Cross-case analysis of innovative pedagogical practices using technology

Article · June 2010
DOI: 10.1109/ICETC.2010.5529178

Alona Forkosh Baruch
Levinsky College of Education

D. Mioduser
Tel Aviv University

Innovative Pedagogical Practices Using Technology: Cross-Case Analysis of the SITESm2 Data

Alona Forkosh-Baruch, Tel-Aviv University, alonabar@post.tau.ac.il
Rafi Nachmias, Tel-Aviv University, nachmias@post.tau.ac.il
David Mioduser, Tel-Aviv University, miodu@post.tau.ac.il

Abstract

The study reported herewith is based on data collected in the IEA SITESm2 study, conducted between the years 2000-2002, including case studies of innovative pedagogical practices using technology within schools (Kozma, 2003). Our study offers secondary analysis of the 174 cases from the 26 participating countries (see http://sitesm2.org), attempting to identify domains and levels of innovative practices, as well as factors involved in its successful implementation. Our study quantifies the qualitative data collected and reported in the SITESm2 database as narrative case studies. In order to achieve this goal, a theoretical as well as a methodological framework was developed and a pilot study was carried out using the 10 local technology-based innovations, in an attempt to assess our framework. Our report in this paper includes analysis of the full database. Results show that: (a) diffusion of ICT-based innovations within schools is a complex and gradual process, affecting each of the school domains differently; (b) factors are involved in the innovation on varying levels. Considering results from the SITES2006 study, stating that ICT implementation is practiced mostly with regards to a traditional educational paradigm, it is imperative we learn as much as we can from the successful and exemplary educational initiatives of the SITESm2 study, mostly based on an emerging paradigm, referred to in the SITES2006 study as the life-long-learning and connectedness paradigms.

Keywords: secondary analysis, domains, factors, innovative practices

Introduction

Information and communication technologies (ICT) have been a part of our lives for the last few decades, affecting individuals' and societies' venues of life at all possible levels – e.g work, business and consumption of goods, communications and organizational issues, leisure time, as well as education, i.e. teaching and learning processes. However, with respect to schools, these maintain their traditional image as organizations inclined to a rather conservative structure. In the midst of an era of continuous transformation stemming from the characteristics of the

Information Age, schools are perceived, even at the threshold of the new millennium, as social organizations with a remarkable conservative tendency to preserve their long-established structure, adopting change only by modest incremental steps, one step at a time. Much effort is being made by educational systems worldwide to successfully implement ICT in schools, in an attempt to facilitate significant changes in teachers' instruction and students' learning. These changes, which are the focus of our secondary analysis, are expected to affect school life and the school milieu altogether, at various levels, via the creation of new learning contexts and configurations (beyond the traditional time and space constructs), the development of new pedagogical solutions, or the expansion of schooling beyond school boundaries (Mioduser, Nachmias, Tubin and Forkosh-Baruch, 2003; Nachmias, Mioduser, Cohen, Tubin and Forkosh-Baruch, 2004).

Background

Traditional organizational-structure and functioning of schools are well rooted within education systems all over the world. What Tyack and Cuban (1995) define as the *grammar of the school* (e.g., age-graded classrooms, rigid time units) has been shaped by social and economical forces, engraving a standardized institutional template, which inhibits the adoption of change and slows down the process even in institutes that are willing to consider alterations in their teaching and learning processes.

Schools tend to maintain their traditional teaching and learning paradigms, with predispositions to a somewhat conservative structure (Law, Pelgrum & Plomp, 2008). This hinders the adoption of change at large even in schools that experiment focal modifications in teaching and learning processes. Yet, educational systems, led by policymakers, recognize the advantages of technology implementation in education, as means for supporting individual growth, professional development and systemic change in educational contexts (Gibson, 2002). Hence, changes in school structure do occur in correspondence with transformations in the social-economical environment within which the school functions. ICT is an example of a novelty or innovation conveying fundamental impact, thereby transforming all aspects of our lives. Therefore, it is only expected that ICT implementation in schools will affect their grammar and bring about, as a result, the essential transformations in their structure (Watson, 2001).

