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Analysis Schema for the Study of Domains and Levels of Pedagogical Innovation in Schools Using ICT

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Abstract

Many educational systems worldwide are putting much work in the assimilation of ICT in schools, fostering significant changes in the processes of instruction and learning. These changes occur in schools at various levels by means of, e.g., the creation of new learning configurations (beyond traditional time and space configurations), the devise of novel pedagogical solutions, or through the expansion of the school's knowledge-resources space into cyberspace. These transformations, and the processes by which they occur, have become highly interesting research themes with obvious theoretical (e.g., cognitive or curricular issues) as well as practical (e.g., policy or planning issues) implications. We present an analysis schema for the systematic study of these transformational processes in schools using ICT. The schema's dimensions are located within a grid defined by two axes. The horizontal axis represents levels of innovation from preliminary alterations in the school's routine due to the initial assimilation of ICT, to far-reaching transformations of pedagogical practices and learning processes. The vertical axis details domains of innovation, focusing on four main constituents of the school milieu: time/space configurations, students, teachers, and the curriculum. A detailed description of the dimensions as well as the variables suggested for their operationalization, is presented. Implications of using the analysis tool for researchers, practitioners and policy makers are discussed.

Keywords: ICT, pedagogical innovation, school reform, analysis schema, case studies

1. Introduction

Information and communication technologies (ICT) have been a crucial factor affecting the way we work, trade, communicate and socialize, approach personal social or national conflicts, consume physical and cultural goods, spend leisure time, and learn, for more than six decades. Against this background of continuous transformation, schools are still perceived as social organizations with a strong conservative tendency to preserve their traditional structure, and adopt change only by modest (and slow) incremental steps. Nevertheless, a great deal of work is being done in many educational systems worldwide towards the assimilation of ICT into schools, fostering significant changes in the way instruction and learning take place. These changes affect school life at various levels by means, for instance, of the creation of new learning configurations (beyond traditional time and space configurations), the devise of novel pedagogical solutions, or through the expansion of the school's knowledge-resources space into cyberspace. These transformations, and the processes by which they occur, have become highly interesting research themes with obvious theoretical (e.g., cognitive or curricular issues) as well as practical (e.g., policy or planning issues) implications. In this paper we present an analysis schema for the systematic study of these transformational processes in schools using ICT.

The work reported here is the result of our involvement in two international studies on school innovation using ICT. One is the IEA's Second Information Technology in Education Study (SITES) Module 2, focusing on innovative pedagogical practices at the classroom level (Kozma, 2000). The other is a study sponsored by the OECD, focusing on innovations at the school system level as a result of ICT implementation (OECD/CERI, 2000; Venezky and Davis, 2002). As the Israeli contribution, we comprehensively examined ten case studies, ten schools that have incorporated ICT in unique ways and succeeded in devising innovative classroom pedagogies and school system changes.

This is the first of two articles reporting on the levels of innovation found in the participating schools. Here we present the conceptual framework or analysis schema we developed for characterizing the ICT-based innovations in schools, while in the next paper we report on the results of using the schema to analyze data collected in ten Israeli schools (Tubin *et al.*, in press). Below we will briefly present the background for the development of the analysis schema, then to offer a detailed description of its dimensions and variables.

2. Background

The roots of the traditional organizational structure of schools go deep, and attempts to change it meet serious resistance. What Tyack and Cuban (1995) term as the *grammar of the school* (e.g., age-graded classrooms, rigid time units) has been molded over many years by social and economical forces, to become a standardized institutional template. By this perspective changes in the school structure occur in correspondence with transformations in the social/economical environment within which the school is inscribed and operates (e.g., the rapid expansion of elementary education in the nineteen century, or the differentiation of secondary schools in the twentieth century). Today ICT has a fundamental social and economical impact transforming our lives in all possible realms, and so, it is only natural to expect that the incorporation of ICT in schools will affect its grammar and lead to crucial transformations in its structure (Watson, 2001).

