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Factors Involved in the Implementation of Pedagogical Innovations Using Technology

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Abstract

This paper analyzes the factors involved in successful implementation of innovative pedagogical practices using ICT in ten Israeli schools. The research questions addressed are:

1. What is the configuration and intensity level of the various factors involved in the implementation of innovative pedagogical practices using ICT in schools?
2. Can a connection be identified between the level of intensity of the different factors affecting the innovation and the level of change in various domains of innovation (e.g., teacher role, student role, curriculum, and time and space configurations)?

Data from ten case studies in Israeli schools were analyzed using the framework developed to measure the intensity of the factors involved in the innovation. Infrastructure, factors within the school, school climate and educational policy were found to be the most involved categories. These factors mostly affect aspects of the innovation related to teacher roles, instructional contents and teaching methods.

Keywords: ICT, educational innovation, school organization, case study, international study

The rapid and pervasive implementation of new information and communication technologies (ICT) in the education system raises expectations regarding its potential for and contribution to the improvement of education. In spite of the accelerated implementation pace of ICT infrastructure in the educational system, including connection to the Internet, we are only at the beginning of a long process (Venezky and Davis, 2001). The goal of this study is to examine the factors affecting successful implementation of innovative pedagogical practices using technology (IPPUTs) within schools.

This study is part of the international study SITES-M2 (Second International Technology in Education Study – Module 2) that examined 174 case studies of innovative pedagogical practices using technology in about 30 countries across the world, including Israel (Kozma, 2003). Common case study methods were used to collect data from principals and supervisors, teachers, students and parents as to the role of ICT in these innovative practices and the factors affecting and influencing them. Data analysis led to the formulation of implications at the policy as well as the practice levels.

This is the third of three papers reporting on innovations within ten Israeli schools that participated in the international study. In the first we presented the *innovation analysis*

schema for analyzing ICT-based educational innovations (Mioduser *et al*., 2003). The second paper presented the data collected in ten Israeli innovative schools, and its interpretation using the analysis schema (Tubin *et al*., 2003). The current paper deals with factors involved in the successful implementation of IPPUTs in these schools.

The main objective of this paper is to define the factors (e.g., human, infrastructural, organizational, internal, external) involved in the application of educational innovations using technology, to measure the intensity of each factor's involvement and to trace the connections between these factors and the levels of innovation in different school domains (e.g., learning, teaching, curriculum, time/space configuration). Our research questions were:

1. What is the configuration and intensity level of the various factors involved in the implementation of innovative pedagogical practices using ICT in schools?
2. Can a connection be identified between the level of intensity of the different factors affecting the innovation and the level of change in the various domains of innovation (e.g., teacher role, student role, curriculum, and time and space configurations)?

We believe that the findings of this study will contribute to the clarification of the conceptual framework for ICT implementation in schools, point out the challenges faced by those involved in generating and implementing the innovations, and offer operational courses of action for decision-makers.

Background

Educational change is a compound of complex and dynamic processes involving the transformation of teachers' behavioral patterns, changes in the school's identity, improvement of student performance and adaptation to environmental changes. Many researchers deal with the study of factors assisting or inhibiting the success of educational change in general (Fullan, 2001; Kinsler and Gamble, 2002), and specifically with relation to ICT (Berman and McLaughlin, 1974; Malouf and Schiller, 1995; McLaughlin, 1991). Some emphasize organizational aspects and the means by which the organization, the school in this case, prepares itself for the implementation of change in its structure and activities (Underwood and Underwood, 1990; Tyack and Cuban, 1995; Cuban, 1999). Others emphasize the teachers factor and the means by which teachers cope with the demand to change (Lortie, 1975; Lacey, 1977; Crofton, 1981; Hall and Hord, 1987). Still others examine the contribution of factors outside the school to the implementation of ICT-based innovations (Venezky and Davis, 2001).

A major factor in the adoption of change is the school principal (Fullan, 1998; Sarason, 1993). Studies found that projects receiving the principal's support were more likely to succeed, since the principal's involvement indicates that the project is being taken seriously, and it helps in recruiting both material resources and psychological support (Marsh, 2001; Berman and McLaughlin, 1977). In addition, the principal or leader of the project supplies the vision, which clarifies the joint goals for the benefit of the staff, and allows resource allocation to be conducted in the agreed directions (Rosenholtz, 1989; Meier, 1995).

Teachers are an additional important factor in the introduction of changes in schools. Teachers' resistance may be the result of unsuccessful previous experiences, lack of adequate rewarding, contradictory messages, fear of the unknown and pressure of different interest groups (Fullan, 2001). Therefore, researchers claim that teacher training is a vital component in the introduction of innovation and improvement in schools (Goodlad, 1991; Sarason, 1993). A study examining the characteristics of teacher training in ICT implementation found that, as opposed to the existing model where training occurred prior to the task and outside the school, the most efficient training was in-house and linked to the actual curriculum (Tubin and Chen, 2002).