An innovation in general and relating to ICT implementation in particular, can be regarded as a shift in educational paradigm (Berghel and Sallach, 2004; Law, Pelgrum and Plomp, 2008; Pelgrum and Anderson, 1999). For the last few decades the educational community has adopted the idea that schools should play an essential role in preparing students to act and live in the information society. According to this idea, relying on the life long learning paradigm, the school's main goal is to provide the required skills for living and working in a world of continuous change (Fisher, 2000). ICT, as a driving force behind the creation and evolvement of the information society, plays a major role in this paradigm-shift. Hence, innovations can be defined in operational terms as a wide range of activities and means (e.g., curricular decisions, learning materials, learning configurations, lesson plans, tools and resources) that reflect schools' orientation towards lifelong learning.

Attempts have been made by researchers and practitioners to develop frameworks, aimed to characterize the manner in which ICT may support and promote educational innovation. In IEA's SITES M2 study rationale, ICT-based innovations are characterized in four main dimensions: curriculum content and goals, student practices (activities, products, roles and collaborations), teacher practices (methods, roles and collaborations), and the ways of ICT use in schools (Kozma, 2003). The North Central Regional Educational Laboratory (NCREL) suggests "a framework for understanding the system wide factors that influence the effective use of educational technology" (enGauge, 2002). Lemke and Coughlin (1998) offer a seven-dimension framework of progress indicators from present education to future education: learners, learning environments, professional competency, system capacity, community connections, technology capacity, and accountability. Each dimension is evaluated in a three-level continuum: entry, adaptation, and transformation level. In addition, some researchers focus on change processes and paradigms in the broader sense (e.g. Rogers, 2003; Tyack and Cuban, 1995) and the potential of ICT to facilitate change in several components of the school milieu (e.g. Pelgrum, Brummelhuis, Collis, Plomp, & Janssen, 1997; Plomp, Brummelhuis, & Rapmund., 1996).

Indeed, the incorporation of ICT for eliciting change and innovation is a multi-factor effort, demanding that all involved personnel and means be interconnected in a joint effort to bring about the desired consequences. Researchers study the multiple factors assisting or inhibiting the success of educational change in general (Fullan, 2001; Kinsler and Gamble, 2002), and specifically with relation to ICT (Malouf and Schiller, 1995; Owston, 2007; Tearle, 2003). Emphases of studies focusing on educational change vary: organizational aspects in the implementation of changes in structure and activities (Underwood & Underwood, 1995; Tyack & Cuban, 1995; Cuban, 1999); school leadership and its significance (Wong, 2008; Yuen, Law and Wong, 2003); the teacher factor and their coping with the demand to change (Lacey, 1977; Crofton, 1981; Hall & Hord, 1987); or the contribution of outside-school factors' to implementation of ICT-based innovations (Venezky & Davis, 2001).

In our study, we propose a comprehensive examination of the concept of innovative pedagogical practices, by analyzing levels of change in 9 domains shared by all initiatives using ICT in K-12 schools, as well as analyzing the factors involved in these innovations, using data from the SITESm2 case study database. Hence, the purpose of the study was twofold: (a) validating the conceptual framework, developed by the authors and tested on a pilot of 10 local case-studies; (b) extracting quantitative data from the case studies, thereby creating a comprehensive comparative database which allows statistical manipulation and generalizations, contributing to future research on diffusion of innovations in education, particularly initiatives in which ICT plays a major role as a lever for change.

Our study proposes a secondary in-depth analysis of IEA-SITESm2 international research study using (a) and analysis schema for characterizing ICT-based educational innovations; (b) a classification of factors measuring the intensity of their involvement in the innovation.

