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Domains and Levels of Pedagogical Innovation in Schools Using ICT: Ten Innovative Schools in Israel

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Abstract

The study reported here is based on the results of two international studies: IEA's Second Information Technology in Education Study (SITES) Module 2, focusing on innovative pedagogical practices at the classroom level, and OECD/CERI Case Studies of ICT and Organizational Innovation, focusing on ICT related innovations at the school system level. In the paper we analyze the data collected in ten innovative schools in Israel which have incorporated ICT in unique ways and have succeeded in devising innovative classroom pedagogies and school system changes. The major research questions addressed are: (a) What levels of innovation were observed in the participant schools, and in which domains? (b) How does the level of innovation in the various domains vary among and within schools? (c) What correlation patterns among levels of innovation in the various domains can be identified? The results of ten comprehensive case studies of exemplary schools in Israel were analyzed by mean of the *innovation analysis schema* developed by us for characterizing ICT-based educational innovations.

Keywords: ICT, pedagogical practices, innovation, analysis schema, international study, case study

1. Introduction

The rapid and pervasive integration of new information and communication technologies (ICT) in our life has also prompted increased interest in their potential role in educational systems worldwide. In an effort to identify whether and how these new technologies promote innovative educational change, more than thirty countries co-operated in two international studies on school innovation using ICT. One is the Second Information Technology in Education Study (SITES) Module 2, by the IEA, focusing on innovative pedagogical practices at the classroom level (Kozma, 2000). The other is the Case Studies of ICT and Organizational Innovation, sponsored by the OECD/CERI, focusing on innovations at the school system level as a result of ICT implementation (OECD/CERI, 2000).

This is the second of two papers reporting on the levels of innovation of Israeli schools participating in the two international studies. In the first we presented the *innovation analysis schema* for characterizing the ICT-based educational innovations (Mioduser *et al.*, 2003). We characterized the notion of pedagogical innovation using ICT by four domains (time/space configuration, student roles, teacher roles and curricular changes) and by the level of its integration within the pedagogical practices in the school (assimilation, transition and transformation). In this paper we report on the application of the analysis schema in analyzing the data collected in ten innovative schools in Israel, which have incorporated

ICT in unique ways and succeeded in devising innovative classroom pedagogies and school system changes.

The major research questions addressed in the study reported in this paper are:

(a) What levels of innovation were observed in the participant schools, and in which domains?
(b) How does the level of innovation in the various domains vary among and within schools?
(c) What correlation patterns among level of innovation in the various domains can be identified?

2. Background

A great deal of theoretical and empirical work has been done for several decades regarding the impact of ICT on educational processes (for ample surveys of these research efforts see Becker, 1994; Mioduser and Nachmias, 2002; Pelgrum and Anderson, 1999). The incorporation of ICT into the school has affected its functioning at multiple levels: new configurations of learning spaces and timetables have been created; innovative teaching methods were devised; autonomous and active learning processes using the technology have been adopted; teachers' traditional roles have been expanded, and include personal and group tutoring and guidance functions; and new ICT-based curricular solutions have been generated. ICT in schools has brought about a shift in the teacher's role, from being an instructor to acting as a guide, assisting students in finding their own learning method and evaluating their learning processes and outcomes; students, from being passive learners have become active learners collaborating with their peers; and schools, once isolated from society have become integrated into society, actively involving the parents in their children's schooling (SITESm2, 2000).

ICT-implementation in Israeli schools goes back as far as the 70's. However in 1993, the Ministry of Education released an operative proposal for the computerization of the whole education system known as the "5-Year National Computerization Program", for the years 1994–1999. Its main goals were to supply infrastructure according to defined standards (hardware configurations and software requirements), to provide pre- and in-service training to most teachers in the system, and to foster equity of access to the technology for most students. Currently, the second phase of the computerization program (for the years 2000–2005) is being implemented. Built on the conclusions of the previous phase, the goals pursued in the new plan focus on students' acquisition of learning and knowledge handling skills, on ICT-related ethical issues, on expanding the depth and scope of teacher training programs, on the incorporation of network technologies into teaching and learning, and on encouraging experimentation, research and evaluation by schools and research institutions.

Nowadays, technology plays a substantial role in many Israeli schools, replacing traditional practices and contributing to changes in the curriculum as well as in teacher–student educational transactions (Nachmias *et al.*, 2000). Innovative pedagogical practices using technology are, in fact, emerging in many of our schools, resulting in changes in teaching and learning processes and outcomes, as well as providing students with life-long-learners'

skills, competencies, and ICT-literacy needed in the information society. These changes are often supported by ICT, and some are impossible to accomplish without it (Salomon, 2000).

2.1. The international studies

The work reported here is the result of our involvement in two international studies on school innovation using ICT. One is the Second Information Technology in Education Study (SITES) Module 2, by the IEA (Kozma, 2000), and the other is the Case Studies of ICT and Organizational Innovation, sponsored by the OECD/CERI (OECD/CERI, 2000). Both studies concentrated on case studies of successful and innovative implementations of ICT in about 30 countries. In Israel, we examined comprehensively ten cases, i.e., ten schools that have incorporated ICT in unique ways and succeeded in devising innovative classroom pedagogies and school system changes.