Many researchers claim that without major change in the school structure (allocation of classes and teaching units) and in the learning processes (teaching and assessment methods) no significant change in educational process can occur (Sizer, 1993; Tyack and Cuban, 1995). Vital components of this change are organization of time and space, role distribution, communication patterns among teachers and school policy. In specific relation to ICT, a crucial factor contributing to the promotion of the innovation is the availability of infrastructure resources: hardware, in terms of the number of computers in the school available for students and teachers for educational purposes, and the quality and functioning of equipment (speed of processors, OS-operating systems, peripherals and access to the Internet); as well as available software, general and educational (Venezky and Davis, 2001). However, availability of ICT alone is insufficient and must be accompanied by technical as well as pedagogical support (Pelgrum and Anderson, 1999).

Finally, the literature addresses the role of factors external to the school. Conceiving of the school as an open organizational system with reciprocal relationships with its surroundings allows for adequate space for external intervention that fosters tendencies of change, even if this is not always very efficient (Gibton, 2001; Scheurich and Fuller, 1995). Among the salient intervening factors are the Ministry of Education, municipalities, academic supervisors and consultants, or private agents (e.g., software houses, educational services suppliers). Significant change is becoming more comprehensive and complex over time, with their implementation demanding government involvement, commitment of leaders as well as a large variety of resources. At the same time, these processes often refer to unrealistic timetables, unfit demands, simplistic solutions, and involve unsuitable resources allocation and inconsistency in performance (Fullan, 2001; Gibton, 2001). Hence the importance of systematic attempts to study the generation, development and implementation of educational innovations, with emphasis on the factors affecting these processes.

Analysis of Factors Involved in the Implementation of IPPUTs

For the current study, an analysis framework was developed based on existing literature and on the conceptual model of the SITES-M2 international study (Kozma, 2000). This framework was used to map the intensity of factors involved in the implementation of innovations using ICT in 10 Israeli schools. The analysis framework is composed of 2 axes: the vertical axis presents the various factors gathered in seven categories, and the horizontal one indicates the intensity of the factors' influence, i.e. the involvement and influence of

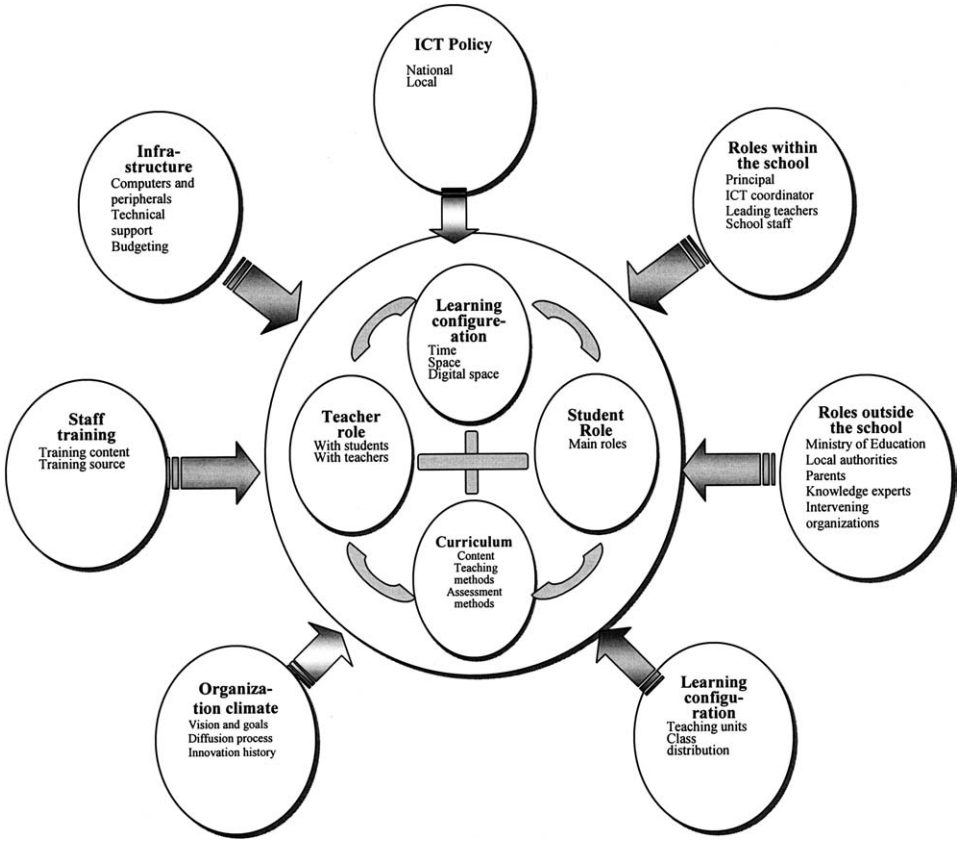

Figure 1. Configuration of the factors involved in innovations using ICT.

