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Models of pedagogical implementation of ICT in Israeli schools

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Abstract The paper analyses the data collected in 10 schools in Israel which have incorporated ICT in unique ways and have succeeded in devising innovative classroom pedagogies and changes in teachers and students roles and outcomes. The major research questions addressed are: What levels of innovation were observed in the participant schools, and in which domains? How did the level of innovation in the various domains vary among and within schools? What correlation patterns among levels of innovation in the various domains can be identified? The data were analysed by mean of the *innovation analysis schema* developed for characterising ICT-based educational innovations. The findings indicate that most schools were in a transition stage towards fully innovative pedagogical implementation; school activities were effected differentially by ICT, thus creating 'islands of innovation'; these islands however, have the potential to pull forward other areas of activity and people in the school; the domains most affected by ICT were the school's *digital space*, the didactic solutions implemented and the students' roles and outcomes.

Keywords: Analysis schema; Case study; Computer; ICT usage; Innovation; Israel; Models; Pedagogy; Primary; Schools; Secondary

Introduction

A great deal of theoretical and empirical work has been done for several decades regarding the impact of ICT on educational processes (for surveys of these research efforts see Becker, 1994; Pelgrum & Anderson, 1999; Mioduser & Nachmias, 2002). 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 have been 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.

This paper reports the results of a study conducted as part of two international research projects on school innovation using ICT. One is the *Second Information Technology in Education Study (SITES) Module 2*, by the International Association for the Evaluation of Educational Achievement (IEA) (Kozma, 2000) and the other is the *Case Studies of ICT and Organizational Innovation*, sponsored by the OECD

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(Venezky & Davis, 2002). Both studies concentrated on case studies of successful and innovative implementations of ICT in about 30 countries. In Israel, 10 schools that have incorporated ICT in unique ways and succeeded in devising innovative classroom pedagogies and school system changes were examined (for a broad description of the study and its results see Tubin *et al*., in press). The research questions addressed were:

- What levels of innovation, and in which domains, were observed in the schools?
- Do levels of innovation vary among domains within a school?
- What are the relationships among levels of innovation in the different domains?

Method

School selection procedure

To select the participating schools a preliminary list of about 100 cases (recommended by the Ministry of Education, school networks, non-profit educational organisations, and Universities) of innovative usage of ICT in schools was created. By the application of defined selection criteria, the study's expert advisors' panel together with the research team selected the final list of case studies.

The selection criteria stated that an appropriate candidate was a school practice:

- that showed evidence of significant changes in any relevant educational issue (e.g. roles of teachers and students, the goals of the curriculum or infrastructure);
- in which technology played a substantial role;
- that showed evidence of measurable positive student outcomes;
- that was sustainable, transferable, and scalable;
- that was innovative, as locally defined in each country.

Data collection tools

Eleven tools were designed by the international research group and adapted locally: Principal's questionnaire; Principal's interview; computer-coordinator questionnaire; computer-coordinator interview; administrator or supervisor interview; focus-group interview of teachers involved in the innovation, and teachers not involved in the innovation; focus-group interview of students involved in the innovation; focus-group interview of parents familiar with the innovation; observations; learning products analysis.

Data collection process

Data was collected between December 2000 and June 2001 in 10 schools, by a team comprising nine researchers. Small teams of 2–3 researchers 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 typically lasted 45 minutes and were held in pairs. All interviews were recorded and all observations were written down. All data were transcribed into digital files and uploaded to the Israeli research website (http://muse.tau.ac.il/ict).

Data analysis

For the systematic analysis of ICT-based pedagogical innovations in the participant schools, the *innovations analysis schema* was developed (for a detailed description of the schema see Tubin *et al.*, in press). The schema's dimensions are defined by two axes (Table 1). The horizontal axis represents *levels of innovation*, ranging 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 levels were defined. The first level — *assimilation* — is the situation in which specific pedagogical situations change qualitatively, but the school curriculum as a whole (e.g. content and goals), the instructional means (e.g. textbooks), the learning environment (e.g. classrooms), and the learning organisation (e.g. timetable) remain unchanged. The second level — *transition* — is a situation in which ICT supports the integration, within the school's everyday functioning, of new contents, didactic solutions, and organisational solutions side-by-side with the traditional ones. In the third level — *transformation* — substantive changes take place in the school system as a whole. Traditional processes still exist, but the school identity is mainly defined by the rationale and goals of new approaches and lines of operation; student and teacher roles are enriched with new dimensions; new curricular contents are introduced; new teaching methods are developed and implemented; and for particular activities the traditional time and space configuration is transformed.

