studies database website described in Chap. 9 provided the conceptual framework for identifying cases and collecting relevant data. The database also provided sample case reports for comparison and discussion purposes. The main objectives of this work were to stimulate teacher exchange of cases and to facilitate the formation of networked innovation communities of teachers and schools sharing similar pedagogical goals at the classroom level.

The Good Practices website was thus conceptualized and co-constructed with the central involvement of the teachers, who both developed the cases and used them to stimulate debate about good practices. The task of identifying, constructing, and then uploading the case studies onto the website led, as hoped, to the formation of several successful communities, such as networks relating to mobile learning and ICT-supported English language learning. Unfortunately, the impact of this project was limited by the understanding of the funders, who focused on quantitative accountability, that is, the number of innovative cases the teachers seconded to the project collated, rather than on the initially less tangible but more significant long-term outcome of establishing a small number of cohesive innovation communities. This system-level obstacle is one example of the kind of ecological challenges that stakeholders face when endeavoring to implement an ecological (gardening) model of change.

The eLeadership Stories project, an initiative that built on an e-leadership course in Hong Kong, used the SITES-M2 case studies database as an important resource to stimulate discussion about ICT-supported innovations and the importance of vision building and multilevel leadership. The aim of this project was to build a network of innovating schools by providing different groups of personnel in the network with multilevel professional development opportunities. These people included principals, teachers, and technology coordinators, each of whom was asked to address identified common learning needs. The level of success in regard to these aims differed considerably among the ten or so schools that participated in this project. In schools where the principals were committed to a clearly articulated educational vision and saw ICT use and the support from this project as advantageous leverages for achieving that vision, there was clear progress and achievement within the 1-year project duration. The networking support that the project accorded to parties within and outside of it also helped the schools work successfully toward their goal. However, even with this support, goals were still unlikely to be achieved unless the work (the reform process) was orchestrated and leveraged by the principal.

The hope that the schools in this project would form a close collaborative network beyond the 1-year mark did not materialize. It seems that forming a network of schools in the Hong Kong context is even more difficult than forming networks of teachers. One possible explanation is the long history of professional teacher associations in Hong Kong. These play important roles in in-service professional development of teachers in specific subject areas, but they lack models of how schools can network and collaborate to achieve specific educational goals. In fact, because of the threat of inadequate enrolment posed by falling birthrates, schools in Hong Kong tended to be in competitive rather than collaborative relationships at the time of the e-Leadership Stories project.

Summary and Reflections

The studies reported in this book were inspired by two important ideas:

- Effective use of ICT to support pedagogical innovations plays a disruptive role that brings transformative changes to teaching and learning in the classroom.
- Pedagogical innovations as emergent phenomena are both deeply influenced by and influence the contextual environment in which they are situated.

The SITES-M2 case studies, collected by researchers in 28 education systems from five continents with diverse social, economic, cultural, and political backgrounds, followed the same set of selection criteria and a common methodology for data collection and writing up the reports. These case reports provided a rich resource well suited to our ecologically-inspired investigations.

The diversity and range of innovation profiles identified in the analyzed cases and the relatively lower sustainability of the more innovative cases provide empirical evidence for the appropriateness of adopting an ecological model when studying pedagogical innovations. This is because pedagogical innovations are organically connected to the contextual environments within which the innovations emerge. We do not, however, support a staged model of change. Our findings relating to the sustainability and transfer of innovations strongly favor an ecological model that positions change as a continuing process instituted right at the very beginning of an innovation.

Sustaining innovations requires changing the educational environment at the school level and beyond. We consider, on the basis of our findings, that learning within and across all levels of the school and the wider education system (i.e., organizational learning) is the key mechanism for changing the educational ecology to align with the needs of pedagogical innovations. Cases where architectures for learning within and beyond the school context were established right at the initiation stage of an innovation provided remarkable success stories in terms of sustainability and transfer. These architectures for learning provided a mechanism through which both the innovations and their environments co-evolved interactively, removing the sustainability hurdle evident in staged models of innovation and change.

Our model of presenting and using innovation-based case studies for professional development and change highlights the ecological nature of innovations. Rather than advising educational stakeholders to model practice on exemplars of innovation, we urge them to analyze and interpret each innovation in context – to examine the interaction and interdependence of the characteristics of each with its environmental conditions. For the educationalists participating in our trials of ecologically-oriented professional development uses of the SITES-M2 case studies, the cases not only stimulated discussion of these but also encouraged reflection on their own experience and organizational context. This process left participants feeling better equipped to identify a pathway of change and innovation that would build on the existing strength and innovation history of their own work contexts.