each factor on a 5-level scale, 1 being the lowest and 5 being the highest influence. The factor categories (Figure 1) are:

- *Roles within the school* – this category includes the principal, the computer coordinator and leading teachers, a group of staff members with additional roles in the operation of the innovation that are outstanding in their contribution. The involvement of these factors is measured on a scale referring to the extent of identification with the innovation, the type of involvement (passive vs. active) and the level of involvement.
- *Roles outside the school* – this category includes parents, external institutions involved (e.g., academic, industries, business institutes, pedagogical institutes), subject-matter experts (virtual teachers, writers of curricula, researchers and academic faculty), position holders in the Ministry of Education (supervisors, ICT advisors) and municipal position holders (director of the education department, regional coordina-

tor). The involvement of these factors is measured according to domains of involvement (financial-professional) as well as the nature of involvement (formal vs. substantial).

- *Organization of learning* – this category includes the two factors comprising the main component of the school's organizational structure (Tyack and Cuban, 1995): the layout of the learning units (lessons, fixed time units, activity hours) and the allocation of students into learning groups (single-aged, multi-aged, according to fields of interest, content, etc.). The scale is determined by the extent of flexibility, mobility or rigidity in the school's timetable.
- *Organizational climate* – this category includes the vision and goals for ICT in the school. Involvement is measured in terms of the stage of vision consolidation and clarity. An additional factor is the innovation history of the school, measured by past involvement in innovations, openness to innovations and readiness to experience innovations. Also included is the process of diffusion of the innovation in the school (Rogers, 1995), measured by the number of participants in it and time allocated for the innovation.
- *Staff training and development* – two factors are included in this category: first, the contents of the training activities measured by their relevance (the extent to which they match teachers' needs); second, the source of the staff development, measured by the accessibility of resources to the innovation operators: the range lies between external training – the less accessible type of instruction – to continuous and accessible internal training.
- *Infrastructure and resources* – this category involves ICT infrastructure measured as student:computer ratio as well as the amount of peripherals, availability and extent of use of infrastructure (from minimal to maximal utilization). Furthermore, we include technical support within the school, measured by the type of support and its accessibility on a scale ranging from external and less accessible support, to satisfactory internal support backed by external teams as the need arises. An additional factor examined was the budgeting of the innovation in terms of amount of resources and satisfaction from them.
- *ICT policy* – in this category we include national and local ICT policy. Policy considers the guidelines of the National Computerization Program and local ICT pedagogical policy, as expressed in accessibility to the Internet, acquisition of equipment and staff training. This factor is measured by the type of support given as a result of these factors (budget, training) and its effect.

Figure 1 presents the factors involved in innovations using ICT divided into categories, and their interrelationships with the innovation domains, including students, teachers, the curriculum and space/time learning configuration.

"Innovation" was defined as pedagogical practices that promote active and independent learning processes, provide students with information-handling competencies and skills, encourage collaborative and project-based learning, address issues of equity and redefine traditional space and time learning configurations (Mioduser *et al.*, 2003).

Method

Ten Israeli cases (schools) that have implemented ICT in innovative and unique ways and succeeded in incorporating innovative educational pedagogies and school-wide changes were examined.

The methodology used in this study combines qualitative as well as quantitative data collection and analysis tools. The study was conducted as a multiple case study procedure suitable for examining new, complex and unique phenomena (Yin, 1984), as is the case of school-wide innovations using ICT.

Population consisted of ten schools throughout Israel, including two elementary, one junior high, three upper high schools and four 6-year high schools. The schools were chosen by the research team and by the research steering committee, which included leading figures in the field of ICT in education from both the education system and the academy. In this paper schools will be referred as IL0XX, according to the code used in the SITES M2 school coding; each school is characterized by implementing a unique innovation using ICT:

IL001 – "Beehive" Communication Projects: Students participate in ten different virtual communities within a nation wide web-based learning environment, with an emphasis on developing language skills.

IL002 – Computer Trustees: students assist in maintenance of the school computers and construction of the school website, tutoring teachers as well as senior citizens and children with special needs.

IL003 – ICT Saturated Learning Environment: a school planned and constructed as a model for the future, that views ICT as a means for empowering students; computers are implemented in most spaces and subjects as well as in assessment, communication, pedagogical and organizational administration.

IL006 – Computerized Radio Division: radio broadcasting is directed and produced by students using electronic equipment, digital editing devices and broadcast production software, encouraging interaction between the community and the school.

IL007 – Website Story: a three-year construction process of a school Internet site, including information and interactive learning activities, based on the usage of innovative technology serving innovative teaching paradigms.

IL008 – Aviv, a Virtual High School: students from all grades participate in eight virtual courses dealing with several subjects, some linked to the regular curriculum, others being extra-curricular and complementary.

IL009 – The Excellence Center: deals with computer literacy and entrepreneurial studies, offering courses to 200 students. Its goal: raising future technological leadership; the center was adopted by local hi-tech industries.