Domains and Levels of ICT Implementation

Four major domains of innovation are included in our analysis schema of innovative pedagogical practices using technology: organizational issues (mainly concerning time and space configurations), student roles, teacher roles, and curriculum issues. Our analysis schema (see methodology section) is based on a number of assumptions: (a) An educational innovation is usually not a one-shot event, but rather a complex process evolving over time and involving many participants. The diffusion process of the innovation is time consuming, requiring the bridging between traditional technology and ICT; (b) Furthermore, we assume that when incorporating a new technology we use previously recognized models as input to its assimilation process, resulting in a period of transition. For example, when first incorporating computer technology in education, developers replicated the programmed instruction paradigm by means of the new technology, initially in the form of electronic worksheets and booklets evolving eventually into sophisticated drill and practice and structured tutoring software (Venezky and Osin, 1991); (c) There are several levels of implementation of the technology-based innovation. As opposed to the term "stages", we prefer the term "levels", which represent growing complexity that requires greater resource input (e.g. time, training, infrastructure, alteration of curriculum). However, this does not imply homogeneity in levels of innovation in the domains included in the school milieu – rather, different domains can be characterized as more or less innovative, whilst the overall "innovativeness" of the educational enterprise gives a more general notion (Mioduser, Nachmias, Tubin and Forkosh-Baruch, 2003).

Factors involved in ICT Implementation

Educational change – being a multifaceted complex and dynamic process and involving the transformation of teachers' behavioral patterns, change in the school's identity, improvement of student performance and adaptation to environmental changes – relies on the interaction among several factors. In our study, the assumptions underlying the definition of the array of factors involved in the innovations were: (a) being a complex process, innovations compromise interaction among many factors, e.g., human factors (inner-school as well as outsiders) institutional configurations, training issues, policy issues or infrastructure issues relating directly to ICT; (b) The several factors involved in the innovation must be pre-arranged in a meaningful layout, in an attempt to further understand what underlies behind successful innovations using technology; (c) Not all factors and groups of factors can or should be equally involved in the innovation, therefore a scale should be assembled for measuring the rate of involvement of each one – for greater insight of the innovations. For the study, the defined factors (see methodology section) were classified into groups, each group representing a different aspect of the organization (Nachmias, Mioduser, Cohen, Tubin and Forkosh-Baruch, 2004). Factor groups included in our analysis included position holders and staff within the school, role players outside the school, issues related to learning organization, organizational climate, staff training matters, aspects of infrastructure and resources, and finally, ICT policy on different levels.

Methodology and Data Sources

The data source used for this study was the case study database of the innovative pedagogical practices using technology' located online at http://sitesm2.org – altogether, 174 case studies were used for our secondary analysis. To qualify for the study, international criteria stated that the data include innovations exhibiting evidence of significant changes subsequent to ICT introduction, ascribing a substantial role to technology, as well as showing indication of sustainability, transferability, and scalability.

Data Analyses Tools

For the systematic analysis of ICT-based pedagogical innovations in the schools' international database, we developed the *domain analysis schema*, described herewith (Table 1). The schema's dimensions are located within a grid defined by two axes. The horizontal axis represents the levels of innovation, beginning with minor alterations of the school's routine as a result of ICT assimilation, to eventual extensive transformations of pedagogy and learning processes. Three main levels were defined, creating a progressive continuum regarding the innovation: assimilation, transition and transformation levels; 2 additional sub-levels were inserted between 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. Three of the four domains were further detailed, generating a total of 9 items representing the school milieu.

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.

Each innovation was graded on a 1-5 Likert scale in 9 domains; the scale indicates the level of innovation in each of the domains according to 3 major levels (assimilation, transition and transformation) and two in-between levels (for details, see Mioduser, Nachmias, Tubin, & Forkosh-Baruch, 2003; Tubin, Mioduser, Nachmias and Forkosh-Baruch, 2003). Also, grading was carried out with regards to 21 factors involved in the innovation, also on a 5-point scale, according to the indicators detailed in Table 2 (for details, see Nachmias, Mioduser, Cohen, Tubin and Forkosh-Baruch, 2004).