An ecological model of leadership for sustainable change and innovation has to engage multilevel leadership involvement at different levels of the education system. We were fortunate to have the opportunity to stimulate and support technology-enhanced educational innovations through three projects that employed, as the catalyst resource, case-based professional and e-leadership development activities. One of these projects focused on building teacher networks around commonly shared professional and innovation interests. The other two projects, one local and the other international, sought to build multilevel networks of learning to foster e-leadership at school and system levels. While the SITES-M2 case studies database served as valuable resources in all three projects and had varying successes in stimulating collaboration and innovation among the project participants, only one (the international project) was successful in fostering the establishment of *sustained* networks of learning and innovation.

When reflecting on our experience in these projects, we realized that although building professional and e-leadership development networks as architectures for learning is consistent with an ecological approach to innovation and change, the different ecological conditions created by policy, cultural, and other contextual conditions can support or impede these efforts. Positive experience of networking and collaborating with other institutions and/or sectors of the education system needs to be nurtured. And an organization's or system's history of networking needs to be take into account during work directed at developing policies or strategies for any type of educational innovation, including those supported by technology. We hope the theoretical framework and studies reported in this book will contribute to continuing efforts worldwide to leverage the potential of ICT to transform education to align with the needs of the twenty-first century. We also hope our work will stimulate further studies that will enrich our understanding of educational change and innovation.

References

Adelman, C., Jenkins, D., & Kemmis, S. (Eds.). (1983). *Rethinking case study: Notes from the Second Cambridge Conference*. Melbourne: Deakin University Press.
Adelman, H. S., & Taylor, L. (2003). On sustainability of project innovations as systemic change. *Journal of Educational and Psychological Consultation, 14*(1), 1–25.
Alexander, R. J. (2000). *Culture and pedagogy: International comparisons in primary education*. Oxford: Blackwell.
Anderson, G. L. (1998). Toward authentic participation: Deconstructing the discourses of participatory reform in education. *American Educational Research Journal, 35*(4), 571–603.
Anderson, R. E., & Plomp, T. (2008). National contexts. In N. Law, W. J. Pelgrum, & T. Plomp (Eds.), *Pedagogy and ICT use in schools around the world: Findings from the IEA SITES 2006 study* (pp. 37–66). Hong Kong: CERC and Springer.
APEC Education Foundation. (2009). *White paper on APEC Education Foundation 1997–2008*. Seoul, Korea: APEC Education Foundation.
Applegate, L. M., McFarlan, F. W., & McKenney, J. L. (1999). *Corporate information systems management*. Irwin: McGraw-Hill.
Argyris, C., & Schön, D. A. (1978). *Organizational learning: A theory of action perspective*. Reading: Addison-Wesley.
Atkin, J. M. (1998). The OECD study of innovation in science, mathematics, and technology education. *Journal of Curriculum Studies, 30*(6), 647–660.
Banathy, B. H. (1991). *Systems design of education: A journey to create the future*. Englewood Cliffs: Educational Technology Publications.
Banathy, B. H. (1994). Designing educational systems: Creating our future in a changing world. In C. M. Reigeluth & R. J. Garfinkle (Eds.), *Systemic change in education* (pp. 27–34). Englewood Cliffs: Educational Technology Publications.
Banathy, B. H., & Jenlink, P. M. (2004). Systems inquiry and its application in education. In D. H. Jonassen (Ed.), *Handbook of research on educational communications and technology* (2nd ed., pp. 37–57). Mahwah: Lawrence Erlbaum.
Barnett, H. (1953). *Innovation*. New York: McGraw-Hill.
Bar-Yam, Y. (2002). Complexity rising: From human beings to human civilization, a complexity profile. In *Encyclopedia of Life Support Systems (EOLSS)*. Oxford, UK: UNESCO, EOLSS.
Bates, A. W. (2000). *Managing technological change: Strategies for college and university leaders*. San Francisco: Jossey-Bass.
Bennett, C. K. (1996). Schools, technology, and educational leadership: A framework for change. *NASSP Bulletin, 80*(577), 57–65.
Black, H. C. (1979). *Case law: Black's law dictionary* (5th ed.). St Paul: West Publishing.
Black, P., & Atkin, J. M. (Eds.). (1996). *Changing the subject: Innovations in science, mathematics and technology education*. London: Routledge and OECD.

N. Law et al., *Educational Innovations Beyond Technology: Nurturing Leadership and Establishing Learning Organizations*, DOI 10.1007/978-0-387-71148-5,