IL010 – 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 the region. The web serves as a meeting place for Arab and Jewish students, initiating joint projects.

IL013 – Man and his Surroundings Website: contains descriptions and research of physical and human aspects of the area, mainly a salt flat; materials are related to the earth sciences, biology, computer sciences and the arts; also fostering joint work with peers in a nearby Jordanian school.

IL015 – Computerized Greenhouse: combines research and final projects for biology students, offering students opportunities for real-life projects in their accreditation studies. Data generated are shared with academic and educational research institutes.

Criteria for selection of the innovations were formulated with reference to the framework of the international study (Kozma, 2000). These included substantial influence on teaching and learning methods, changes in pedagogy, in teacher roles, in the curriculum, in student outcomes, and intensive usage of ICT. In addition, we considered the chances that the innovation be transferred to other domains and places (transferability); be widely implemented (scalability); be viable over a long period of time (sustainability) and be influential on school texture (OECD/CERI, 2000; Kozma, 2000).

Data collection tools included questionnaires, interviews and observations developed for the international study, translated into the Hebrew language. Interviews were held with principals, computer coordinators and supervisors. Focus group discussions included separate sessions with innovation teachers, teachers from the school not involved in the innovation, students participating in the innovation and their parents (Kozma, 2003).

Analysis and data processing method: using the above presented analysis framework, the categories and factors were examined and their intensity was mapped. The mapping of the factors' involvement was measured by three independent researchers. These researchers graded the involvement of each of the factors defined in the research framework on a scale ranging from 1 to 5, 1 being least involved and 5 being most involved. Cases of disagreement were followed by discussions, aimed at reaching full agreement. Alongside the qualitative data, including examples, quotes and statements, quantitative data were produced: frequencies, means, standard deviations and correlations. As a main methodological reservation, it should be noted that the validity of the statistical procedures is limited due to the relatively small number of schools (10 altogether).

Results

Research question 1. What is the configuration and intensity level of the various factors involved in the implementation in schools of innovative pedagogical practices using ICT?

Table 1 presents the frequencies of schools by factors involved in the innovation (rows) and intensity level (columns). We considered 210 school-values (referred to from now on as SV, 21 factors by 10 schools). Data shows that in most schools most factors are mildly involved. About 20% of the SV relate to factors that were involved with low intensity. For 46% of the SV (99) the factors were involved at a high intensity level.

A closer examination of the intensity level of the factors involved, together with qualitative data collected, yields the following findings.

Table 1. Frequencies distribution of schools by intensity level of factors involved in implementation of innovations using ICT (figures in columns: number of schools, $N = 10$)

Factors	Intensity				
	1	2	3	4	5
Roles within the school					
Principal			2	3	5
ICT coordinator			5	1	4
Leading teachers	1			3	6
School staff		7	2		1
Roles outside the school					
Ministry of Education		2	6	1	1
Local authorities		2	5	2	1
Parents	1	7	1		1
Knowledge experts	5		1	3	1
Intervening organizations	1		2	2	5
Learning configuration					
Teaching units	5	2	3		
Class distribution	6	1	3		
Organization climate					
Vision and goals	1		3	3	3
Diffusion process	2	2	1	3	2
Innovation history			1	4	5
Staff training					
Training content		1	6	2	1
Training source		1	6	1	2
Infra-structure					
Computers and peripherals			3	7	
Technical support			1	4	5
Budgeting			3	3	4
ICT policy					
National		1	6	3	
Local			3	4	3
Total					
210	22	26	63	49	50

Roles within the school. The principal and leading teachers are ranked high in the intensity of their involvement. Principals are highly significant in leading processes, planning, and budgeting. They consider the innovation important to the school and are motivated by interest, beliefs, dreams, improvement of teaching and learning processes, competition with other schools, prestige and the need to be up to date.

Teachers see the principals as visionaries, role models, encouragers of innovation, open to new ideas and facilitators of teamwork. "The innovation will go on as long as the principal is in the school, because he's mad about it. . . " (expression by involved teachers, in school IL013).

But the principals cannot act on their own. In all schools leading teachers were identified as playing a major role. These figures act in teams, exhibiting solidarity and playing a clear role in the dissemination of the innovation. In IL013 the principal says: "The stability depends on the leading staff. . . There's something extremely important in a leading figure, but there's something much bigger [stronger] in a leading staff". Leading staff are usually not adequately rewarded for their extra input and much of their activity is voluntary. Therefore, a vital component of the stability of the innovation is these leaders' motivation.

The computer coordinators were also found to be a factor with considerable impact on the innovation, playing a twofold role: one, as technical and pedagogical coaches and assistants in solving problems, and two, as leading figures in implementing the innovation, especially in cooperation with staff members. "If not for her initiating character, her openness to change, her support of fellow teachers, her encouragement to join the process and her actions towards fund raising, I doubt that we would have overcome the problems that came up in the course of the innovation" (Teacher, IL002).