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 analysed each case-study's data using the above schema. 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 (it should be noted that the analysis units in this study are specific innovative pedagogical practices using ICT within schools, and not the whole school). The evaluation resulted in 90 school-level-locations (SLL), for 9 sub-domains in 10 schools. Out of the 90 SLLs, matching judgment was reached for 75 (83%) in the first evaluation round. The remaining 17% were discussed and elucidated by the evaluators and members of the research team, until agreement was reached.

Results

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

Levels of innovations in schools

The 10 schools presented in this study were chosen because they were considered as 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 distribution of the Israeli schools by level of innovation for each domain.

Data indicate that most schools, in most of the innovation domains, were at the transition level (65 out of the 90 SLLs — 72%), and only in few domains (17 SLLs — 19%) they had reached the transformation level. Taking into account that the 10 schools were selected as models for innovation, this distribution shows a different pattern than expected. Specific data by domain follows.

Time and space configurations

Physical space. In general, the classroom walls remained intact. Eight out of the 10 schools were in the assimilation and transition levels, with their computers located in public spaces (e.g. computer room, laboratory). The two remaining schools were in the transformation level. For example, in school IL003 the building was designed from scratch in an innovative and technology oriented approach, integrating extensive ICT facilities in all learning spaces (see description in a later section).

Table 1. Levels and domains of pedagogical innovation using ICT

Domains	Levels	Assimilation	Transition	Transformation
Time and space configur-ation	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 organisations.
	Time	Mainly embedded in the schools schedule and timetable.	Flexible access for individuals within constraints of school's 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 to 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 the 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.

Digital space. Most of the schools were located in the transition level and beyond. For example, several schools had developed websites serving as online newsboards, as portals to dynamic learning centres, or as gateways to websites all over the world.

Time configuration. Schools at the assimilation level incorporated ICT activities within their structured schedule and timetable. One example is school IL008, which operated 13 virtual courses embedded in the regular timetable. At the transition level, periods were organised in time-blocks within which the students (12yrs. - 18yrs.) were free to use the computer for their needs (e.g. students acting as computer trustees were allowed to skip regular lessons for completing their computer assignments). Five schools located at the highest levels of innovation showed a fairly flexible organisation of time. For example, high school IL006 allowed its students (15yrs. - 18yrs.) in the radio division to use ICT and work on their radio programmes during the school day and beyond, according to their needs.

Student role

Most of the innovative practices (6 out of 10) caused a significant change in the role of the students who became website constructors, teachers' assistants in ICT-related matters, or ICT projects managers. For example, in high school IL009 the students (12yrs. - 14yrs.) worked in teams to solve real problems and to accomplish projects invited (and funded) by local high-tech companies.

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

Domains	Levels	Assimilation	Transition		Transformation	
Time and space configuration	Physical space	3	2	3		2
	Digital space		1	4	3	2
	Time	2		3	3	2
Student role	Main roles		2	2	5	1
Teacher role	With students		1	4	3	2
	With teachers	1	2	5	1	1
Curriculum	Content		2	2	2	4
	Didactic solutions		2	5	1	2
	Assessment methods	2		3	4	1

Teacher role

Teacher/student interaction. Schools that were in the transition level and beyond showed interesting changes in teachers' role. For example, in high school IL007, teacher/student (15yrs. - 18yrs.) teams worked together in developing websites in about 20 subjects. This interaction eventually made the teacher more familiar with the technology, and the students more knowledgeable with the subject under study.

Teacher/teacher interaction. In 8 out of 10 innovative practices the relationship among teachers were in the transition level and below, showing limited team work.

Curriculum change

Content. ICT use affects curricular contents in diverse forms. In 4 schools in which the innovative practices pertain to the transition level or below, ICT supported only a sort of expansion of the traditional subjects. At the transformation level, schools used ICT for dealing with new subjects. For example students in high school IL013 (12yrs. - 18yrs.) developed a comprehensive website about the salt flat near to which their regional school is located (see description in a later section).

Didactic solutions. Most of the innovations observed pertain, regarding didactic practices, to the transition level, e.g. the use of digital worksheets to practice earlier studied topics, or searching the Internet for information to be used in class. At the transformation level the learning activities were qualitatively upgraded by the use of ICT. For example, in the greenhouse at high School IL015, the students engaged in research projects dealing with real problems like fish nutrition or water contamination (see description in a later section).

Assessment methods. In school innovations at the assimilation level, ICT is implemented in a traditional fashion. Innovations located at the transition (3 schools) and transformation (5 schools) levels, included the use of novel assessment procedures such as polls, websites design contest, or digital portfolios.