The analysis schema proposed in this paper is meant to be a tool for examining the levels of innovation and change in schools that extensively embrace ICT. "Innovation", however, is not a clearly defined concept, and *educational innovation* is even more difficult to characterize (Fullan, 2000). Several frameworks have been developed by researchers and practitioners with the aim to characterize the ways ICT may support and promote educational innovation. For example, Means *et al.* (1993) suggest that technology may support the transition from conventional to reform approaches to instruction as regards to a number of dimensions, e.g., the curriculum, time configuration, teacher and student practices and roles, grouping and collaboration. In SITES M2 study Kozma (2000) characterizes ICT-based innovations 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. The North Central Regional Educational Laboratory (NCREL) offers schools and educators "a framework for understanding the system wide factors that influence the effective use of educational technology" (enGauge, 2002). The framework refers to essential conditions required for fostering ICT implementation in schools, in six dimensions: a shared vision, teaching and learning practices, educators proficiency, digital-age equity, robust access anywhere-anytime, and leadership. Lemke and Coughlin (1998) present a seven dimensions framework of progress indicators from education today to education tomorrow: learners, learning environments, professional competency, system capacity, community connections, technology capacity, accountability. Each dimension is evaluated in a continuum including three levels: entry, adaptation, and transformation level.

The schema proposed in this paper combines insights from this previous work, as well as from the actual data collected in the case studies. For the examination of a school's state of affairs in terms of innovation, two sets of referential indicators have been defined: one relating to the domains or aspects of the school's life which are compromised by the innovation, and the other to the criteria for establishing how far and deep the innovation is transforming these domains. In this section we will briefly present the background for the analysis tool proposed in this paper, regarding both the *domains of innovation* and the *levels of innovation* in schools using ICT.

2.1. Domains of educational innovation

School life is the result of the complex interrelationships among a multifaceted as well as disparate set of factors and variables, such as educational philosophies, pragmatic decisions, resources available (e.g., physical economical, temporal), and people involved. Educational innovations may relate to any of these variables. For this succinct background survey we will characterize educational innovations at different levels, from broad philosophical to very specific and practical aspects of school life. The five levels to be discussed focus on shifts in educational paradigms, in time-and-space configuration, in pedagogical practices, in learning and cognitive processes, and in curricular solutions.

At the most general level, an innovation can be regarded as a shift in educational paradigm (Pelgrum *et al.*, 1997). For the last two decades the educational community has adopted the outlook that views school as an essential agent for the preparation of students to act and live in the information society. According to this paradigm, with its lifelong-learning orientation, the school's main goal is to supply the skills required to live and work in a world in continuous change (Fisher, 2000). ICT, as a driving force behind the creation and evolvement of the information society, plays a central role in this paradigm-shift affecting both contents (new technology-related concepts and skills included in the curriculum) and general skills (e.g., learning how to learn, acquiring generic knowledge-manipulation skills, teamwork skills). At this level, innovations can be defined in operational terms as the wide range of activities and means (e.g., curricular decisions, learning materials, learning configurations, lesson plans, tools and resources) that reflect the school's educational-philosophical orientation towards lifelong learning.

On the school's time-and-space-configuration level, innovation can be defined in terms of the extent to which observed solutions depart from the traditional temporal and spatial arrangements in the school. For such structural innovations to occur there should be significant demands originating in either the school's inner or outer environment (Simon, 1996): ICT, by permeating *both* of these environments, may pose these demands. In the outer environment, ICT is clearly affecting the traditional perception of time and space (see, e.g., globalization processes and the global village phenomenon, cyberspace, internet time, virtual environments). In the inner environment ICT is seriously challenging the traditional definitions of rigid spaces and time slots (e.g., through access *any time from anywhere* to globally distributed knowledge resources, technology-mediated asynchronous teamwork, alternative communication channels among students and teachers). Innovation at this level implies the creation of alternative learning configurations dictated more by the inherent demands of the learning tasks than by external, predetermined institutional constraints.