Table 2: Levels of factors involved in pedagogical innovation using ICT

Factor categories	Factors	Indicators 1 2 3 4 5
Roles within the school	Principal	Extent of identification and personal resources devoted to the innovation
	Computer coordinator	
	Leading teachers	
	Teaching staff	
Roles outside the school	Parents and the community	Extent of involvement in the innovation
	External institutes involved	
	subject-matter experts	
	Policymakers in the Ministry of Education	
	Municipal position holders	
Organization of learning	Learning units in terms of time, place or content	Rate of flexibility
	Allocation of students into learning groups	
Organizational climate	ICT vision and goals in the school	Clarity of the vision
	Diffusion of the innovation in the school	Scope of the innovation
	Innovation history of the school	Prior experience / involvement in innovations, openness to innovations
Staff training	Content of training	Relevance and response to needs
	Source of staff development	Accessibility to training source
Infrastructure and resources	Amount of computers and peripherals	Amount, availability and extent of use of infrastructure
	Technical support	Type of support and its accessibility
	Budgeting of the innovation	Amount of sources and satisfaction
ICT policy	National	Type of support and its influence
	Local or regional	

A sample consisting 15% of the total cases was double-graded by 2 independent judges, leading to an agreement rate of 94.34% of the ratings; agreement was defined as exact matching of grading or a gap of 1 between two gradings. A quantitative database was constructed as a result of the transformation of the narratives into numerical data, enabling statistic procedures and tests.

Findings and Discussion

Domains and Levels of ICT Implementation

Findings refer to two major issues examined in our study: domains and levels of innovativeness in the pedagogical practices using technology. In the analysis of the domains, their averages were computed using all 174 cases, 9 gradings for each sub-domain. The higher the average level, the greater the rate of innovativeness was considered. The following table displays the average levels of innovation for each domain and sub-domain (Table 3).

Table 3: Averages of levels of innovativeness of 4 domains and 9 sub-domains of innovative pedagogical practices using technology (including SD)

Domains	Sub-domains	Average	SD	Average	SD
Time and space configuration	Physical space	2.69	1.42	2.88	1.13
	Digital space	3.16	1.21		
	Time	2.78	1.46		
Student roles	Main roles	3.23	1.29	3.23	1.29
Teacher roles	With students	3.32	0.96	3.18	0.92
	With teachers	3.02	1.36		
Curriculum	Content	3.07	1.16	3.10	0.98
	Didactic solutions	3.31	1.00		
	Assessment methods	2.92	1.45		
	Total Average			3.10	1.08

The average levels of innovation in the four domains range from 2.88 (the lowest level) to 3.23 (the highest level), with an average of 3.10 on a 1-5 Likert scale. The highest level of innovativeness was measured for the domain *student roles* (3.23); however, the variance in this domain was also the highest (SD=1.29), implying a broad range of values compared to other domains. The lowest level of innovativeness was measured for the domain *time and space configuration* (2.88). In this domain, variance was also relatively high, 1.13, second highest among the domains, also implying a wide range of values for this domain. This finding indicates that although there are differences between domains in average values of innovativeness, the range is also of great importance. Apparently, the extreme averages are composed of broader ranges of values, implying quite high values for *student roles* and quite low values for *time and space configuration*. This emphasizes the potential of innovative pedagogical practices to facilitate change in *student roles*; however, it also highlights the difficulty in applying change in terms of schools' *time and space configuration*.

In three of the four domains we defined sub-domains, in an attempt to get more precise data about the levels of innovation of the different aspects of the school milieu, as well as the variances. Also, the domain averages may display a somewhat general notion of the analysis of the innovation. The grading was similar to that of the domains: on a 1-5 Likert scale.

As may be expected, the range between the lowest average and the highest average has grown, the lowest (2.69) belonging to *physical space*, and the highest (3.32) being that of *teacher roles with students*, suggesting change in teacher-student interaction, towards being an advisor and supporting learning rather than being the information provider. Other high averages belong to a sub-domain of the curriculum, i.e. *didactic solutions* (3.31) and to *student main roles* (3.23). The latter joins the finding relating to *teacher role with students*, indicating that students developed ICT proficiency and continuously use it for learning tasks and for creating knowledge. The lower average values refer to *physical space* (2.69), *time*, (2.78) – both belonging to the *time and space configuration* domain, and *assessment methods* (2.92). Data indicate that indeed time and space post restrictions to innovative practices using ICT, with two of the three sub-domains bellow transition level. As for assessment, it seems that while didactic solutions indicate a shift towards novel pedagogy, assessment is still relatively traditional in nature.