"Innovation" was defined as pedagogical practices that pursue some or several of the following goals: to promote active and independent learning processes, in which students take responsibility for their own learning; to provide students with information-handling competencies and skills; to encourage collaborative and project-based learning; to provide individualized instruction; to addresses issues of equity; to decompose traditional space and time learning configurations; to "break down" classroom walls; to improve social cohesiveness and understanding by having students interact with groups and cultures that they would not interact with otherwise. In addition to classroom level transformations, the OECD/CERI study put particular emphasis on systemic changes at the school level as a result of ICT implementation. Additional variables considered were the sustainability, transferability and scalability potential of the observed innovations.

3. Method

3.1. School selection procedure

To select the participating schools a preliminary list of about 100 cases of innovative usage of ICT in schools was created. Candidate cases were recommended by the Ministry of Education, school networks, non-profit educational organizations, and universities. At the next stage, the research team collected information on each case from various sources, such as the schools themselves, school-networks management, or supervisors and superintendents. An initial reduction of the list was achieved on the basis of criteria such as: cases of similar nature, projects that were only at an initial stage, cases that did not respond to the nationally defined selection criteria. As a result, a list of about 40 cases remained for the final selection stage. All these cases, and the selection criteria, were presented to the study's expert advisors panel which together with the research team (altogether about 15 people) proposed the final list of candidates for the studies.

The selection of appropriate schools was based on the following criteria (defined for the international study and modified to accommodate the particular circumstances and cultural features of our country). To qualify, a school must:

(1) Show evidence of significant changes subsequent to ICT introduction, in roles of teachers and students, the goals of the curriculum, assessment practices, and/or the educational materials or infrastructure.
(2) Ascribe a substantial role to technology.
(3) Show evidence of measurable positive student ICT-related outcomes.
(4) Show sustainable, transferable, and scalable ICT practice.
(5) Show innovative ICT – related practices, as locally defined (SITESm2, 2000).

At the end of the procedure ten schools were selected for the study (a brief description of each school innovation appears in Appendix A – The full reports for all schools can be found at http://muse.tau.ac.il/ict). It should be noted that the analysis unit in this study is a specific innovative pedagogical practice using ICT within the school, and not the school as a whole.

3.2. Data collection tools

In order to conduct a comprehensive case study in each school the international research teams created a set of eleven qualitative data collection tools: principal questionnaire; principal interview; computer-coordinator questionnaire; computer-coordinator interview; administrator or supervisor interview; focus-group interview of teachers involved in the innovation; focus-group interview of teachers not involved in the innovation; focus-group interview of students involved in the innovation; focus-group interview of parents involved or familiar with the innovation; observations (according to defined guidelines); learning products analysis.

3.3. Data collection process

Data were collected between December 2000 and June 2001, in ten schools. The research team consisted of nine researchers altogether, working in teams of 2–3 researchers each. Each team was responsible for data collection and reporting in one of the participating schools. The teams visited the schools 3–5 times spending altogether about 60 person-hours per school. A typical interview lasted about an hour and a half, and was carried by one researcher. Classroom observations lasted 45 minutes and were conducted by two researchers. All interviews were audio recorded and all observation details were written down. All data were transcribed onto digital files and uploaded onto the Israeli research Website (http://muse.tau.ac.il/ict). A data matrix was built for further reference.

Table 1. Levels and domains of pedagogical innovation using ICT

Domains	Levels		
	Assimilation	Transition	Transformation
Time and space configuration			
Physical space	Public spaces	Public and personal spaces	Personal and community spaces in school and beyond
Digital space	Desktop and Internet applications usage	Flexible Internet use and content creation	Virtual learning spaces and organizations
Time	Mainly embedded in the school schedule and timetable	Flexible access for individuals within constraints of school schedule	Any time for all in school hours and beyond
Student role			
Main roles	Using ICT for accomplishing curricular assignments	Development of ICT generic expertise – for usage, maintenance, and creation	Personal assimilation of ICT as learning, creation and working means
Teacher role			
With students	Main source of leadership, information, and knowledge	Pedagogic authority, mentor, supporter, coordinator	Expert colleague, partner in the process of discovery
With teachers	Acting individually, functional peer interaction	Team work, collaboration, mutual help	Acting cooperatively, organic solidarity
Curriculum			
Content	Traditional subjects enriched with ICT	Expanded subjects incorporating new knowledge resources	New subjects; design and development using ICT
Didactic solutions	Tutorial packages, constrained use of generic tools and Internet	Open assignments and projects using generic tools and Internet	Virtual environments; development of personal digital spaces
Assessment methods	Digital versions of standard assessment means	Criteria development for assessing digital products	Digital alternative assessment: projects, portfolio, etc.

3.4. Data analysis

For the systematic analysis of ICT-based pedagogical innovations in the participant schools we developed the *innovations analysis schema* (for a detailed description of it see Mioduser *et al.*, 2003). The schema's dimensions are located within a grid defined by two axes (Table 1). The horizontal axis represents levels of innovation, from preliminary alterations of the school's routine due to the initial assimilation of ICT, to far-reaching transformations of pedagogical practices and learning processes. Three main levels were defined, conforming a progressive continuum regarding the innovation: assimilation, transition and transformation levels. The vertical axis details domains of innovation, focusing on four main constituents of the school's milieu: time/space configurations, students, teachers, and the curriculum.