On the pedagogical level innovations are defined in terms of novel didactic solutions reflecting theoretical shifts (e.g., from a behaviourist to a constructivist perception of the learning process) or technological changes – as in ICT implementation. Pedagogical innovations may take the form, for example, of novel instructional formats, increased delegation of responsibility and control over the learning process to the students, or alternative methods for the assessment of learning. In the SITES M2 design document the following examples of pedagogical innovations are mentioned: activities that promote active and independent learning in which students take responsibility for their own learning, set their own learning goals, create their own learning activities, and/or assess their own progress and/or the progress of other students; engage students in collaborative, project-based learning in which students work with others on complex, extended, real-world-like problems or projects; provide students with individualized instruction, customized to meet the needs of students with different entry levels, interests, or conceptual difficulties; "break down the walls" of the classroom – for example, by extending the school day, changing the organization of the class, or involving other people (such as parents, scientists, or business professionals) in the education process; address issues of equity for students of different genders or ethnic or social groups and/or provide access to instruction or information for students who would not have access otherwise because of geographic or socioeconomic reasons (Kozma, 2000). ICT's properties create the need to examine fundamental questions regarding the desired features of pedagogical models that use this technology, e.g., learning environments on the World Wide Web (*Webagogies* (Mioduser *et al.*, 2000)), hybrid face-to-face/virtual courses (Nachmias *et al.*, 2000), or virtual discussion groups (Oren *et al.*, 2002).

On the level of learning and cognition processes, innovations may address, for instance, types of processes fostered (e.g., enquiry, design), target skills (e.g., information handling, modeling), or metacognitions (e.g., reflection, meta-level knowledge). Researchers stress the central role of knowledge technologies in general (e.g., writing, print, information delivery means), and ICT in particular, for the development of cognitive process and skills (diSessa, 2000; Mioduser, in press; Olson, 1994). Current examples are the use of learning tools enabling scientific visualization or modelling of phenomena thus supporting alternative perceptions of facts and processes (Edelson *et al.*, 2000); the use of hypermediaauthoring learning tools supporting the acquisition of "hyper" thinking and representational skills (Erickson and Lehrer, 1998); or ICT tools serving as *cognitive prostheses* for physically challenged people's learning processes, compensating for impaired functioning due to physical (e.g., vision, hearing, motoric) handicaps (Lahav and Mioduser, 2001).

Finally, on the curricular level innovations should be related not only to contents but to the very perception of the curriculum itself. It is fairly evident what kinds of content-related innovations the widespread implementation of ICT has occasioned: as the corpus of knowledge related to the new technologies became formalized and structured, new subjects encompassing a whole set of new concepts and skills (e.g., information or computer literacy, programming, skills and strategies for information handling) entered the curriculum. But a more radical innovation concerns new approaches to the fundamental definition of the curriculum. Innovations can be found in alternative views of the structure of the curriculum, e.g., non-linear and non-hierarchical organization of contents, self-contained content units; in the multiplicity of sources and resources converging into any given content unit, e.g., a book, the Web, a distantly located expert; or in the dynamic approach towards the curriculum, by which it is no longer viewed as a frozen product (expected to be modified only in the next printed edition), but as a knowledge entity subject to continuous change. Most, if not all of these innovations are possible due to the inherent features of ICT. For example, digital technology facilitates the effortless merging of multiple representational means and continuous updating of the materials, and hypertext fits naturally with the idea of a highly hyperlinked and structurally distributed curriculum. In a slow but steady process, the conceptual guidelines and pragmatics of the *hypercurriculum* are evolving (Mioduser *et al.*, 2000).

Given this wide scope of ICT related issues, we have defined four main domains of innovation to be included in our analysis schema: organizational issues (instantiated mainly in time and space configurations), student roles, teacher roles, and curriculum. As regards to student and teacher roles, it should be noted here that the perspective adopted for our analysis is that of the overall (institutional) mapping of the school innovative practices using ICT, rather than that of the personal characteristics of individuals teaching or learning with ICT. For this reason the proposed scheme considers teacher and student roles and practices as they appear inscribed within the overall picture of the innovative pedagogical practice. Individual learning and cognitive processes (e.g., skills acquisition, information handling processes) are beyond the aims and scope of the proposed schema, and the data collected in the case studies regarding these are being actually analyzed and will be reported elsewhere.

2.2. Levels of innovation

An educational innovation is not (usually) a one-shot event. It is a complex process evolving over time and involving many actors. This process was extensively studied in organizations of various types. We will now briefly review some ideas which are especially relevant to our examination of innovation processes in schools using ICT.