Blumenfeld, P., Fishman, B. J., Krajcik, J., Marx, R. W., & Soloway, E. (2000). Creating usable innovations in systemic reform: Scaling up technology-embedded project-based science in urban schools. *Educational Psychologist, 35*(3), 149–164.
Bransford, J., Slowinski, M., Vye, N., & Mosborg, S. (2008). The learning sciences, technology and designs for educational systems: Some thoughts about change. In J. Visser & M. Visser-Valfrey (Eds.), *Learners in a changing learning landscape: Reflections from a dialogue on new roles and expectations* (pp. 37–67). London: Springer.
Cash, J. I., & McLeod, P. L. (1985). Managing the introduction of information systems technology in strategically dependent companies. *Journal of Management Information Systems, 1*(4), 5–23.
Christensen, C. M. (1997). *The innovator's dilemma: When new technologies cause great firms to fail*. Boston: Harvard Business Press.
Christensen, C. M., & Raynor, M. E. (2003). *The innovator's dilemma: When new technologies cause great firms to fail*. Boston: Harvard Business School Press.
Collins, A., & Halverson, R. (2009). *Rethinking education in the age of technology: The digital revolution and schooling in America*. New York: Teachers College Press.
Crainer, S. (1998). *Key management ideas* (3rd ed.). London: Prentice Hall.
Cuban, L. (2001). *Oversold and underused: Computers in the classroom*. Cambridge: Harvard University Press.
Davis, N. (2008). How may teacher learning be promoted for educational renewal with IT? In J. M. Voogt & G. Knezek (Eds.), *International handbook of information technology in primary and secondary education*. New York: Springer.
Department of Education, Queensland (1995a). *Guidelines for the Use of Computers in Learning*. Queensland: Publishing Services for Studies Directorate.
Department of Education, Queensland (1995b). *Computers in Learning – Policy*. Queensland: Publishing Services for Studies Directorate.
Department for Education and Skills (DfES). (2003). *Building schools for the future: Consultation on a new approach to capital investment*. Retrieved from www.teachernet.gov.uk/_doc/3611/Building%20schools%20for%20the%20future.pdf
Dill, D. D., & Friedman, C. P. (1979). An analysis of frameworks for innovation and change in higher education. *Review of Educational Research, 49*(3), 411–435.
Drucker, P. (1994). *Post-capitalist society*. New York: HarperCollins.
Edwards, P., Fox, R., & Phillips, R. (1997). Microbiology project case study. In R. Phillips (Ed.), *The developer's handbook to interactive multimedia* (pp. 157–175). London: Kogan Page.
Elmore, R. (2004). *School reform from the inside out: Policy, practice, and performance*. Boston: Harvard Education Press.
Ely, D. P. (1990). Conditions that facilitate the implementation of educational technology innovations. *Journal of Research on Computing in Education, 23*(2), 298–305.
EMB (Education and Manpower Bureau HKSAR). (1998). *Information technology for learning in a new era: Five-year strategy 1998/99 to 2002/03*. Hong Kong. Retrieved from http://www.edb.gov.hk/FileManager/EN/Content_2309/five%20year%20strategy%2099%20to%2003.zip
EMB (Education and Manpower Bureau HKSAR). (2001). *Learning to learn: The way forward in curriculum*. Retrieved from http://www.edb.gov.hk/index. aspx?langno=1&nodeID=2877
EMB (Education and Manpower Bureau HKSAR). (2004). *Empowering learning and teaching with information technology*. Retrieved from http://www.edb.gov.hk/ index. aspx?langno=1&nodeID=2497
Engeström, Y. (2005). Toward overcoming the encapsulation of school learning. In H. Daniels (Ed.), *An introduction to Vygotsky* (2nd ed., pp. 157–176). Hove: Routledge.
Erstad, O. (2008). Changing assessment practices and the role of IT. In J. M. Voogt & G. A. Knezek (Eds.), *International handbook of information technology in primary and secondary education* (pp. 181–194). New York: Springer.
European Round Table of Industrialists. (1997). *Investing in knowledge: The integration of technology in European education*. Brussels: European Round Table of Industrialists.
Evans, P. (1995). Hathaway on CD: An interactive multimedia case study of a school. Retrieved from http://www.ascilite.org.au/conferences/melbourne95/smtu/papers/evans.pdf

Fenstermacher, G. D., & Soltis, J. F. (2004). *Approaches to teaching* (4th ed.). New York: Teachers College Press.

Fiol, C. M., & Lyles, A. L. (1985). Organizational learning. *The Academy of Management Review, 10*(4), 803–813.

Fishman, B., Marx, R. W., Blumenfeld, P., Krajcik, J., & Soloway, E. (2004). Creating a framework for research on systemic technology innovations. *Journal of the Learning Sciences, 13*(1), 43–76.

Flanagan, L., & Jacobsen, M. (2003). Technology leadership for the twenty-first century principal. *Journal of Educational Administration, 41*(2), 124–142.

Fullan, M. (1992). *Successful school improvement: The implementation perspective and beyond*. London: Open University Press.

Fullan, M. (1993). *Change forces: Probing the depth of educational reform*. London: Falmer.

Fullan, M. (1999). *Change forces: The sequel*. London: Falmer.

Fullan, M. (2000). The three stories of education reform. *Phi Delta Kappan, 81*(8), 581–584.

Fullan, M. (2001). *Leading in a culture of change*. San Francisco: Jossey-Bass.

Fullan, M. (2005). *Leadership and sustainability*. Thousand Oaks: Corwin.