Two independent evaluators analyzed the case study data using the *innovation analysis schema*. Their judgment was based on the information collected, as well as on personal communications with the members of the research team responsible for data collection.

Each evaluator came up with a scaling for each school in each domain on a 5-point scale (1 – basic assimilation level, 2 – beginning of the transition, 3 – transition level, 4 – beginning of the transformation level, and 5 – full transformation level). The evaluation resulted in 90 sub-domain-level-locations (SLL), for 9 sub domains in 10 schools. Out of the 90 SLL matching judgment was reached for 75 (83%) in the first evaluation round. The remaining 17% were discussed and elucidated by the evaluators and other members of the research team until full agreement was reached. The final results of the scaling were analyzed in various ways as presented in this paper.

4. Results

The study results are reported here according to the research questions, namely levels of innovations in school, characteristics of innovations in schools, and relationships among the domains.

4.1. Levels of innovation in schools

The ten schools presented in this study were chosen because they were considered successful examples of "using ICT for pedagogical practices in an innovative way". Yet, the question remains whether and how this innovation is reflected in some or all domains of the school's activity. Table 2 presents the frequencies of Israeli innovative practices by innovation levels and domains.

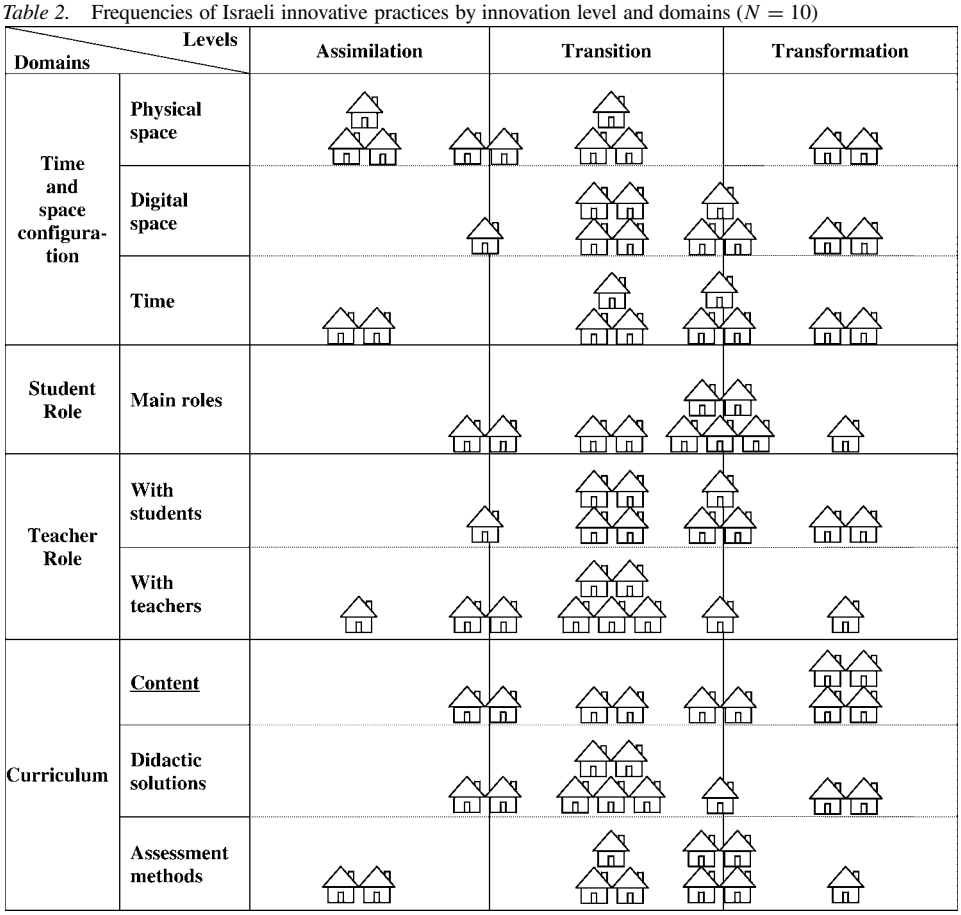
Data indicate that most schools, in most of the innovation domains, are at or around the transition level (65 out of the 90 SLL – 72%), and only in a few domains (17 SLL – 19%) they reached the transformation level. An alternative reading of the data shows that 53 SLL (59%) are either at the transitional level, or at the shift-towards-transformational level, with only 20 SLL (22%) at the lower stages of the innovation scale.

Specific data for each domain, with examples of schools located at its various levels of innovation, are presented in the following sections.

4.2. Time and space configurations

4.2.1. Physical space In general, the "classroom walls" remained intact. Eight out of the 10 schools are at the assimilation and transition levels, with their computers located in public spaces (e.g., computer room, laboratory). The two remaining schools are at the transformation level. For example, the building of school IL003 was designed from scratch in an innovative and technology-oriented approach: "Homes" for 72 students were planed instead of classrooms. In each "home" there are three learning environments: the open space teaching area, the computer gallery (containing about 16 computers), and the mini-auditorium. In this environment the students access ICT according to their learning needs, in about one third of their learning activities.