As for variances, it seems that in general, in the sub-domains with the higher average values, there seems to be lower variance, whereas in the sub-domains with the lower values there tend to be higher variances (e.g. *teacher role with students* with the highest average of 3.32 and the lowest standard deviation of 0.96, as opposed to the lowest average calculated for the *time* sub-domain, ת2.78 with a standard deviation of 1.46, the highest of the values).

On the whole, data indicate that most cases, in most of the innovation domains, are clustered around the transitional level of "innovativeness", despite their being chosen as exemplary and novel initiatives. However, some domains seem to be inclined to "innovativeness" more than others, including *student and teacher roles*, as well as *didactic solutions*, while others maintain a low level of novelty, including *assessment methods* and *time and space configuration*.

Factors involved in ICT Implementation

Findings in this section refer to factors and factor groups involved in the pedagogical practices using technology. Analysis of these factors involved measurement of their involvement, according to the indicators detailed in Table 2. Averages were computed for factor grading in 174 cases, 21 gradings for each case, as well as calculation of average for each factor group. The higher the average level – the greater the rate of involvement of the factor or factor group was considered. The subsequent table demonstrates the average levels of involvement of the factors and factor groups of the cases examined and graded (Table 4).

Table 4: Averages of levels of involvement of 7 factor groups and 21 factors of innovative pedagogical practices using technology (including SD)

Factor categories	Average	SD	Factors	Average	SD
1 Roles within the school	3.62	0.79	Principal	3.78	1.14
			ICT coordinator	3.52	1.42
			Leading teachers	4.53	0.85
			Teaching staff	2.66	1.35
2 Roles outside the school	2.09	0.83	Parents and the community	2.25	1.24
			External institutes involved	2.67	1.63
			Subject-matter experts	1.76	1.31
			Policymakers in the Ministry of Education	2.08	1.37
			Municipal position holders	1.73	1.12
3 Organization of learning	2.96	1.19	Learning units in terms of time, place or content	3.17	1.29
			Allocation of students into learning groups	2.74	1.37
4 Organizational climate	3.40	0.96	ICT vision and goals in the school	3.66	1.24
			Diffusion of the innovation in the school	2.95	1.34
			Innovation history of the school	3.58	1.14
5 Staff training	3.45	1.10	Content of training	3.49	1.15
			Source of staff development	3.42	1.17
6 Infrastructure and resources	3.41	0.96	Amount of computers and peripherals	3.45	1.17
			Technical support	3.50	1.10
			Budgeting of the innovation	3.24	1.18
7 ICT policy	2.94	1.11	National	3.16	1.30
			Local or regional	2.71	1.39

The average levels of involvement of the factor groups involved in the innovations range between 3.62, the highest average, for *roles within the school*, and 2.09, the lowest average value, for *roles outside the school*. Both extreme averages relate to the people involved in the innovations; however, the point indicated in these figures is that inner human resources are by far more involved in the successful implementation of innovative pedagogical practices using technology that outside human resources. All in all, there are many factors and factor groups involved in ICT-supported innovations in schools – this stems from the fact that in general, in spite of differences in levels of involvement of the factor groups, figures are centralized around the middle values. Not one of the factor groups has an involvement value of 4.0 and above – as mentioned, the highest value of involvement is 3.62; this points out the necessity of a whole set of factor involvement, each factor contributing uniquely to the success of the innovation.

Variance within each of the factor groups also contributes to our insight relating their involvement in successful implementation of ICT and novel practices. As mentioned, 3.62 was the highest average level of involvement, measured for *roles within the school*; however, variance was the lowest in this factor group (SD=0.62), indicating relative uniformity within this factor group, as well as confirming the importance of factors in this group and their involvement in the innovation. At the other end of the average values, *roles outside the school*, whilst the involvement average was the lowest, the variance was also relatively low (SD=0.69), second lowest altogether. This also indicated that values in this case are relatively homogeneous; in this case, the meaning is a confirmation of the low involvement of factors outside the school. Perhaps this enforces the necessity of leaning on internal human resources to launch an ICT-supported innovation, rather than external ones.