Fullan, M. (2007). *The new meaning of educational change* (4th ed.). New York: Teachers College Press.

Fullan, M., Cuttress, C., & Kilcher, A. (2005). Forces for leaders of change. *Journal of Staff Development, 26*(4), 54–58.

Fullan, M., Hill, P., & Crévola, C. (2006). *Breakthrough*. Toronto: Ontario Principals' Council.

Gagné, R. M. (1965). *The conditions of learning*. New York: Holt, Rinehart & Winston.

Goodman, J. (1994). External change agents and grassroots school reform: Reflections from the field. *Journal of Curriculum and Supervision, 9*(2), 113–135.

Graetz, F. (2000). Strategic change leadership. *Management Decision, 38*(8), 550–562.

Gregorio, L. C., & Byron, I. (2001). *Capacity-building for curriculum specialists in East and South-east Asia: Final report of the training seminar*. Bangkok: Thai Ministry of Education.

Gronn, P. (2002). Distributed leadership. In K. Leithwood, P. Hallinger, K. Seashore-Louis, G. Furman-Brown, P. Gronn, W. Mulford, & K. Riley (Eds.), *Second international handbook of educational leadership and administration* (pp. 697–734). Dordrecht: Kluwer.

Hallinger, P., & Heck, R. H. (1988). Exploring the principal's contribution to school effectiveness: 1980–1995. *School Effectiveness and School Improvement, 9*(2), 157–191.

Halverson, R., & Collins, A. (2006). Information technologies and the future of schooling in the United States. *Research and Practice in Technology Enhanced Learning, 1*(2), 145–156.

Hannan, A., English, S., & Silver, H. (1999). Why innovate? Some preliminary findings from a research project on "Innovations in teaching and learning in higher education. *Studies in Higher Education, 24*(3), 279–289.

Hargreaves, A. (2003). *Teaching in the knowledge society: Education in the age of insecurity*. Philadelphia: Open University Press.

Hargreaves, A., & Fink, D. (2004). Seven principles of sustainable leadership. *Educational Leadership, 61*(7), 8–13.

Hargreaves, A., & Giles, C. (2003). The knowledge society school: An endangered entity. In A. Hargreaves (Ed.), *Teaching in the knowledge society: Education in the age of insecurity* (pp. 98–124). Philadelphia: Open University Press.

Hargreaves, A., & Goodson, I. (2006). Educational change over time? The sustainability and nonsustainability of three decades of secondary school change and continuity. *Educational Administration Quarterly, 42*(1), 3.

Harris, A., & Chapman, C. (2002). *Democratic leadership for school improvement in challenging contexts.* Paper presented at the the International Congress on School Effectiveness and Improvement, Copenhagen, Denmark.

Hendricks-Lee, M. S., Soled, S. W., & Yinger, R. J. (1995). Focus on research sustaining reform through teacher learning. *Language Arts, 72*(4), 288–292.

Herried, C. F. (2004). The case study: Can case studies be used to teach critical thinking? *Journal of College Science Teaching, 33*(6), 12–15.

Hiebert, J., Gallimore, R., Garnier, H., Givvin, K. B., Hollingsworth, H., & Jacobs, J., et al. (2003). *Teaching mathematics in seven countries: Results from the TIMSS 1999 video study* (No. NCES 2003-013). Washington, DC: National Center for Education Statistics.

Hill, P., & Crévola, C. (2003). Organizational learning. In B. Davis & J. West-Burnham (Eds.), *Handbook of educational leadership and management* (pp. 394–403). London: Pearson Education.

Hopkins, D. (2001). *School improvement for real*. London: RoutledgeFalmer.

Hopkins, D., & Levin, B. (2000). Government policy and school development. *School Leadership and Management, 20*(1), 15–30.

Hutchins, C. L. (1994). State systems of education and systemic change. In C. M. Reigeluth & R. J. Garfinkle (Eds.), *Systemic change in education* (pp. 15–25). Englewood Cliffs: Educational Technology Publications.

International Society for Technology in Education (ISTE). (1998). *National educational technology standards for students*. Eugene: International Society for Technology in Education.

International Society for Technology in Education (ISTE). (2007). *National educational technology standards for students* (2nd ed.). Eugene: International Society for Technology in Education.

Istance, D. (2008). *Directions for schooling and educational innovation from recent OECD analyses*. Paper presented at the Slovenian Presidency Conference on Promoting Innovation and Creativity: Schools' Response to the Challenges of Future Societies, Brdo, Slovenia, 8–10 April. Retrieved from http://www.mss.gov.si/en/zakonodaja_in_dokumenti/events/conference_promoting_innovation_and_creativity/

Jackson, B., & Kelley, C. (2002). Exceptional and innovative programs in educational leadership. *Educational Administration Quarterly, 38*(2), 192.