Table 2. Frequencies of Israeli innovative practices by innovation level and domains ($N = 10$)



4.2.2. Digital space None of the innovation practices pertain to the first innovation level, which restrains the virtual space to the desktop computer only. Most of the schools are at the transition level and beyond. For example, several schools have developed Websites serving as online news board, as portals to dynamic learning centers, or as virtual gateways to Websites all over the world. School IL001 uses a digital-projects-portal organized and developed by a specialist outside the school. All 22 classes in the school participate in at least one project, on a variety of subjects. The students spend two hours a week working on a given topic using diverse ICT formats, e.g., digital surveys, interest-group chats, or online tutorials. At the most advanced level, high school IL013 developed a Web-learning center containing students' projects, a bank of textual and visual geographical and historical materials, learning activities and lesson plans, links to relevant Websites, and sections for special education and immigrant students.

4.2.3. Time configuration Schools at the assimilation level incorporate ICT activities within their structured schedule and timetable. One example is school IL008, which runs

13 virtual courses (in subjects like English, Social Studies, and Communication Studies) developed by the Ort educational network. The virtual courses are embedded in the regular timetable, resembling regular face-to-face courses in length. At the transition level, periods are organized in time-blocks within which the students are free to use the computer for their needs (e.g., students appointed as "computer trustees" are allowed to skip regular lessons for completing their computer assignments). Five schools located at the highest levels of innovation showed a fairly flexible organization of time. For example, high school IL006 allows students at the Radio Division to use ICT and work on their radio programs during the school day and beyond, till late afternoon, according to their needs.

4.3. Student role

Most of the innovative practices (6 out of 10) have caused a significant change in student roles, with some becoming Website constructors, others teacher assistants in ICT-related matters, or ICT project managers. In high school IL009 the students worked in teams to solve real problems and to accomplish projects invited (and funded) by local high-tech companies. At the assimilation and transition levels (4 out of 10 schools), a broadening in scope of student roles was observed, but still within the constraints delineated by teachers. For example, in junior high IL002 a group of 40 computer trustees (out of about 600 students) were in charge of a whole new set of functions, e.g., hardware and software maintenance, general phone support, home visits for solving ICT failures, and teacher and student training in ICT skills. But no changes had taken place yet in the usual pedagogical practices at school, and the computer trustees still hade to fulfill, in addition, their traditional roles as learners.

4.4. Teacher role

4.4.1. Teacher/student interaction Schools that were in the transition level and beyond it showed interesting changes in teacher roles toward functioning as mentor and coordinator. For example, in elementary school IL001 (transition level), the students work on digital projects under the supervision of the teachers for about two hours a week: one hour in the classroom (focusing on skills such as planning, writing texts, editing a report, or managing a virtual discussion) and a second hour in the computer lab. At the transformation level, teacher and student work together on Web-based projects, either searching and discovering existent Websites or developing their own. At this level the teacher functions as subject expert and the student as computer expert. This interaction eventually makes the teacher more familiar with the technology and the students more knowledgeable with the subject under study. For example, in high school IL007, teams of teachers and students were working together on developing Websites on about 20 subjects, which would serve the ongoing teaching and learning in the school.

4.4.2. Teacher/teacher interaction In 8 out of 10 innovative practices the relationship among teachers is at the transition level and below, showing only limited teamwork and

collaboration. For example, the "Center for Leadership and Excellence in Technology" at high school IL009 aims to encourage students (currently 200 out of 1200) to pursue to technological studies by connecting them to the local hi-tech industry and offering them courses such as Webmaster, Web design, network administration, business entrepreneurship and creative thinking. Due to the extraordinary workload and scope of contents of the center's activity, the teachers' learning of skills and contents is mainly an individual effort rather than a group endeavor. In contrast, at the transformation level a great deal of teamwork was observed. For example, at elementary school IL003, the teachers work in teams to develop the school's curriculum and ICT-based learning materials. The expertise and specialization that the teachers gain during these curriculum development activities enhance both the support of, and need for, close interactions among participant teachers.

4.5. Curriculum change

4.5.1. Content ICT use affects curricular contents in diverse ways. In four schools whose innovative practices pertain to the transition level or below, ICT supported a sort of expansion of the traditional subjects. For example, in high school IL007, the French language teacher asked her students to find their favorite French songs and food on the Internet to enrich their own Website. Schools at the transformation level used ICT for design and development of Web learning environments. For example students in high school IL013 developed a virtual environment of the salt flat near to which their kibbutzim and regional school are located. A special component in their innovative practice was the collaboration with Jordanian students from the village of Rah'me. The international border divides the salt flat between Jordan and Israel (with Israeli and Jordanian settlements being located at both edges of the flat). This represented the opportunity to work together, also (but not only) using ICT, on subject matter related to this shared natural phenomenon.

4.5.2. Didactic solutions In term of didactic practices most of the innovations observed pertain to the transition level, e.g., the use of digital worksheets stored in Websites to practice earlier studied topics, or searching the Internet for information to be used in class. For example, at elementary school IL001 the students are involved in the "browsing and eating" project, in which they can participate in a national digital survey about their eating habits, and can compare them to national data and averages. At the transformation level the learning activities are qualitatively upgraded by the use of ICT. For example, in the greenhouse at high school IL015, the students engage in research projects dealing with real problems like fish nutrition or water contamination. The work is executed at the greenhouse, under academic expert's supervision, and with the support of other students and the greenhouse pedagogical manager.