First we should consider the extent to which the innovation triggers a gradual departure from previous patterns of work in the school, in any of the domains surveyed in the previous section (Pelgrum *et al.*, 1997). The lessons learned from previous cycles of technological change in general, and in education in particular, are helpful here. The process by which new technologies are first used with reference to known models, before eliciting the evolvement of new cultures and languages and provoking substantial change, has been well documented for previous technologies (e.g., print technology at first used within the manuscript culture, the initial design of automobiles as carriages without horses, or cinematography first taking the form of filmed theater). As experienced professionals in education we hold substantial models regarding the various facets of our practice (e.g., how to build a lesson plan, to assess a learner's performance or behaviour, to develop a learning unit). These models are usually tied to the technological resources at hand, and they mutually affect each other. It seems reasonable to assume that when facing a new technology we use these models as input to its assimilation process. The result is usually a period at which we replicate the known models by means of the new technology. For example, when first assimilating the 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 then evolving in time into sophisticated drill and practice and structured tutoring software (Venezky and Osin, 1991). In the current Internet revolution, the vast majority of educational Websites is still built upon the hypermedia-CD model, and most online activities still resemble the automatic-feedback and behaviourist-type transactions of classic CAI (Mioduser *et al.*, 2000). But gradually new understandings and practices evolve, together with new formulations of alternative approaches. This transitional phase eventually leads to a transformational one, at which new models of action using technology are developed (e.g., advanced transportation culture [cars/highways/signal-systems/insurance-services/laws], an artistic language unique to film making, or novel pedagogical solutions using computers).

Another perspective relates to the distinction among phases in the innovation implementation process. Rogers (1995) distinguishes between two main phases: adoption and diffusion. The *adoption phase* compromises mainly individuals, the leaders of the innovation who: (a) become *aware of* emerging needs that demand innovative solutions, or of the potential of an innovative idea to satisfy existing needs; (b) are able to *evaluate* in advance the potential benefits of the innovation; (c) decide to *adopt* it and act to implement it (even if initially on a small scale). The *diffusion phase* focuses on the organization, on the process by which an innovation is communicated through certain channels among the members of the social system over time. The distinction between the individual and the institutional phases also implies important differences in the demands the organization faces concerning a number of key variables such as number of people involved, required resources (e.g., time, space, knowledge, people), or extent of organizational change to be made.

The characterization of the phase in the innovation process at which a school currently is located, is critical for understanding the innovation's present impact on the school's life, as well as for foreseeing in which direction it may evolve. In consequence we incorporated, as complementary dimension in our analysis schema, a three-phase progression, indicating levels of change (depth, extension) generated by ICT implementation: assimilation, transition and transformation (these phases will be presented in detail in section 3).

3. Innovations Analysis Schema

For the systematic analysis of ICT-based pedagogical innovations in the participating schools we developed the *innovations analysis schema.* The schema's dimensions are located within a grid defined by two axes (see Table 1). The horizontal axis represents levels of innovation, from preliminary alterations of the school's routine due to the initial assimilation of ICT, to far-reaching transformations in pedagogical practices and learning processes. The vertical axis details domains of innovation, focusing on four main

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'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 tool
Teacher	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	Professional exchange, organic solidarity
	Content	ICT basic skills, standard applications use	ICT concepts, processes and advanced skills	Design and development using ICT
Curriculum	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.

constituents of the school's milieu: time/space configurations, students, teachers, and the curriculum.

Before proceeding with a detailed discussion of the schema and its components, we will consider a series of basic issues we had to deal with during its development. The first of these relates to the nature of the process of introduction and implementation of the innovation. It appears that the implementation of ICT-based pedagogical innovations is an evolving process that may be best analyzed, in terms of a continuous line of development, rather than in terms of a series of discrete and independent events. Among the factors supporting this conclusion are:

- The *versatile* character of ICT technology, which enables a wide range of uses as well as multiple levels of implementation.
- The *complex* character of ICT technology, which requires gradual assimilation processes on the part of both individuals and organizations.
- The adoption and diffusion of any innovation (e.g., a novel ICT-based pedagogical practice) is by definition a process requiring time and proceeding through various phases.
- Technological shifts in organizations are gradual developments rather than drastic transformations, and they are in direct relation to the disparity between existent and new technologies. It is reasonable to expect that schools' transition from the traditional chalk-and-board/print technologies to ICT technologies will require time and will proceed through several transformational stages.