Little effect was found with regards to the school staff as a whole. Excluding one school, in which all 55 staff members were involved in the innovation, staff were graded as having a moderate-and-lesser influence, mainly in two ways: playing minor roles in the innovation (such as having computer trustees in his or her class), and promoting the innovation without involvement in its implementation.

Partners outside the school. Intervening organizations have a profound influence on the innovation. In all schools an external factor was involved, in financing, planning and decision-making processes or in the diffusion of the innovation. Among these were academic institutions, research institutes, hi-tech industries or companies that see schools as sites for technological development, for examining products and learning about their potential implementation in the educational system. For example, the computerized greenhouse "was supported warmly in the hi-tech world. A connection was established with the hi-tech industry. They help us, and we invite them to conferences" (The innovation director, IL015).

Decision makers at the Ministry of Education and in the municipalities were moderately involved. Most schools reported that the ministry was open to the innovation, backing it with moral, pedagogical and financial support. The ministry supports ICT implementation via trainers and conferences. Some schools reported that the ministry sees itself as a partner in the planning and executing of the innovation. Others reported difficulties the ministry created in the approval of curricula and their insufficient directing of policy in the field of virtual courses; as claimed by one of the principals: "The ministry does what it can, but not what is necessary".

All schools were financially supported by their local authorities; they also supported about half of the schools in content-related aspects. However, the support was not always as required, due to equity issues with reference to the remaining local schools. Local authorities also took responsibility for the public relations of the innovations, by forging links with governmental and industrial authorities and transmitting a positive impression of the schools' activities.

Low intensity of influence was found for the factors "parents" and discipline-experts. In most schools parent support was financial. The parents felt involved and updated, aware of he benefits of the innovation. In two schools the extent of parent involvement was higher compared to others, reaching a maximum level of collaboration and sharing in decision-making, in implementation and diffusion of the innovation, in leading educational processes and in participation in teacher training sessions.

In half the schools there was no expert involvement. Such involvement came from experts from local research institutes, engineers, programmers and computer experts. Only in one school external expert teachers taught virtual courses in cooperation with local teachers and students. According to local teachers, the virtual teacher supplied additional knowledge, tools and skills, acting as a mediator.

Learning configuration. About half the schools reported minor change in the nature of the teaching units. The innovation was conducted as part of the traditional timetable, the timing of the activity depending on accessibility of computer labs. Sometimes activities occurred in parallel with the regular timetable, including a small group of students, and sometimes the timetable was modified according to needs. In most cases the innovation potential was not realized due to lack of compatibility to the timetable.

Also the "distribution of students" factor was low in involvement. Most than half the schools kept the traditional single-age classes. One school was flexible, distributing students into groups. A considerable change was spotted in the formation of mixed-aged student groups in certain disciplines, although limitations of time and number of students were not overcome.

Organizational climate. The "innovation history" of the school, the "vision" and the "ICT goals" factors were all found to be highly involved in the implementation of the innovation. All schools but one had a rich and long history of innovation. The schools initiate innovative projects in different domains, and present them in conferences, exhibitions, contests and conventions in Israel and abroad. For example, IL010 won first place in a contest in Japan for its innovation. In another school students' papers won awards and diplomas (IL015).

The schools visions include goals such as: substantial ICT implementation in education, educating an independent learner, increasing teachers' sensitivity to students' needs, making learning time and place more flexible, variability of fields of interest, increasing motivation, increasing parents' connection with the school and using outside resources. Only one school was found to have a unclear ICT vision and goals, in terms of the desired goals and purposes of diffusion of ICT within the school.

The "diffusion of the innovation" factor ranges from specific and localized diffusion, where only leading figures are involved (without interaction with the entire school staff), through a wider implementation, with additional staff joining the innovation, and finally, maximum involvement, as the innovation becomes an integral part of the school life. In half the schools the innovation is conducted along with the regular school life in terms of physical space and time slots. In contrast, in IL009 for example, the Excellence Center is at a separate location within the school, and involves separate activities. The center is

open both during school hours and in the afternoon, and is attended by 200 students (out of 1250 in the school) mostly the excellent (most able) ones, learning courses of their choice by their own initiative and motivation.

Staff training. This factor was mildly involved, both with respect to the contents and source of training. In all schools teachers received external training according to their needs and interests. In schools that rated high on this factor, training was supplied by resources within the school, involving external support of experts according to needs. An interesting phenomenon was detected in IL002, in which students, computer trustees, had a part in staff training: "The training of computer trustees left a strong impression because of two reasons: one, we learned through the point of view of the kids, and secondly, not less important, the kids found out that we are also flesh and blood: not always understanding and knowing, and in fact, behaving like them, like students". (A teacher)

Infrastructure and resources. All factors within this category are ranked high in their involvement, the lowest one being "computers and peripherals". Most schools nowadays were found to have an incomplete infrastructure, used to its maximum. The need for upgrading equipment was always raised. The existing infrastructure, above the national average, did not succeed in supporting all developments, e.g. distance learning and development of teaching units.