Another high level of involvement, 3.45 of 5, was measured for the factor group *staff training*, indicating that this issue is imperative to the success of innovative practices using technology. However, variance in this category is relatively high, 1.10, suggesting different levels of involvement in ICT-supported innovations. *Infrastructure and resources*, as well as *organizational climate*, were also factor groups with reasonably high levels of involvement (3.41 and 3.40 respectively); in contrast, variance was relatively low (SD=0.96), emphasizing the importance of these factor groups for the innovations. In comparison, other factor groups exhibited low average values of involvement and rather high values of variance: *organization of learning* (involvement average: 2.96, SD=1.19) and *ICT policy* (involvement average: 2.94, SD=1.11). This is somewhat surprising, considering the fact that a prominent advantage of ICT implementation is the opportunity for promoting ubiquitous learning, reflected in flexibility in place and time, contents, allocation of students into learning groups, and all in al – re-organizing the learning situation (Watson, 2006). Still, the high variances within these factor groups indicate that in some of the innovations higher values of flexibility are noted. With reference to the rather low average value of ICT policy, this also poses an interesting point: while countries around the world put in enormous efforts to create and formalize ICT policies, it seems that these are not major factors that support the innovations and influence them (Plomp, Pelgrum, Law & Quale, 2003).

Examination of all factors, not only of the seven factor groups, was essential for a more detailed and comprehensive understanding of ICT supported pedagogical innovations. Therefore, averages and variances were computed for each of the factors, using all 174 cases.

Table 5: Averages of levels of involvement of the 21 factors of innovative pedagogical practices using technology (including SD) according to average value (highest to lowest), including reference group

Factor group (no.)	Factors	Average	SD
1	Leading teachers	4.53	0.85
1	Principal	3.78	1.14
4	ICT vision and goals in the school	3.66	1.24
4	Innovation history of the school	3.58	1.14
1	ICT coordinator	3.52	1.42
6	Technical support	3.5	1.1
5	Content of training	3.49	1.15
6	Amount of computers and peripherals	3.45	1.17
5	Source of staff development	3.42	1.17
6	Budgeting of the innovation	3.24	1.18
3	Learning units in terms of time, place or content	3.17	1.29
7	National ICT policy	3.16	1.3
4	Diffusion of the innovation in the school	2.95	1.34
3	Allocation of students into learning groups	2.74	1.37
7	Local or regional ICT policy	2.71	1.39
2	External institutes involved	2.67	1.63
1	Teaching staff	2.66	1.35
2	Parents and the community	2.25	1.24
2	Policymakers in the Ministry of Education	2.08	1.37
2	Subject-matter experts	1.76	1.31
2	Municipal position holders	1.73	1.12

Although in general, the factor groups sketch quite a clear picture of the tendency of certain factors to be involved in the innovation more than others, some factors that differently than most factors within their group. One salient example is the factor *teaching staff*, its average of involvement (2.66) being extremely low compared to the average of its group, *roles within the school* (3.62). This may indicate that an ICT-supported educational innovation may not need to necessarily involve all staff members in the school; rather, it can involve only leading teachers. With reference to this factor group, another interesting figure is the high average value of *leading teachers* (4.53), far higher than all other average values. This factor is unmistakably the most affecting factor in ICT-supported pedagogic innovations. The relatively low variance of this factor, the lowest among all 21 factors (SD=0.85), validates this statement. Interestingly, the *ICT coordinator* is not the highest-involved factor in the pedagogical innovation, with an average estimate of 3.52. This indicated that not all ICT-supported entrepreneurships require massive and intensive involvement of the leading ICT staff; of course, their involvement is relatively high, but not the highest. This statement is confirmed by the high variance measured for this factor (SD=1.42), the second highest among all factors.

Two additional factors which may be of interest belong to the *organizational climate* of the school: *ICT vision and goals* and *innovation history* – both referring to the school (averages

3.66 and 3.58 respectively). However, the third factor in this group, diffusion of the innovation in the school, is of a lesser involvement rate (2.95). This may indicate that the scope of the innovation is less significant as a factor involved in the innovation and its success. And certainly complies with the figure relating to the involvement of the whole of the school teaching staff, which was also relatively low.

To conclude, analysis of the factors involved in the innovations indicates that the most powerful factors involved in innovations' successful implementations were factors within the school and ones referring to the schools' organizational climate – both internal groups of factors, followed by infrastructure and staff training and development.