An issue that complements the previous one relates to the nature of the phases (functional, operational) of the innovation adoption and implementation process. Are these stages (stations on the path towards full implementation) or perhaps levels (implicating in addition degrees of complexity and hierarchy)? In our schema we define the innovation adoption process in terms of progressive levels. This is not to say that when a school achieves a certain level it cannot revert to the previous one. But a such a move will be a transformation demanding once again a great deal of resources, e.g., staff training, equipment, curriculum changes. In addition, the school may perform differently in different domains simultaneously.

A third issue, highly relevant to the development of an analysis tool, relates to the possibility to define ICT-based pedagogical innovations in generic terms. Is the pedagogical practice an innovation only in the eyes of the innovator or the innovation customers and associated with a particular context and circumstance, or can we define it in general and universal terms? We will tend to relate to ICT-based pedagogical innovations in generic terms and as models that can be potentially adopted by most schools, on the basis of the following considerations:

- It is generally accepted that all schools in modern society hold common generic, structural features (Goodlad, 1984; Sizer, 1973; Tyack and Cuban, 1995). It is likely that generic models of ICT-based pedagogical innovations fit schools everywhere, taking into account necessary adaptations to contextual features and needs.
- ICT technology is a global phenomenon. Hardware and software, available to most consumers, possess identical features all over the world, demanding the acquisition of similar knowledge and skills despite cultural and/or language differences.

- Countries worldwide, as part of their national policies have been making large investments in ICT, including in the educational field.

> "In a world rapidly becoming more and more digital every day, ICT needs to be part of the everyday school experience… Modern institutions – businesses, courts, sports organizations, and the like – require the use of word processors, spread sheets, graphing software, data bases, and other information-oriented applications. Schools that don't prepare their students to use these are failing part of their educational mission" (OECD/CERI, 2000).

Yet, when we use these generic definitions to study ICT-based innovations in particular schools, we have to be aware of the significant disparity still existing between goals/intentions as formulated in policy documents by formal educational systems in different countries, and the crucial economical and cultural gaps among (and sometimes within) countries and societies impeding the actual realization of these goals.

3.1. Horizontal axis: levels of innovation

On this axis of the schema we have defined three qualitatively different main levels which constitute a progressive continuum of innovation: assimilation, transition, and transformation levels. Each level is assumed to be more advanced than the previous one. It should be noted that this is an indication of the level of innovation of ICT usage in a school, and not of the quality of the school as an educational institute.

3.1.1. Assimilation The first level of innovation refers to the situation in which ICT technology is first introduced into the school. The technology is integrated as a useful tool in common learning activities (e.g., for word processing, spreadsheet calculations, multimedia presentations) and in specific projects. At this level specific pedagogical situations change qualitatively but the school curriculum as a whole (content and goals), the instructional means (textbooks), the learning environment (classes, labs), and the learning organization (timetable) remain unchanged.

3.1.2. Transition At the second level ICT supports the integration within the school's everyday functioning of new contents, didactic solutions, and organizational solutions side by side with the tradition ones. In this transitional stage the school keeps its identity and basic course of operation while changing the character of particular activities.

3.1.3. Transformation At the third level substantive changes take place in the school as a whole. Traditional processes still exist, but the school identity is mainly defined by the rationale and goals of the new lines of operation. Student and teacher roles are enriched with new dimensions, new contents are introduced to the curriculum, new teaching methods are developed and implemented, and for particular activities the traditional time and space configuration is completely transformed.

3.2. *The vertical axis: domains of innovation*

The vertical axis of the schema refers to the main components of the teaching/learning situation: student, teacher, curriculum, and organizational context. To paraphrase Shakespeare[1], *all the school's a stage, and all teachers and students merely players…* but here comes ICT and alters the plot! ICT introduction into the school seems to affect student and teacher roles, processes, norms, and student/teacher and student/student interactions (Pelgrum *et al.*, 1997; Plomp *et al.*, 1996; Turner, 1986).

With the proposed schema, our intention is to look at the successive levels of transformation taking place in the above four domains due to the integration of ICT into the school culture. For each domain (and its sub-domains) a series of variables have been defined, serving as operational means to characterize the actual situation in the schools participating in the study.