Great importance was attributed to "technical support". Half the schools were graded with maximum intensity on this factor, reporting sufficient inner and outer support, mostly the former. The other schools reported using part inner support and part external support, according to needs, except for one school, which used mostly external support. Support was supplied by the local authorities and by expert companies. In two schools computer trustees were a vital part of the support: "They distributed a booklet on frequent failures and are operating a support center by phone". (Teacher)

All schools received *financial* support from two external sources, at least. However, only four schools indicated that the amount was sufficient for the operation of the innovation, its maintenance and development. The financing bodies are mostly the municipality, the Ministry of Education, and parents. Budgets are used for financing infrastructure (hardware and software), technical support, staff training, rewarding teachers, operating online courses, etc. The limitation of funds is the result of a commitment of the municipality to equally distribute resources among all schools. On the national level, there is fear of breaking standards, through, for instance, special approvals for virtual courses or matriculations curricula.

National and local ICT policy. There is consensus about the importance of ICT implementation in teaching, and indeed, schools that engage in it are greatly supported. However, local policy was found to be more supportive than national policy. Local policy supports and encourages financing of infrastructure, participation in costs of Internet connection, technical support and staff training.

Most schools ranked national policy as being mildly influential, although some claimed that its influence de facto was minor. They indicated that they are not familiar with

Table 2. Rating of factors involved in implementation of innovations using ICT according to average degree of involvement

Category	Name of factor	Average	*SD*
High			
Organizational climate	History of innovation	4.4	0.70
Infrastructure	Technical support	4.4	0.70
Roles within the school	Principals	4.3	0.82
Roles within the school	Leading staff	4.3	1.26
Infrastructure	Budgeting of the innovation	4.1	0.88
ICT policy	Local policy	4.0	0.82
Roles outside the school	Intervening organization	4.0	1.33
Roles within the school	Computer coordinator	3.9	0.99
Medium			
Infrastructure	Computers and peripherals	3.7	0.48
Organizational climate	ICT vision and goals	3.7	1.27
Training	Source of training	3.4	0.97
Training	Contents of training	3.3	0.82
ICT policy	National ICT policy	3.2	0.63
Roles outside the school	Local ICT policy	3.2	0.92
Roles outside the school	Ministry of Education	3.1	0.88
Organizational climate	Diffusion of innovation	3.1	1.52
Low			
Roles within the school	School staff	2.5	0.97
Roles outside the school	Disciplinary experts	2.5	1.65
Roles outside the school	Parents	2.3	1.06
Learning configuration	Teaching units	1.8	0.92
Learning configuration	Class distribution	1.7	0.95

national-level documents or written papers addressing the issue at the school level. National policy effects can be recognized in staff training plans, in efforts to disseminate innovative ideas, and in infrastructure supply by equipping schools with an "ICT package" (computers, software and Internet connection). It seems that the Ministry of Education actively supports establishment of infrastructure and training, yet does not interfere in the manner of ICT implementation in pedagogical processes. Some see the matriculation exams as a major factor inhibiting implementation of innovations at the high school level.

Rating of factors according to involvement level and category

Still regarding Research question 1, Table 2 presents the rating of factors by their degree of involvement.

This rating by intensity level leads to several observations: The distribution of levels of involvement of the factors covers an ample range of values (averages between 1.7 and 4.4); about a third of the factors show a high level of involvement; there is no overlap or correspondence between the factors' average level of involvement and the categories to

which they belong (e.g., within a given category ample variation in level of involvement of factors can be found).

Factors related to "infrastructure" and to leading roles within the school clearly have high levels of involvement in the innovation. In contrast, factors related to the "learning configuration" (e.g., time/space organization) had very low involvement. Categories of factors related to organizational aspects (e.g., climate, policy) were found to have noticeable involvement in the innovation.

Research question 2. Can a connection be identified between the level of involvement of the different factors affecting the innovation and the level of change in the various domains of innovation (e.g., teacher role, student role, curriculum and time and space configurations)?

Table 3 presents correlations among the involvement levels of the various factors and the level of innovation in the domains of the innovative pedagogical practice using technology (for additional details about the domains of innovation, their definition and characteristics, see Tubin *et al*., 2003; Mioduser *et al*., 2003).

Factors within the school. Significant correlation was found between the involvement of all staff members as well as of specific teachers leading the innovation, on one hand, and change in teachers' relations with their fellow staff, on the other. The more staff members and leading figures are involved, the expertise of teachers involved in the innovation grows, their commitment to one another becomes greater, and their collaboration increases.

Learning configuration. Significant correlation was found between the organization of teaching units (time/space) and the sub-domains teacher roles (among teachers) and innovation content. The more flexible and varied the organization of teaching units, the more the relationships between teachers changed and the level of content innovation increased (e.g., by the creation of interdisciplinary subjects, or subjects developed according to students' choice). A similar result was obtained with relation to allocation of students to classes: the more openness and flexibility they displayed, the more solutions related to the configuration of the physical space were innovative (e.g., for learning within and beyond school hours), as well as contents and teaching methods (e.g., implementation of inquiry tasks, projects).