Characteristics of innovations in school

Although all schools in this study were innovative in a particular way, they differed from each other in many aspects. This section examines how the levels of innovation in the different domains were distributed within schools (Table 3). For each school, two coefficients were calculated: the first is school overall level of innovation (average level for all domains). The second coefficient is a measure of deviation of the nine domains from this average (SD).

Table 3. Schools levels of innovation in all nine domains

Domains	**Schools**	IL001	IL002	IL003	IL006	IL007	IL008	IL009	IL010	IL013	IL015
Time and space configur-ation	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	2
	With teachers	3	1	5	2	3	3	3	3	4	5
Curri-culum	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
Average level		2.7	2.0	4.1	3.4	3.0	2.2	3.7	2.9	4.4	4.7
Deviation		0.7	0.9	0.8	0.9	0.7	0.8	0.7	1.2	0.7	1.0

The variation in innovation level among all innovative practices suggests that ICT implementation is a process, and different schools perform at different stages of this process. The deviation of the level of innovation per domains within each school indicates that the innovative pedagogical practices have a differential impact on the diverse domains. In some of the schools the innovation level was homogenous (similar records for all domains), while in others it was very heterogeneous. This coherence can be observed at any location in the innovation level scale, e.g. IL002's innovative practice was consistently located in all domains slightly below the transition level, and IL015 was coherently located at the transformation level.

Correlation among domains of innovation

The third research question relates to the degree of correlation (Table 4) among innovation levels in the diverse domains (given that only 10 schools are being analysed, the indices should be viewed primarily as an indication of 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 patterns. The curriculum-related domains usually correlate moderately and highly 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 indicating that this is a central domain of the innovative practices.

Table 4 Correlation matrix of the innovation domains (n = 10 schools)

	Physical space	**Digital space**	**Time**	**Student role**	**Teacher - student**	**Teacher-teacher-**	**Content**	**Didactic solutions**	**Assess-ment**
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

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

Examples of distinctive models of innovation in different domains

This section gives examples of practices in specific schools, which illustrate unique aspects of the innovations in different domains.

Innovation in students' role: Computer trustees

The innovation in school IL002 was based on the involvement of students (12yrs. - 15yrs.) in the process of ICT implementation within the school. The students acted as tutors for the school staff in teacher-training courses, and assisted them in planning and implementing ICT-based lessons. They acted in a number of circles outside the school as well. They had adopted a special education school where they trained students to use the computer, to edit presentations, to search the Internet and to download learning materials. They also ran 'The Inter-Generation Connection' training senior citizens in surfing the web, using email and ICT tools. The activities supplied the senior citizens with a communication channel, as well as learning skills and enrichment to their leisure time.

The core innovation of the trustees project was that it allowed students to play an authentic and substantial role in the school's community. Students play commonly the (passive) consumers role in the school system. On some occasions they are given the possibility to play other roles (e.g. history trial, or one-day student-ruling of the school), but these are mostly simulation exercises and not real-life tasks. The trustees were considered as valuable human resources being owners of knowledge which had authentic meaning for others inside and outside the school.

Alternative space, time and curriculum: The computerised greenhouse

The computerised greenhouse is an exceptional learning environment functioning in a kibbutzim regional school. About 15 years ago the greenhouse was computerised, and ICT became an integral part of its functioning and of the learning activities in it as well. Every year, about 50–70 students (12yr. - 18yr.) plan and carry out projects in biology, technology, ecology and agriculture as part of their high school

matriculation studies. The greenhouse works as an autonomous organisation. It is run by a team including the director (also a conceptual artist) and a few part-time instructors and assistants (students) who coordinate the different fields (fish, plants, water, ICT). In addition, there are experts from research institutes and the Ministry of Agriculture who instruct the students in their research. The activity hours are every day within and after school hours, sometimes till late evening.

To explain the greenhouse's model, the director drew a triangle in which one of its sides is education, another research and experimenting and the third is art and innovation. This integration is what creates the special atmosphere on the one hand, and the flexibility of the greenhouse on the other. '*The model I believe in is the creation of islands outside the school, that can sustain themselves financially . . .* for *example, they could find contacts with high-tech companies willing to invest.'*

A 12th grade student who spent the last 5 years working in the greenhouse, commented on the learning atmosphere: *'this is nothing compared to the classroom'*, [Here] *'you don't just come, take your measurements and leave with your log, like in other schools. Here there's brotherhood, love, it's fun to work here with the people. I, for instance, am in charge of the whole fish team. If 8th grade students come, and the fish topic will interest them, I'll push them towards it, I'll get them into it, I'll want them to take care of the fish after me'.*

The greenhouse allows students to be involved in projects with real scientific, technological and economical value, in a temporal/spatial/ social/curricular configuration that represents a highly innovative alternative to traditional schooling.