James, C., & Connolly, U. (2000). *Effective change in schools*. London: RoutledgeFalmer.

Johnston, C., & Caldwell, B. (2001). Leadership and organisational learning in the quest for world class schools. *The International Journal of Educational Management, 15*(2), 94–101.

Joyce, B., & Weil, M. (2000). *Models of teaching* (6th ed.). Boston: Allyn and Bacon.

Karsten, S., Voncken, E., & Voorthuis, M. (2000). Dutch primary schools and concept of the learning organization. *The Learning Organization, 7*(3), 145–155.

Kearsley, G., & Lynch, W. (1992). Educational leadership in the age of technology: The new skills. *Journal of Research on Computing in Education, 25*(1), 50–60.

Kezar, A. J. (2001). *Understanding and facilitating organizational change in the 21st century: Recent research and conceptualizations*. San Francisco: Jossey-Bass.

King, N., & Anderson, N. (1995). *Innovation and change in organizations*. New York: Routledge.

Koehler, M. J., & Mishra, P. (2005). What happens when teachers design educational technology? The development of technological pedagogical content knowledge. *Journal of Educational Computer Research, 32*(2), 131–152.

Kozma, R. (Ed.). (2003). *Technology, innovation, and educational change: A global perspective*. Eugene: International Society for Technology in Education.

Kozma, R. (2005). *ICT, education reform, and economic growth: A white paper*. San Francisco, CA: Intel Corporation. Retrieved from http://download.intel.com/education/wsis/ICT_Education_Reform_Economic_Growth.pdf

Kozma, R. (2008). *ICT, education reform, and economic growth: A conceptual framework*. San Francisco, CA: Intel Corporation. http://download.intel.com/education/EvidenceOfImpact/Kozma_ICT_Framework.pdf

Kramer, R. (2007). Leading change through action learning. *Public Manager, 36*(3), 38–44.

Larsson, P., Löwstedt, J., & Shani, A. B. (2001). IT and the learning organization: Exploring the myths of change. *Organizational Development Journal, 19*(1), 73–91.

Laudon, K. C., & Laudon, J. P. (1998). *Management information systems: New approaches to organization and technology*. Upper Saddle River: Prentice Hall.

Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. Cambridge: Cambridge University Press.

Law, N. (2003). Innovative classroom practices and the teacher of the future. In C. Dowling & K. W. Lai (Eds.), *Information and communication technology and the teacher of the future* (pp. 171–182). Dordrecht: Kluwer Academic.

Law, N. (2004). Teachers and teaching innovations in a connected world. In A. Brown & N. Davis (Eds.), *Digital technology, communities and education* (pp. 145–163). London: RoutledgeFalmer.

Law, N. (2008). Technology-supported pedagogical innovations: The challenge of sustainability and transferability in the information age. In C. H. Ng & P. Renshaw (Eds.), *Reforming learning: Issues, concepts and practices in the Asia-Pacific region* (pp. 319–344). Dordrecht: Springer.

Law, N., & Chow, A. (2008a). Teacher characteristics, contextual factors, and how these affect the pedagogical use of ICT. In N. Law, W. J. Pelgrum, & T. Plomp (Eds.), *Pedagogy and ICT use in schools around the world: Findings from the IEA SITES 2006 study* (pp. 181–219). Hong Kong: CERC and Springer.

Law, N., & Chow, A. (2008b). Pedagogical orientations in mathematics and science and the use of ICT. In N. Law, W. J. Pelgrum, & T. Plomp (Eds.), *Pedagogy and ICT use in schools around the world: Findings from the IEA SITES 2006 study* (pp. 121–179). Hong Kong: CERC and Springer.

Law, N., Chow, A., & Yuen, H. K. (2004). *Methodological approaches to comparing pedagogical innovations using technology*. Paper presented at the First IEA International Research Conference, Lefkosia, Cyprus.

Law, N., Kankaanranta, M., & Chow, A. (2005). Technology-supported educational innovations in Finland and Hong Kong: A tale of two systems. *Human Technology, 1*(2), 176–201.

Law, N., Pelgrum, W. J., & Plomp, T. (Eds.). (2008). *Pedagogy and ICT use in schools around the world: Findings from the IEA SITES 2006 study*. Hong Kong: CERC and Springer.

Law, N., Yuen, A., & Chow, A. (2003). *SITES-Module 2 Hong Kong Study Centre secondary analysis*. Hong Kong: Centre for Information Technology in Education, University of Hong Kong.

Law, N., Yuen, H. K., Ki, W. W., Li, S. C., Lee, Y., & Chow, Y. (Eds.). (2000). *Changing classrooms and changing schools: A study of good practices in using ICT in Hong Kong schools*. Hong Kong: Centre for Information Technology in Education, University of Hong Kong.

Leithwood, K., Jantzi, D., & Steinbach, R. (1999). *Changing leadership for changing times*. London: Open University Press.