Organizational climate. A positive correlation was found between the school's innovation history and the level of innovation in relationships among teachers. The longer and the richer the school's innovation history, the more teachers display expertise and cooperation in the application of the innovation.

Staff training and development. A positive correlation was found between the relevance of the staff training and the level of innovation in teachers' role relating to their peers. Also, a negative correlation was found between accessibility of training and teachers' role

Table 3. Correlations between intensity of the factors involved in implementation of innovations using ICT and the innovation domains

	Physical space	Digital space	Time	Student role	Teacher–student	Teacher–teacher	Content	Didactic solutions	Assessment
Roles within the school									
Principal	0.018	−0.112	−0.371	−0.347	−0.391	0.405	−0.044	−0.115	0.246
ICT coordinator	0.267	−0.046	−0.055	−0.057	−0.162	0.479	−0.200	0.243	0.017
Leading staff	0.248	0.386	0.006	−0.046	0.110	0.670*	0.477	0.344	0.432
School staff	0.532	0.000	0.282	0.294	−0.118	0.779**	0.279	0.378	0.261
Roles outside the school									
Ministry of Education	−0.135	−0.079	−0.295	−0.457	−0.210	0.242	0.124	−0.036	−0.019
Local authorities	−0.016	0.476	0.290	0.498	0.225	0.022	0.236	0.046	0.422
Parents	0.362	0.022	−0.436	−0.270	−0.087	−0.067	−0.119	0.109	0.271
Expert teachers	0.089	0.558	−0.024	0.173	0.139	0.092	0.219	0.222	0.460
Intervening organization	0.498	0.000	0.235	0.429	0.173	−0.151	−0.068	0.236	0.127
Learning configuration									
Teaching units	0.578	0.401	0.307	0.373	0.275	0.637*	0.748*	0.525	0.588
Distribution of students	0.685*	0.461	0.487	0.542	0.461	0.607	0.800**	0.652*	0.587
Organizational climate									
ICT vision and goals	0.106	−0.202	−0.257	−0.320	−0.386	0.540	−0.116	0.075	−0.094
Innovation diffusion	0.262	−0.045	−0.221	−0.188	−0.347	0.603	−0.107	0.186	0.155
Innovation history	0.274	0.428	−0.022	0.164	−0.066	0.780**	0.362	0.270	0.507
Staff training									
Contents	0.377	−0.391	−0.371	−0.347	−0.531	0.650*	0.066	0.013	0.041
Source (accessibility)	0.122	−0.524	−0.584	−0.592	−0.643*	0.564	−0.112	−0.239	−0.070
Infrastructure									
Computers/ peripherals	−0.031	−0.286	−0.503	−0.355	−0.524	0.355	−0.299	−0.239	−0.070
Technical support	−0.042	0.099	0.538	0.491	0.099	0.058	−0.026	0.120	0.024
Budgeting the innovation	0.034	0.184	0.600	0.326	0.447	−0.334	0.227	0.323	0.077
ICT policy									
National ICT policy	0.093	0.509	−0.074	0.000	0.145	0.511	0.486	0.232	0.480
Local/regional ICT policy	−0.542	0.141	−0.384	−0.280	−0.282	0.000	−0.332	−0.385	0.000

* $p < 0.05$.
** $p < 0.01$.

relating to students. However, training was measured with relation to all staff members, while the innovation level of teachers' role was measured only within the boundaries of the innovation. This means that the teacher's role becomes more innovative the less the training is shared by all staff members.

Factors in the categories of roles outside the school, infrastructure and ICT policy were not detected as having significant correlation with any of the innovation domains.

Discussion and Conclusions

There is agreement between researchers that ICT implementation in schools is a complex process, involving many factors (Mioduser *et al.*, 2003; Pelgrum and Anderson, 1999; Venezky and Davis, 2001), but there is still uncertainty as to the extent of involvement of each factor in the implementation of the innovation and its influence on the level of innovation in different domains of the school activity. The current paper addresses this issues, based on data related to 10 case studies of Israeli schools implementing ICT in an innovative manner.

The main finding is that while a whole set of factors are involved in the innovation, not all of them affect it evenly. The most important mix of "ingredients" is: a history of innovation backed by encouraging local ICT policy, in conjunction with three main leading forces: the principal, leading staff and the ICT coordinator. These forces strive to implement the innovation by seeking adequate infrastructure (finance, technical support), and recruiting external intervening organizations.

Conclusions from other studies receive new meanings in the light of our findings. For example, the statement that teachers and their training is one of the main factors in implementing change (ECS, 1999) is proven only partially correct. A group of involved teachers constitutes a factor of high importance, however the staff as a whole is a less critical factor for the success of the innovation. Staff training is mildly necessary for the innovation – it seems that leading staff base their knowledge on other sources, personal ones, as opposed to organized staff training.