Conclusion and Implications

A vast amount of theoretical and empirical work deals with 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), as well as change processes and paradigms (e.g. Rogers, 2003; Tyack and Cuban, 1995) and the potential of ICT to facilitate change in several components of the school milieu (e.g. Pelgrum, Brummelhuis, Collis, Plomp, & Janssen, 1997; Plomp, Brummelhuis, & Rapmund., 1996; Turner, 1986).

The findings we report on in this paper, relating to the SITESm2 database of 174 case-studies from 28 countries, reinforce and expand our observations from a preliminary analysis of 10 Israeli case-studies as reported in our previous publications (Mioduser, Nachmias, Tubin and Forkosh-Baruch, 2003; Nachmias, Mioduser, Cohen, Tubin and Forkosh-Baruch, 2004). Concerning the extent of change and innovation in schools where ICT was implemented in successful practices, our main observation is that "schools remain schools" as regards to overall organizational and pedagogical issues as well. Notwithstanding, focal efforts led by specific agents (e.g., a teacher or groups of teachers highly motivated or a principal resolved to advance innovative ideas) result in highly creative attempts to develop novel pedagogical configurations and learning opportunities. The most encouraging finding is that the main beneficiaries of these innovative practices are the students – the domains for which higher innovation values were found were changes in students' role, changes in teacher/students interaction, and the evolvement of digital learning spaces besides the traditional space/time configurations. While in all other domains school systems are still facing the dilemmas and dissonances characterizing transition stages (towards a meaningful integration of ICT in all aspects of schools' life), evidence for the innovations contribution to the students' learning and to a change in their roles as active agents in the educational process is encouraging.

Concerning the key factors affecting the gestation and implementation of the innovation, the analyses endorse our previous claim that "*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*" (Nachmias et al., 2004, Pp 305). In contrast, local (municipal) and national policies, as well as agents external to the school, are of minor effect on the development of the innovations. These complementary findings represent clear evidence of the centrality of motivated teachers and principals for the evolvement of innovations. At the same time, they stress the need to reformulate the dialog between external agents and policy-makers and the schools' staff, to ensure that formulated policies and offered support fit the needs and advance the ideas of the motivated innovators.

Finally, we expect that the results of this study will contribute to the body of knowledge on ICT-based innovation processes in schools at two major levels. At the theoretical level, empirical knowledge regarding diffusion of technology-supported innovations and the domains and factors involved in the process expand our understanding of these and may lead to further research - aimed to find specific links between levels of innovation and certain factors affecting the nature of the innovations. On the practical level, the conclusions of our study provide policymakers and educators with valuable information in support of their attempts to implement innovative paradigms, in which ICT may play a leading role in shifting education and educators towards emerging educational paradigms. Hence, the implications are in terms of policy, allocation of resources and financing, promoting local initiatives in a bottom-up process, as well as top-down courses of action.

References

Becker, H. (1994). *Analysis and trends of school use of new information technologies*. U.S. Congress Office of Technology Assessment. US Government Printing Office, Washington, DC.

Berghel, H. and Sallach D.L. (2004). A Paradigm Shift in Computing and IT Education. *Communications of the ACM, 47,* 6, 83-88.

Crofton, C. (1981). *Planned Change in the Educational Environment*. Unpublished report. Educational Testing Service, Evanston, Illinois.

Cuban, L. (1999). The lure of curricular Reform and its pitiful history. *Phi Delta Kappan, 75*, 5, 182-185.

Fisher, G. (2000) Lifelong learning – more than training. *Journal of Interactive Learning Research, 11*, 3/4, 265–294.

Fullan, M. (2001) *The New Meaning of Educational Change, 3rd edition*. Teachers College, Columbia University, New York.

Gibson, I.W. (2002). Leadership, Technology, and Education: achieving a balance in new school leader thinking and behavior in preparation for twenty-first century global learning environments. *Journal of Information Technology for Teacher Education, 11*, 3, 315-334.

Hall, G. E., & Hord, S.M. (1987). *Changing in Schools*. Albany: University of New York Press.

Kinsler, K. and Gamble, M. (2002). *Reforming Schools*. Continuum, New York.