3.2.1. Time and space configuration The first domain refers to the temporal and spatial conditions within which the ICT-based educational activities take place. We distinguish among the following three components:

1. *Physical space* relates to the actual place where ICT supported learning occurs. The continuum goes from *Public spaces* within the school (e.g., labs, libraries) to *Personal spaces in school and beyond.* Two scales are used to locate a school on this continuum:
   - Extent of centralized control over computer use (scale: high to low).
   - Degree of ownership and belonging of the student as regards the space (scale: low to high).
2. *Digital space* refers to the scope and openness of the virtual learning entities within which the students work. This continuum runs from a space constrained to the computer desktop (e.g., tutorials and applications) to the open cyberspace (e.g., distant virtual environments and learning communities). The operational variable for this continuum is:
   - Kind of ICT activity – implying digital space (scale: a progression of activities organized by the dimensions of the virtual operational space, e.g., desktop drill packages, open tools, closed discussion groups, up to tools for browsing the entire Web).
3. *Time* refers to the temporal configuration of the learning activities. Two main aspects are considered: the degree of centralized (i.e., school) control of the students' time and the extent to which changes are introduced in the school's timetable. At the assimilation level, the school keeps its regular timetable, allocating ICT use within the lessons' time (usually 45 or 90 minutes long) and under teacher guidance. At the transition level the school loosens control by allowing the definition of time blocks instead of the regular time units (Tyack and Cuban, 1995), and lets students manage their time within these blocks according to their needs. At the transformation level the focus is displaced from *time as resource,* to the *outcomes* of the time usage, allowing students to define various time configurations according to their learning needs.

[1] "All the world's a stage and all the men and women merely players" (As You Like It, Act II, scene vii).

Thus in this dimension, the continuum ranges from activities *embedded in the public time* (the schedule is determined and controlled by the school staff), through *free use during private time* (time is controlled by the student within the constraints of school hours and activities), to the most advanced level of activities taking place at *any time in school hours and beyond* (under complete student control). The variables used for mapping the temporal aspect of the students' ICT work are:

- The extent of centralized control over the students' time with ICT (scale: from high to low).
- The amount of time spent on learning activities within and out-of-school locations (scale: time spent by locations).
- The number of students that freely access ICT at their own time.

3.2.2. Student role This dimension relates to the observed behaviour of the students using ICT for learning. The continuum depicted ranges from student's use of ICT *to accomplish highly structured assignments* (usually following clearly defined teacher indications), through the gradual building of *independent ICT expertise* by accomplishing open-ended assignments, up to the student's assimilation of ICT *as, personal means for learning and creation* in a varied range of school activities and subjects. The variables serving the mapping of the students' roles are:

- The degree of students' response to, and compliance with, the demands of highly structured ICT assignments.
- The extent to which students use ICT for meaningful learning (e.g., inquiry, creation, personally designed projects) in various subjects and for diverse purposes.

3.2.3. Teacher role In this dimension we look at the effect of ICT incorporation into school activities on the teachers' role, decisions and performance in their interaction with both students and colleagues.

Teacher/students interaction: within this context the teacher's role is characterized on a scale ranging from *main source of leadership,* information, and knowledge, through the role of project manager, mentor, supporter, and coordinator, to the most advanced level of *expert colleague* and partner in the students' self-managed learning. The variables serving the characterization of teachers' role as regards students are:

- The degree of teacher's control over students' activities (scale: from complete control of contents and processes in structured assignments, to partnership in open-ended tasks).
- The repertoire of new roles and forms of interaction implemented by teachers in ICT-based activities.

Teacher/teacher interaction: as regards peer interactions the continuum can be characterized in Durkheim's (1933) terms, as ranging from *mechanic solidarity* to *organic solidarity.* At the assimilation level the teacher *acts individually* and *interacts functionally* with other teachers (a relationship based on sharing similar roles, values, and experiences and on an operational division of labor). On the transition level teachers collaborate in complicated projects that require a great deal of coordination and mutual help, but their fundamental roles remain unchanged. At the transformation level teachers gradually become experts and depend on each other's expertise for implementing complex projects. The relationship among teachers is now based on functional differentiation and specific proficiency, and teamwork becomes the most popular form of work among teachers. The dimensions used to examine this continuum are:

- The degree of dependency/collaboration among teachers as they carry out ICT-based instruction.
- The types and quality of interactions among teachers while carrying on ICT-based instruction.