There is agreement that computers alone do not create innovation (Venezky and Davis, 2001). However, still, to many the amount of computers within a school is an indicator of the extent of ICT implementation, more than the quality and quantity of technological or other support (Pelgrum and Anderson, 1999). In contrast, our data reveal that technical support is more valuable than the amount of computers. This factor is so vital that schools activate several means for achieving it, such as recruiting students as computer trustees, engaging expert teachers or external factors (e.g., a school graduate formerly involved with the computerized greenhouse, or a high-tech-genius who is a former student, and who continues coaching young students on a voluntary basis). This means that full support in an environment with less computers is more effective than having more computers without enough support.

An additional conclusion involves the categorization of the different factors. According to the literature (Fullan, 2001; Kinsler and Gamble, 2002; Kozma, 2000) and Figure 1 presented at the beginning of this paper, the categories are evenly involved in the implementation of the innovation. However, according to our findings, they differ in the extent of their involvement. For example, categories associated with the school itself (infrastructure, roles within the school and organizational climate) are of greater importance than external categories (ICT policy, training, external roles), as presented in Figure 2.

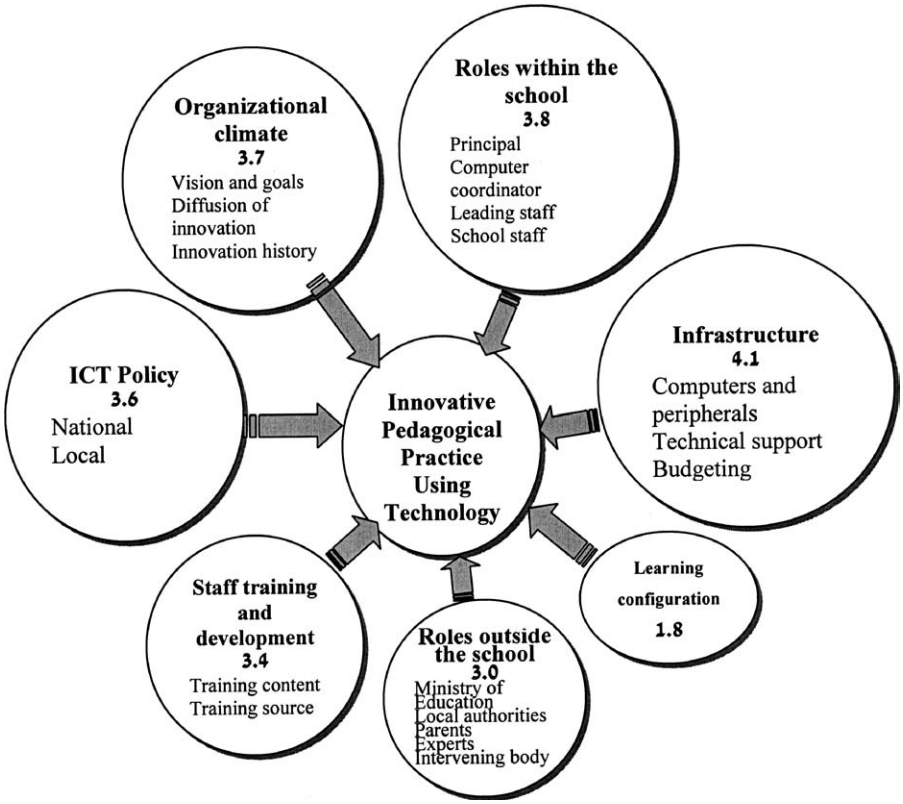

Figure 2. The average intensity of involvement of categories in the implementation of the innovation.

The least powerful category is that of learning configuration. This, along with the low involvement of parents, supports prior findings (Tubin *et al*., 2003, Mioduser *et al*., 2003), stating that innovations using ICT can be implemented even without a major change in learning configuration (time and space). The preservation of the familiar structure of the school reassures parents, in that it can still be considered a "real school" (Tyack and Cuban, 1995).

An attempt to seek connections between the factors and the levels of innovation produced shallow results. In brief, the various factors mostly affect roles of teachers involved in the innovation, and to a minor extent – contents and teaching methods. It obviously will take the examination of a far larger group of schools implementing ICT to construct a more reliable picture of the interactions among the different factors affecting the introduction and sustenance of innovations.

Finally, our findings raise additional questions that deserve to be examined in future research, such as: Why are some factors more important than others? Are their intensities related to, and do they change, as a result of the life cycle of the innovation (e.g., its implementation stage, sustainability issues)? What are the correlations between the fac-

tors and the nature and properties of the innovation? We believe that the findings of this study, addressing the initial identification of the various factors and their intensity level of involvement in the innovations can assist decision-makers (who frequently face key issues addressing financial investments, e.g., computers or training, local supervision or support from intervening organizations) in the planning and implementation of ICT-based school-wide educational innovations.

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