Kozma, R. (ed.) (2003). T*echnology, Innovation and Educational Change – A Global Perspective*. ISTE Publications: Eugene, Oregon.

Lacey, C. (1977). *The Socialization of Teachers*. London: Methuen.

Law, N., Pelgrum, W.J. & Plomp, T. (2008). Pedagogy and ICT Use in Schools around the World: Findings from the IEA SITES 2006 Study. NY: Springer

Mioduser, D. & Nachmias, R. (2002). WWW in education – an overview. In *Handbook on Information Technologies for Education and Training*, H. Adelsberger, B. Collis, and M. Pawlowsky (eds). Kluwer.

Mioduser, D., Nachmias, R., Tubin, D., and Forkosh-Baruch, A. (2003). Analysis schema for the study of domains and levels of pedagogical innovation in schools using ICT. *Education and Information Technologies, 8*, 1, 23–36.

Nachmias, R., Mioduser, D., Cohen, A., Tubin, D., and Forkosh-Baruch, A. (2004). Factors Involved in the Implementation of Pedagogical Innovations Using Technology. *Education and information technologies*, *9*, 3, 291-308.

Owston, R. (2007). Contextual factors that sustain innovative pedagogical practice using technology: an international study. *Journal of Educational Change, 8*, 61-77.

Pelgrum, W. J. & Anderson, R. E. (eds) (1999). *ICT and Emerging Paradigm for Life Long Learning: A Worldwide Educational Assessment of Infrastructure, Goals and Practices*. International Association for the Evaluation of Educational Achievement, The Netherlands.

Pelgrum, W., Brummelhuis, A., Collis, B., Plomp, Tj., & Janssen, I. (1997). *Technology Assessment of Multimedia Systems for Pre-Primary and Primary Schools*. European Parliament, Scientific and Technological Options Assessment Panel, Luxembourg.

Plomp, T., Pelgrum, W.J., Law, N. and Quale, A. (Eds) (2003). *Cross-National Information and Communication Technology Policy and Practices in Education*. US: Information Age Publishing Inc.

Plomp, T., Ten Brummelhuis, A., & Rapmund, R. (1996). *Teaching and Learning for the Future* (Report of the Committee on Multimedia in Teacher Training (COMMITT)) to the Netherlands Minister of Education). Sdu, The Hague.

Rogers, E. (1995). *Diffusion of Innovations* (4th edition). Free Press, New York.

Tearle, P. (2003). ICT implementation: what makes the difference? *British Journal of Educational Technology 34*, 5, 567–583.

Tubin, D., Mioduser, D., Nachmias, R., and Forkosh-Baruch, A. (2003). Domains and levels of pedagogical innovation in schools using ICT: ten innovative schools in Israel. *Education and information technologies, 8*, 2, 127-145.

Turner, J. H. (1986). The Structure of Sociological Theory. Dorsey Press, Chicago.

Tyack, D. and Cuban, L. (Eds.) (1995) Why the grammar of schooling persists. In: *Tinkering Toward Utopia*. Harvard University Press, Cambridge, pp. 85–109.

Underwood, J. and Underwood, G. (1995).*Computers and Learning: Helping children acquire thinking skills.* Oxford: Blackwell.

Venezky, R. L. and Davis, C. (2001) *Que Vademus? The Transformation of Schooling in a Networked World.* OECD/CERI.

Watson, D. (2001) Pedagogy before technology: Re-thinking the relationship between ICT and teaching. *Education and Information Technologies, 6*, 4, 251–266.

Watson, D.M. (2006). Understanding the relationship between ICT and education means exploring innovation and change. *Education and Information Technologies, 11*, 3-4, 199-216.

Wong, K. (2008). School-based Technology Coordinators and Other Human Factors in the Implementation of ICT in Primary Schools: A Comparative Study. *International Journal of Education and Development using ICT, 4*, 1.
Available: http://ijedict.dec.uwi.edu/viewarticle.php?id=368.

Yuen, A.H.K., Law, N. and Wong, K.C. (2003). ICT Implementation and School Leadership: Case Studies of ICT Integration in Teaching and Learning. *Journal of Educational Administration, 41*, 2, 158-170.