Systemic school design and implementation: School of the Future

IL003 is one of 10 schools founded by the Ministry of Education in the 1990s to examine innovative educational models. It was planned and built as advanced schooling model, according to a concept that views ICT as a means for empowering and redefining the relationship between students and knowledge. The innovation of the school was in its holistic perception and integration of several components: the architectural design and physical organisation supporting the pedagogical approach; professional teams that develop and adapt curricula; the organisation into two-year 'homes' (instead of regular classes); the implementation of ICT in almost all disciplines; a variety of teaching and learning methods; an emphasis on self studying and student responsibility; the use of alternative assessment methods.

The school 'homes' were spaces for about 75 students (5yrs. - 12yrs.) of double-age grades, taught and administrated by 2–3 teachers. In each home there were 3 environments: the open space teaching area, the computer gallery and the mini-auditorium. ICT-supported learning was implemented in about 30% of the lessons. Most of the communication between staff members was through email and all didactic materials are stored in electronic databases. At the end of the 6th grade the school tests the students' mastery of ICT skills.

The academic advisor of the project assessed: '*Maybe the most evident achievement is that the teachers have become a learning community. . . . not only students, but also teachers learn in this school all the time . . . The school norms have become academic in nature, you can inquire about anything, doubt anything, you have to work hard, prepare and plan, keep track of processes via documentation and explain steps you take. It is not an ideal place, it has human weaknesses.'*

Curricular innovation: 'Humans and their surroundings' websites

One of the main goals of school IL015 was fostering the independent learner. Special emphasis was put on project-based activities, alternative evaluation, and independent studies. As the Principal (a Geologist) explained: '*the students begin with a personal project in grade 1, and end with their final project in grade 12 . . . in a variety of contents, and at different skill levels*'.

A central curricular project in the school was its continuously developing website, conceived as a dynamic learning centre containing projects by students, a bank of geographical and historical textual and visual materials, learning activities, and sections for special education and immigrant students. A special component in it was the collaboration between the school's and Jordanian students from the village of Rah'me about the nearby salt flat which is divided by the international border. This represented the opportunity to work together, also (but not only) using ICT, in issues related to the shared natural phenomenon. As phrased by a teacher: *'if we can not go now to Jordan, by pressing a key we can bring peace closer'*.

According to the Principal, one of the reasons why the school became *'a good place to go to'*, were the numerous projects running at the same time (e.g. academic such as the website construction, social as the absorption of the Ethiopian students, or cultural as theatre or music groups). '*Some teachers call me 'a community centre director', but I have no problem with that. I believe that is the way one should work. With all the respect to us as teachers, there are many situations at which students learn a lot by themselves without our intervention, and we should facilitate these situations in school. Computers are an excellent example'*.

Discussion

The extent to which ICT implementation in education has affected the structure and functioning of schools, pedagogies in use, contents being taught, or achievements, has been a matter of controversy over the years (e.g. Cuban, 1986; Schank & 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; Voogt & Odenthal, 1999; Venezky & Davis, 2002). This paper gives some details of findings in 10 Israeli schools, as part of two international studies.

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 10 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 is a complex and gradual process, even under the most favourable conditions (e.g. motivated leaders, infrastructure, human and financial resources).

Not all areas of activity in the school are affected in similar way. Usually resources and efforts are allocated mainly to foster the innovation's goals in a defined area (e.g. a subject, a specific population, a novel pedagogical configuration). As a result, in nearly all schools significant changes took place mainly in those sub-domains that were relevant to the innovation foci.

The findings indicate that the domains 'digital space' and 'didactic solutions' underwent the most significant changes by the implementation of ICT. Next were the student role, the teacher/student interactions, and the assessment methods. Less affected 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 were the students. The innovations implied for them new roles, learning situations, patterns of interaction with the teachers, learning spaces, and forms of assessment.

A central conclusion of the study relates to the type of relation existing between the innovation and the school's context. In many schools, the practices appeared to be 'islands of innovation', clearly discernible in the surrounding sea of traditional practices. The innovation is driven by a small but highly motivated group (from within and outside school), with explicit support of the Principal. However, in a few schools the studied practice was a part of an intricate web of innovative projects where the encouragement for innovation is embedded in an explicit vision and policy, and staff and students are committed to its implementation.

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 sceptical 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 & Davis, 2002). It is fairly clear that these are times of transitions both for technology and pedagogy (Dede, 1996). The task for researchers is to accompany these exciting processes, shed light on the factors for success and failure, recognise evolving trends, and help to devise new and improved pedagogically sound practices using ICT.

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