Lemke, J., & Sabelli, N. (2008). Complex systems and educational change: Towards a new research agenda. *Educational Philosophy and Theory, 40*(1), 118–129.

Leskes, A., Grogan, W. R., Canham, R. P., & O'Brien, J. (2003). Designing institutional change. *Liberal Education, 89*(1), 32–41.

Lorange, P. (1996). A business school as a learning organization. *The Learning Organization, 3*(5), 5–12.

Louis, K. S. (2006). *Organizing for school change*. London: Taylor and Francis.

Lueddeke, G. R. (1999). Toward a constructivist framework for guiding change and innovation in higher education. *Journal of Higher Education, 70*(3), 235–260.

Marsick, V. J., & O'Neil, J. (1999). The many faces of action learning. *Management Learning, 30*(2), 159–176.

McDade, S. A. (1995). Case study pedagogy to advance critical thinking. *Teaching of Psychology, 22*(1), 9–10.

Merriam, S. B. (1998). *Qualitative research and case study applications in education* (2nd ed.). San Francisco: Jossey-Bass.

Merseth, K. (1991). Supporting beginning teachers with computer networks. *Journal of Teacher Education, 42*, 140–147.

Michigan Institute of Technology Sloan Management. (2004). *Distibuted leadership model*. Retrieved from http://sloanleadership.mit.edu/index.php

Miles, M. B., & Huberman, A. M. (1994). *Qualitative data analysis: An expanded sourcebook* (2nd ed.). Thousand Oaks: Sage.

Milligan, G. W. (1980). An examination of the effect of six types of error perturbation on fifteen clustering algorithms. *Psychometrika, 45*, 325–342.

Milligan, G. W. (1981). A review of Monte Carlo tests of cluster analysis. *Multivariate Behavioral Research, 16*, 379–407.

Mioduser, D., Nachimias, R., Tubin, D., & Forkosh-Baruch, A. (2003). Analysis schema for the study of domains and levels of pedagogical innovation in schools using ICT. *Education and Information Technologies, 8*(1), 23–36.

Mishra, P., & Koehler, M. J. (2006). Technological pedagogical content knowledge: A framework for teacher knowledge. *Teachers College Record, 108*, 1017–1054.

Mooij, T., & Smeets, E. (2001). Modelling and supporting ICT implementation in secondary schools. *Computers & Education, 36*(3), 265–281.

Morey, L. C., Blashfield, R. K., & Skinner, H. A. (1983). A comparison of cluster analysis techniques within a sequential validation framework. *Multivariate Behavioral Research, 18*, 309–329.

Mumtaz, S. (2000). Factors affecting teachers' use of information and communications technology: A review of the literature. *Technology, Pedagogy and Education, 9*(3), 319–342.

Nonaka, I., & Takeuchi, H. (1995). *The knowledge creating company: How Japanese companies create the dynamics of innovation*. New York: Oxford University Press.

Oakes, J., Quartz, K., Ryan, S., & Lipton, M. (2002). *Becoming good American schools: The struggle for civic virtue in education reform*. San Francisco: Jossey-Bass.

Oblinger, D., & Hawkins, B. (2006). The myth about no significant difference: Using technology produces no significant difference. *Educause Review, 41*(6), 14–15.

Olson, J. (2002). Systemic change/teacher tradition: Legends of reform continue. *Journal of Curriculum Studies, 34*(2), 129–137.

Owston, R. D. (2003). School context, sustainability and transferability of innovation. In R. B. Kozma (Ed.), *Technology, innovation and educational change: A global perspective* (pp. 125–161). Eugene: International Society for Technology in Education.

Partnership for 21st Century Skills. (2003). *Learning for the 21st century: A report and MILE guide for 21st century skills.* Retrieved from http://www.21stcenturyskills.org/downloads/P21_Report.pdf

Partnership for 21st Century Skills. (2007). *The intellectual and policy foundations of the 21st century skills framework*. Tucson: Partnership for 21st Century Skills.

Pelgrum, W. J., & Anderson, R. E. (Eds.). (1999). *ICT and the emerging paradigm for life long learning: A worldwide educational assessment of infrastructure, goals and practices*. Amsterdam: International Association for the Evaluation of Educational Achievement and The University of Twente.

Pelgrum, W. J., & Law, N. (2003). *ICT in education around the world: Trends, problems and prospects*. Paris: UNESCO, International Institute for Educational Planning.

Pierson, M. (2001). Technology integration practice as a function of pedagogical expertise. *Journal of Research on Computing in Education, 33*(4), 413–430.

Plomp, T., Anderson, R. E., Law, N., & Quale, A. (Eds.). (2003). *Cross-national information and communication technology policy and practices in education*. Greenwich: Information Age Publishing.

Plomp, T., Anderson, R. E., Law, N., & Quale, A. (Eds.). (2009). *Cross-national information and communication technology policies and practices in education* (2nd ed.). Greenwich: Information Age Publishing.