3.2.4. The curriculum This dimension relates to changes in curricular aspects due to the implementation of ICT technology. We examined three main issues: changes in content, in didactic solutions, and in assessment methods.

Content refers to ICT related knowledge, concepts and skills incorporated in the curriculum. The content scale ranges from *ICT basic skills and applications use,* through *ICT technology concepts and advanced use skills,* to knowledge and skills on *ICT use for design and development* of products in various subjects. The variables considered are:

- The extent to which ICT is the subject in ICT activities.
- The extent to which ICT knowledge and skills serve for the construction of knowledge and products in different subjects.
- The extent to which the contents in ICT activities depart from the formal curriculum (e.g., by breaking the walls of standard curricular disciplines generating new topical compounds, or dealing with cutting edge themes which are not yet part of the traditional curriculum).

Didactic solutions relate to new teaching methods and activities based on the use of ICT. The continuum in this case ranges from the *implementation of structured activities* (e.g., use of structured packages and directed use of generic tools and Internet), through *open-ended assignments* and projects, to *the design of learning activities based on the individual and group use of cyberspace* (e.g., virtual environments, collaborative synchronic and asynchronous projects). The variables for the didactic domain are:

- The degree of control and structuring excerpted by the teacher in designing and implementing a didactic solution.
- The repertoire of novel didactic solutions implemented in ICT-based activities.

Assessment methods concern changes in the ways used to evaluate the students' performance. The scale developed ranges from the use of *digital versions of standard and traditional assessment* resources, through the attempt to develop particular *criteria for the evaluation of students work using ICT,* to the creation of *new assessment tools and procedures* that suit the nature of ICT-based learning processes and products (e.g., digital portfolios, computer-log analysis schemas). The variables for this domain are:

- The extent to which the students participate in the evaluation of their work.
- The degree to which the results of the assessment feed back into the learning process.
- The repertoire of new ICT-based assessment procedures and tools.

4. Concluding Remarks

As mentioned above, the context for the formulation of the analysis schema is our participation, on behalf of Israel, in two international comparative studies, by IEA and OECD/CERI, of successful cases of ICT implementation in schools. The ten Israeli case studies are part of a large data base of cases from about 30 countries, conforming an impressive collection of innovative pedagogical practices using ICT. These data may well be of great value for people dealing with educational issues at all levels: researchers, practitioners, policy makers, staff trainers, curriculum developers or dedicated-technology designers. For this potential to be realized, appropriate analysis tools are needed to organize and interpret the collected data and generate mindful conclusions. One of such tools is the analysis schema proposed here.

A key purpose for the development of the tool was to allow us to perform the cross-case analysis of the ten Israeli studies. All variables described above for all domains (and sub-domains) were operationalized and used to analyze the case studies (this analysis is reported in (Tubin *et al.*, in press). The implementation of the tool resulted in a comprehensive map of the innovations in all schools showing what was done, by whom, and at what level.

Moreover, this mapping also makes it possible to start dealing with more complex questions regarding ICT-based pedagogical innovations, such as: what are the main trends or forms of innovation in the cases considered; in what domains and sub-domains is ICT use still at a preliminary state of adoption, in transition towards new models, or has transformed learning and teaching; what school-variables or school-factors are correlated with different levels of innovation in different domains; or what is the prospect for an innovation (in a particular domain), taking place in most studied schools, to become widely implemented in the educational system (the transferability and scalability question).

As regards to predictive power, it should be noted that the schema is a descriptive and not a prescriptive tool. This means that by mapping the actual situation in a school or set of schools, we get a picture of, for example, transitional stages in most schools in a given domain, or of what transformations may take place in other domains. It will however be difficult to claim that an observed innovation path in a given domain will be necessarily followed by any school. As more and more data from schools are incorporated in the schema's cells, the tool will represent a multiple dimensions innovation-space within which different schools will show different innovation patterns according to their particular characteristics.

We believe that innovative pedagogical uses of ICT in schools all over the world have reached critical mass, defying the time-and-again heard claim that the technology has had no significant impact on schools' life. Prompted by the need to systematically study these exciting processes and document them in depth, we developed the analysis tool presented in this paper.

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