4.5.3. Assessment methods In school innovations at the assimilation level ICT is implemented in interesting ways but without any consideration of assessment needs and procedures. For example, the upper secondary IL010 has developed a "Peace Network" with Arab schools in Israel, in Jordan, in the Palestinian authority and in other countries. Pairs

of classes work with each other on joint assignments, such as analyzing a poem, learning about the family structure in different societies, or analyzing customs in their cultures (e.g., wedding traditions). The innovation aimed to enrich students as human beings, as future citizens, and to supply them with conflict solving skills, but no assessments tools were used to evaluate to what extent these goals were achieved (given the nature of these goals, traditional assessment will be inappropriate).

The rest of the school innovations were located at the transition (3 schools) and transformation (5 schools) levels. These innovations included the use of assessment procedures such as voting in polls, participating in a Website design contest, or constructing digital portfolios. For instance, in elementary school IL003 students manage their digital portfolios in their computerized folder, keeping records of all learning activities and products. The assessment of their work, including self-reflection, is reported in the school diploma.

4.6. Variation in innovation level along all domains among and within schools

The second research question addresses the extent of variation among and within schools, regarding the observed level of innovation in each domain. Although all schools in this study were selected for being innovative, they differed from each other in many aspects.

Table 3. Schools' levels of innovation

Domains	School									
	IL001	IL002	IL003	IL006	IL007	IL008	IL009	IL010	IL013	IL015
Time and space configuration										
Physical space	3	1	5	2	2	1	3	1	3	5
Digital space	3	2	3	4	4	3	4	3	5	5
Time	1	3	4	4	3	1	3	4	5	5
Student role										
Main roles	2	3	4	4	4	2	4	3	4	5
Teacher role										
With students	3	3	3	4	3	2	4	4	5	5
With teachers	3	1	5	2	3	3	3	3	4	2
Curriculum										
Content	3	2	5	4	2	3	5	4	5	5
Didactic solutions	3	2	4	3	3	2	3	3	5	5
Assessment methods	3	1	4	4	3	3	4	1	4	5
School average level of innovation	2.7	2.0	4.1	3.4	3.0	2.2	3.7	2.9	4.4	4.7
School deviation of domains	0.7	0.9	0.8	0.9	0.7	0.8	0.7	1.2	0.7	1.0

Table 3 presents the level of innovation in all nine domains for all schools. For each school, two coefficients were calculated. The first is the school's average level of innovation. The second coefficient is the standard deviation of the nine domains from this average.

The findings reveal variation among schools in average level (from 2.0 to 4.7) of the innovative practices being implemented. Three schools show a high average level of innovation (above 4), indicating that the practices have promoted significant changes in most domains. In contrast, in four schools the average level of innovation is located between the assimilation and transition phases (bellow 3). Given that all practices examined were selected as successful examples of ICT-based pedagogical processes, this variation among schools suggests that a high level of transformation in all domains could be a desired outcome of, but by no means a prerequisite for, these successful processes.

Another finding is that in most schools the innovative practices do not compromise all domains at the same level. For example, in school IL010 (the Peace Network as virtual encounter site for children from Jewish and Arab schools), significant transformations were observed as regards to time configuration, teacher/student interactions, and curricular contents, whereas the physical space configuration and the assessment means underwent only minor changes. In school IL007 the practice focuses on students as Website developers, therefore resulting in significant changes in the digital space configuration and in student roles more than in domains of lesser relevance. These findings imply that different innovative practices address different aspects of the pedagogical process, leading to dissimilar impact in the various domains according to the goals and scope of the practice.

The deviation of the innovation level of the domains within each school indicates that in general the variation within and among schools is low (*SD* ranging from 0.7 to 1.2). In other words, the overall configuration of levels of innovation in the different domains within a school is fairly homogeneous. This coherent picture can be anchored at any location on the innovation scale, e.g., IL002's innovative practice is consistently located, in all domains, slightly below the transition level, and IL015's coherently at the transformation level.

Figure 1 shows the relative location of each school in a two-dimensional space whose axes are the average level of innovation and the deviation from this average. The space can be divided by the vertical axis into two areas: above and below the median (i.e., 3), and by the horizontal axis into three areas of variation (for *SD* equaling 0.7, 1.4, and 2.1).

As regards the average level of innovation, six innovative practices are located in the upper area (i.e., transitional and transformational phases), and four in the lower area (assimilation to transitional phases). As regards the variation, all innovative practices are located in the central area, suggesting that most domains are affected at a similar level with moderate differences among domains. In general, this space can serve as tool for the further classification and analysis of other types of pedagogical practices and schools, based on their performance in the different domains. For example, extreme cases can be a school performing at the highest level in all domains (A) or the lowest (B) with no variation among domains, or a school performing at the strict average level (3) with maximum variation (C).