Plomp, T., ten Brummelhuis, A., & Rapmund, R. (Eds.). (1996). *Teaching and learning for the future*. Den Haag: Committee on Multimedia in Teacher Training, Dutch Ministry of Education.

Reigeluth, C. M., & Garfinkle, R. J. (Eds.). (1994). *Systemic change in education*. Englewood Cliffs: Educational Technology Publications.

Richardson, B. (1994). Towards a comprehensive view of the case method in management development. *Industrial and Commercial Training, 26*(9), 3–10.

Riel, M. (1998). Teaching and learning in the educational communities of the future. In C. Dede (Ed.), *Learning with technology: ASCD yearbook 1998*. Alexandria: Association for Supervision and Curriculum Development.

Robitaille, D. F., & Garden, R. A. (Eds.). (1996). *TIMSS monograph No 2: Research questions & study design*. Vancouver: Pacific Education Press.

Rogers, E. M. (2003). *Diffusion of innovations* (5th ed.). New York: The Free Press.

Russell, T. (1999). *The no significant difference phenomenon*. Raleigh: North Carolina State University.

Russell, T. L. (n.d.). *No significant difference phenomenon*. Retrieved from http://nosignificantdifference.wcet.info/about.asp

Schlossman, S. R., Gleeson, M., Sedlak, D., & Grayson, A. (1994). *The beginnings of graduate education in the United States*. Santa Monica: Graduate Management Admission Council.

Scoter, J. V. (2008). The potential of IT to foster literacy development in kindergarten. In J. M. Voogt & G. A. Knezek (Eds.), *International handbook of information technology in primary and secondary education* (pp. 149–162). New York: Springer.

Secretary's Commission on Achieving Necessary Skills (SCANS). (1991). *What work requires of schools: A SCANS report for America 2000*. Washington: SCANS, US Department of Labor.

Senge, P. (1990). *The fifth discipline: The art and science of the learning organization*. New York: Currency Doubleday.

Senge, P., Cambron-McCabe, N., Lucas, T., Smith, B., Dutton, J., & Kleiner, A. (2000). *Schools that learn: A fifth discipline fieldbook for educators, parents, and everyone who cares about education*. New York: Doubleday.

Senge, P., & Käufer, K. H. (2000). Communities of leaders or no leadership at all. In S. Chowdhury (Ed.), *Management 21C* (pp. 186–204). London: Prentice Hall.

Seperich, G. J., Woolverton, M. J., Beierlein, J. G., & Hahn, D. E. (Eds.). (1996). *Cases in agribusiness management* (2nd ed.). Scottsdale: Gorsuch Scarisbrick.

Sergiovanni, T. (2001). *Leadership: What's in it for schools?* London: RoutledgeFalmer.

Shulman, L. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher, 15*(2), 4–14.

Singapore Ministry of Education. (1997). *Masterplan for IT in education.* Retrieved from http://www.moe.gov.sg/edumall/mpite/index.html

Singapore Ministry of Education. (2002). *Masterplan for IT in education.* Retrieved from http://www.moe.gov.sg/edumall/mp2/mp2.htm

Smith, L. M. (Ed.). (1978). *An evolving logic of participant observation: Educational ethnography and other case studies*. Itasca: Peacock.

Spillane, J. (2006). *Distributed leadership*. San Franscisco: Jossey-Bass.

Spillane, J., Halverson, R., & Diamond, J. (2004). Towards a theory of leadership practice: A distributed perspective. *Journal of Curriculum Studies, 36*(1), 3–34.

Spratt, C., Palmer, S., & Coldwell, J. (2000). Using technologies in teaching: An initiative in academic staff development. *Educational Technology and Society, 3*(3), 455–461.

Stake, R. (1981). *Case study methodology: An epistemological advocacy.* Paper presented at the Minnesota Evaluation Conference, Minneapolis.

Stake, R. (1995). *The art of case study research*. Thousand Oaks: Sage.

Stein, M., & Coburn, C. (2008). Architectures for learning: A comparative analysis of two urban school districts. *American Journal of Education, 114*(4), 583–626.

Stigler, J. W., Gonzales, P., Kawanaka, T., Knoll, S., & Serrano, A. (1999). *The TIMSS videotape classroom study: Methods and findings from an exploratory research project on eighth-grade mathematics instruction in Germany, Japan and the United States (research and development report)*. Washington: US Department of Education, National Center for Education Statistics.

Stigler, J. W., & Hiebert, J. (1999). *The teaching gap: Best ideas from the world's teachers for improving education in the classroom*. New York: Free Press.

Sudzina, M. R. (1997). Case study as a constructivist pedagogy for teaching educational psychology. *Educational Psychology Review, 9*(2), 199–217.

Suharwoto, G. (2006). Developing and implementing a technology pedagogical content knowledge (TPCK) for teaching mathematics with technology. In C. M. Crawford, R. Carlsen, K. McFerrin, J. Price, R. Weber, & D. A. Willis (Eds.), *Proceedings of Society for Information Technology & Teacher Education International Conference 2006* (pp. 3824–3828). Chesapeake: Association for the Advancement of Computing in Education.

Tarragó, F. R. (2009). National policies and practices on ICT in education: Catalonia, Spain. In T. Plomp, R. E. Anderson, N. Law, & A. Quale (Eds.), *Cross-national information and communication technology policy and practices in education* (2nd ed., pp. 135–152). Greenwich: Information Age Publishing.

Taylor, P. G. (1998). Institutional change in uncertain times: Lone ranging is not enough. *Studies in Higher Education, 23*(3), 269–279.

Taylor, L., Nelson, P., & Adelman, H. (1999). Scaling-up reforms across a school district. *Reading & Writing Quarterly, 15*, 303–325.

Telem, M. (1996). MIS implementation in schools: A systems socio-technical framework. *Computers & Education, 27*(2), 85–93.

Tyack, D., & Cuban, L. (1995). *Tinkering toward Utopia: A century of public school reform*. Cambridge: Harvard Educational Press.

UNESCO. (2003). *Building the capacities of curriculum specialists for educational reform. Final report of the regional seminar held in Vientiane, Lao PDR on 9–13 September 2002*. Bangkok: UNESCO Bangkok.

UNESCO. (2008). *UNESCO's ICT competency standards for teachers: Towards ICT skills for teachers*. Retrieved from http://cst.unesco-ci.org/sites/projects/cst/default.aspx

Venezky, R. L., & Davis, C. (2002). *Quo vademus? The transformation of schooling in a networked world*. Paris: OECD and CERI.

Voogt, J. M., & Knezek, G. A. (Eds.). (2008). *International handbook of information technology in primary and secondary education*. New York: Springer.

Voogt, J. M., & Odenthal, L. E. (1998). *Emergent practices geportretteerd: Conceptueel raamwerk [Portraits of emergent practices: Conceptual framework]*. Enschede: University of Twente.

Walker, R. (2002). Case study, case records and multimedia. *Cambridge Journal of Education, 32*(1), 109–127.

Wallace, M. (2002). Modelling distributed leadership and management effectiveness: Primary school senior management teams in England and Wales. *School Effectiveness and School Improvement, 13*(2), 163–186.

Wassermann, S. (1994). *Introduction to case method teaching: A guide to the galaxy*. New York: Teachers College Press.

Watkins, D. A., & Biggs, J. B. (Eds.). (1996). *The Chinese learner: Cultural, psychological and contextual influences*. Hong Kong: Comparative Education Research Centre, University of Hong Kong.

Watkins, D. A., & Biggs, J. B. (Eds.). (2001). *Teaching the Chinese learner: Psychological and pedagogical perspectives*. Hong Kong: Comparative Education Research Centre, University of Hong Kong.

Watkins, K. E., & Marsick, V. J. (Eds.). (1996). *In action: Creating the learning organization*. Alexandria: ASTD.

Webb, M. (2008). Impact of IT on science education. In J. M. Voogt & G. A. Knezek (Eds.), *International handbook of information technology in primary and secondary education* (pp. 133–148). New York: Springer.

Webb, M., & Cox, M. (2004). A review of pedagogy related to information and communications technology. *Technology, Pedagogy and Education, 13*(3), 235–286.

Wenger, E. (1998). Communities of practice: Learning as a social system. *Systems Thinker, 9*(5), 1–5.

West, M. (2000). Supporting school improvement: Observations on the inside, reflections from the outside. *School Leadership and Management, 20*(1), 43–60.

Wheatley, M. J. (1999). *Leadership and the new science: Discovering order in a chaotic world* (2nd ed.). San Francisco: Berrett-Koehler.

Yin, R. (1994). *Case study research: Design and methods* (2nd ed.). Thousand Oaks: Sage.

Yin, R. (2003). *Applications of case study research*. Thousand Oaks: Sage.

Yin, R. (2009). *Case study research: Design and methods* (4th ed.). Thousand Oaks: Sage.

Yuen, H. K., Fox, B., & Law, N. (2004). Curriculum innovations and multi-level e-leadership requirements: Putting research into practice. *Asia-Pacific Cybereducation Journal, 1*(1), 11–18.

Yuen, H. K., Law, N., & Wong, K. C. (2003). ICT implementation and school leadership: Case studies of ICT integration in teaching and learning. *Journal of Educational Administration, 41*(2), 158–170.

Yukl, G. (2002). *Leadership in organizations* (5th ed.). Upper Saddle River: Prentice Hall.

Zhao, Y., & Frank, K. (2003). Factors affecting technology uses in schools: An ecological perspective. *American Educational Research Journal, 40*, 807–840.

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