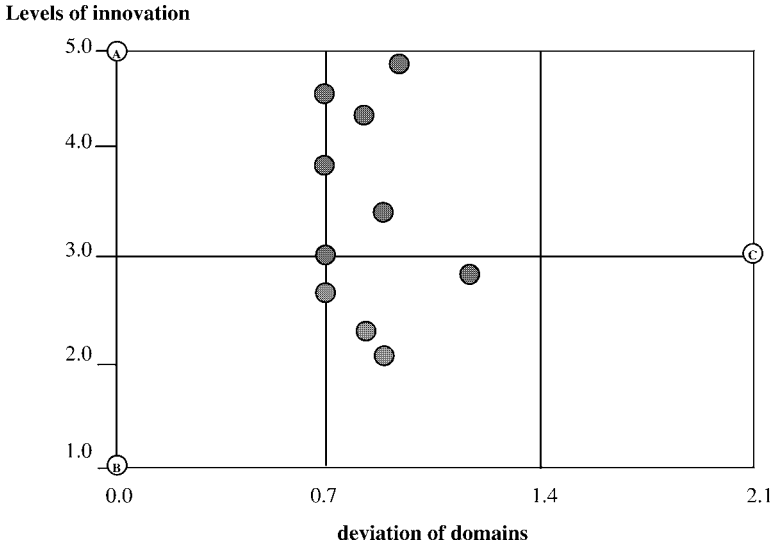


Figure 1. Schools' distribution according to levels of innovation and deviation of domains.

Table 4. Correlation matrix of the innovation domains ($N = 10$ schools)

	Physical space	Digital space	Time	Student role	Teacher–student	Teacher–teachers	Content	Didactic solutions	Assessment
Physical space	1								
Digital space	0.49	1							
Time	0.43	0.58	1						
Student role	0.60	0.71^{*}	0.85^{**}	1					
Teacher–student	0.41	0.76^{**}	0.83^{**}	0.71^{*}	1				
Teacher–teachers	0.44	0.17	0.09	0.05	−0.04	1			
Content	0.67^{*}	0.58	0.61	0.56	0.67^{*}	0.47	1		
Didactic solutions	0.78^{**}	0.78^{**}	0.75^{*}	0.70^{*}	0.78^{**}	0.41	0.73^{*}	1	
Assessment	0.77^{**}	0.77^{**}	0.32	0.60	0.42	0.32	0.64^{*}	0.67^{*}	1

$^{*}p < 0.05$, $^{**}p < 0.01$

4.7. Correlation among domains of innovation

The third research question relates to the degree of correlation (Table 4) among innovation levels in the diverse domains (it must be noted that only ten schools are being analyzed, implying that the correlation indices and their significance should be viewed primarily as an indication of tendencies and general trends).

Changes in student role and in the nature of teacher/student interactions are highly correlated with changes in time and digital space configurations, and with new didactic solutions. In the case of teacher/teacher relationships, most correlations with other domains are very low, suggesting that the innovative practices have had little influence in teachers' communication and work patterns. The curriculum-related domains usually correlate mod-

erately and high with each other and with the rest of the domains, indicating that innovative practices compromise the curriculum in a systemic way, bringing about changes in all its components. Of all the domains, didactic solutions was the one with the highest correlation with nearly all other domains (except teacher/teacher interaction), indicating that this is the central domain of the educational innovative practices.

5. Discussion

The extent to which ICT implementation in education has affected the structure and functioning of schools, pedagogies in use, contents being taught, or learning achievements, has been a matter of controversy over the years (e.g., Cuban, 1986; Schank and Yona, 1991). However in practice, numerous successful examples of innovative ICT uses for teaching and learning are found all over the world (Mioduser *et al.*, 1999; Venezky, 2002; Voogt and Odenthal, 1999). These cases were the subjects of two international studies (IEA's SITES module 2 and OECD/CERI's Case Study) aimed to map the scope and character of the innovations, the areas and aspects of the schools' life that underwent changes, the factors that in conjunction with ICT facilitated these changes, and the prospects of these novel practices to be sustainable, transferable and scalable.

Here we elaborate on our findings in the ten Israeli schools included in the international database. The data collected were analyzed using a schema that relates to the level of innovation (i.e., assimilation, transition, transformation) in four main domains of innovation (i.e., time/space configuration, student role, teacher role, curriculum).

A first overall observation is that most practices in the participant schools, for most domains (and sub domains) considered, occur in the transitional-towards-transformational level. Taking into account that the ten schools were selected as models for innovation, a complete transformation in most aspects could be expected. However, the findings show that the assimilation and diffusion of ICT-based innovations within schools is a complex and gradual process, even under the most favorable conditions (e.g., highly motivated leaders, infrastructure, human and financial resources).

One evident aspect of this process is that not all areas of activity are affected in similar way. The innovative practices studied here concerned particular areas of the school's activity (e.g., a subject, a specific population, a novel pedagogical configuration, or communication). In fact, most resources and efforts were allocated to foster the innovation's goals in the target area, to the detriment of other areas. As a result, in nearly all schools significant changes took place mainly in those sub-domains that were relevant to the innovations focus.

Looking at the whole set of schools, most influenced are the domains of digital space and didactic solutions. Next to be affected were the student role, the teacher/student interactions, and the assessment methods. Less effected by the innovations were the physical space and time configuration, the content areas and the interactions among teachers. An important conclusion can be drawn from these observations: the main beneficiaries of the innovations studied were the students. New didactic solutions, roles, patterns of inter-

action with the teachers, learning spaces, and forms to be assessed in their learning and performance, were offered to them as a result of the innovative practices.

Another central observation is that sub-domains that underwent important changes had the power to pull with them most other domains. It is evident that all different domains were functioning and interacting in systemic fashion, and were affected in varying intensities by the integration of ICT in the school. This configuration of change resulted in a certain coherence in the overall pattern of innovation within schools (as indicated also by the coefficients of deviation level in Table 3). A consistent picture of a school can be located at any stage in the innovation level scale. For example, in school IL002 the innovative practice is consistently located slightly below the transition level in all domains, and school IL015 is coherently located at the transformation level.

As regards the school as a whole, it was already mentioned that the study focused on specific innovation practices, with no intention or possibility to draw school-wide conclusions. However, our data include a great deal of relevant information that transcends the particulars of the innovative practice, e.g., about overall vision and policy of the school and its staff, organization and structure, history of the innovations and factors involved, teachers' and parents' positions regarding many aspects of the school's life, or students' perception of their own schooling experience. These data serve to depict the context and the underlying currents within which the innovative practices evolved.

An example of the type of relation existing between the innovation and the school's context is the "islandness" phenomenon. In many schools, the observed practices appeared to be "islands of innovation", clearly discernible in the surrounding sea of traditional practices. In our study, these islands reflect particular configurations of data for the variables considered at the different domains and level of innovation. For example, in school IL015 (The computerized Greenhouse) the highest levels of transformation were observed for all domains and sub-domains (but one – interaction among teachers). Almost every aspect in the innovation implies a significant departure from the characteristics of traditional practices (e.g., space, time, roles, contents, even physical location outside the school's campus). This configuration is highly demanding (e.g., infrastructure; space, time and human resources; curricular flexibility), and it is evident that it cannot be easily implemented as the regular mode of functioning of the whole school. Other examples of "islands" are less encompassing, focusing on transformations in particular sub-domains. The innovation in School IL009 (Excellence Center) aims to support the development of the future technological leadership among the students, by means of a clear transformation in the students' roles, the way they are assessed, the contents they learn and the space (digital) within which they learn. However, by its very definition the practice is oriented to students who are able to cope with the demands and challenges of the special training and activities. Contrasting with the "islandness" phenomenon, in a few schools the studied practice was a part of an intricate Web of innovative projects and activities of various types, not only ICT-related. In these schools the encouragement of innovations is embedded in explicit vision and policy, and many staff members and students are committed to its implementation.

Key questions related to the "islands of innovation" deserve thus to be examined in depth, as regards for instance to (a) how and why these islands appear and survive, and (b) whether and how they transcend the limits of the specific practice, triggering innovative

processes in other areas and among other groups in school. A detailed elaboration on these questions is beyond the scope of this paper, and it will be presented and discussed in a forthcoming paper by the authors.

Finally, a few words on the continuation of our investigation of the case studies. First, there is the work with the international database. The possibility to analyze data from about 250 cases in about 30 countries enables the examination of questions that are beyond the scope of the present paper. These questions relate, for example, to major trends evolving in the various domains, to fine-resolution issues within each domain, to the role of cultural and contextual factors, or of national policies in the development of the innovative practices, or to organizational models developing for the assimilation and dissemination of ICT-based innovations in schools. The second line of planned work will focus on the identification and close examination of the whole set of factors (e.g., human resources, infrastructure, staff training, policy, outside-school agents) affecting the emergence and sustenance of innovative practices in schools.

In spite of the particular features of educational systems that make them more resistant than other social systems to the adoption of innovations and change, and in spite of the skeptical voices questioning the very need to promote the integration of ICT into teaching and learning process, there is no doubt that there are clear signs of change in countless examples from schools worldwide (Venezky, 2002). It is fairly clear that these are times of transitions both for technology and pedagogy (Dede, 1996). Our role as researchers is to accompany these exciting processes, shed light on the factors for success and failure, recognize evolving trends, and help to devise new and improved pedagogically sound practices using ICT.

Appendix A. The Participating Schools

A.1. IL001 – "Beehive" communication projects

Primary religious education (1–6), 620 students, 50 teachers, mixed SES, 60 computers.

This school is a saturated Web-based learning environment, participating in no less than 10 different virtual communities involved in learning via the Web in different areas. The "Beehive" project is operated by the Center of Educational Technology, a non-profit organization fostering the use of technology in schools and developing, among other products, Web-based learning environments. The emphasis in this school is on virtual communities dealing with language skills: "Reading and Writing", "Reading and Writing Stories", and "About Three Things".

A.2. IL002 – Computer trustees

Lower Secondary Education (7–9), 630 students, 53 teachers, high-mid SES, 70 computers.

In this innovation human resources are viewed as a main factor for supporting the assimilation of ICT in everyday life and in school. Students with the appropriate background

were identified in the school and offered adequate training enabling them to participate in the fluent maintenance of the computers within the school and in the construction and maintenance of the school Website. These students also participate in teacher training courses, each student serving as a tutor to a teacher. This tutoring operates also during school hours, with students helping teachers in using the ICT lab. They were also participating in community projects such as training senior citizens how to use ICT.
[URL: www.bar-lev.kfar-saba.kishurim.k12.il]

A.3. IL003 – ICT saturated learning environment

Primary Education (K-6), 1000 students, 55 teachers, high-middle SES, 200 computers.

The school was planned and built as a future model, according to an educational concept that views ICT as a means for empowering and redefining the relationship between students and knowledge, for facilitating learning skills acquisition, and improving academic achievement. Computers are implemented in most subjects, enabling a variety of learning activities, such as: animation in Arts classes, a class database, a class questionnaire edited in MS-Word, a Web quest. Students engage in ICT on an average of one hour a day, in groups, pairs and individually. Computer-based alternative assessment methods enhance students' involvement.
[URL: www.cramim.rishon.k12.il].

A.4. IL006 – The Radio Division

Secondary Education (7–12), 660 students, 80 teachers, low-middle SES, 130 computers.

The goal of the innovation is to train the students to undertake different profession in the realm of communication professions. The division is dedicated to radio broadcasting directed and produced by the students themselves. The school radio station encourages interaction between the community and the school. The students use innovative electronic equipment, including digital editing devices and specific broadcast production software, trained and guided by a specialist teacher. The students are in charge of the radio programs and create them according to their fields of interest: music, politics, sports, ecology, etc., and broadcast them on a daily basis.

A.5. IL007 – Website story

Upper Secondary Education (10–12), 1250 students, 120 teachers, middle-high SES, 120 computers.

The school's innovative project focuses on the construction of a school Internet site, a three-year project, which is currently ending its second year. The aim of the project is to build a representative as well as an active Internet site, which will serve different populations within the school and outside the school boundaries. The site contains relevant

information for students and teachers, databases in the various school subjects, and numerous interactive learning activities. It is based on the usage of innovative technology, as well as innovative teaching paradigms.

A.6. IL008 – Aviv, a Virtual High School

Secondary Education (7–12), 1260 students, 130 teachers, low-middle SES, 180 computers.

The school participates in courses initiated by ORT Israel, a network of technological education. The Aviv virtual school enables students from all grades to participate in eight virtual courses that deal with several subjects, from computer literacy to ecology or history. Some of the courses (either compulsory or voluntarily) are linked to the regular curriculum, and others are extra-curricular and completely open to all students, according to their fields of interest. The school sets an example in the field of distance learning for other e-learning schools.

A.7. IL009 – The Excellence Center

Secondary Education (7–10 grades), mixed SES, 1250 students, 200 computers.

ICT has been in the process of implementation in teaching and learning in the school for several years, encompassing all groups (lower and upper secondary classes) and all subjects (humanities, electronics, etc.). A major project is the "Excellence Center", which concentrates on computer literacy and entrepreneurial studies, and offers its services to about 200 students from the school and other schools in the area. The goal of the center is to raise future technological leadership. The training supplies students with ample knowledge in computer science and means to foster the assimilation of ICT in as many disciplines as possible. The center was adopted by many hi-tech enterprises in the area.

A.8. IL010 – The Peace Network Project

Upper Secondary Education, 1400 students, 170 teachers, middle-high SES, 140 computers.

The Peace Network project combines usage of the web, e-mail, discussion groups and virtual means, as a lever for fostering peace and communication in Israel and in the region. The web serves as a meeting place for four school populations, from two Jewish and two Arab schools. The subjects that were raised by the students were conflicts and different ways of thinking and approaching their solution. The aim of the developers is to initiate joint projects between Israeli and Arab students, and documenting these learning experiences. The e-learning and discussion is accompanied by actual meetings between students and staff from different religions and nationalities.

A.9. IL013 – Man and Surrounding Website

Secondary Education (7–12 grades), mixed SES, regional school, 380 students, 25 teachers, 25 computers.

The school web site was built as part of the educational curriculum. It contains descriptions and research dealing with physical and human aspects of the area, mainly a salt flat. The students built a database comprising materials related to the Earth Sciences, Biology, Computer Sciences and the Arts. The Website is also used as an interactive interface for online assignments. Since last year, there has been a connection between the school and a couple of schools in Jordan. The Website serves as a virtual meeting place for joint activities between the schools, and its development is due to a joint effort of students from both countries and from the U.S.
[URL: www.school.ardom.co.il, shahroot.kfar-olami.org.il]

A.10. IL015 – Computerized Greenhouse

Secondary Education (7–12), regional school, 800 students, 90 teachers, mid-high SES, 70 computers.

In the year 1984 the educational greenhouse was established in this regional school. The coordinator of the greenhouse has no formal qualification in education. He is an artist and a "natural educator". The definition of his function is complex, due to the interdisciplinary nature of his pedagogical practices. The educational greenhouse serves the purpose of research as well as final projects, which biology students are required to prepare as part of their final high school exams. The greenhouse offers students, usually the more motivated ones among them, opportunities to do real-life projects for their accreditation studies. ICT is integral to the functioning of the greenhouse and the data generates is shared with that of other research institutes in Israel, including academic centers, and the Ministry of Agriculture.

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