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Teachers' Views on Factors Affecting Effective Integration of Information Technology in the Classroom: Developmental Scenery

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This article reports on an exploratory, longitudinal study, which examined six teachers' views on the factors that affect technology use in classrooms. The research examined teachers of grades 4, 5, and 6—for three years, studying the teachers both as a group and as individual case studies. Three case studies were selected for analysis, with the aim of exploring the relation between the changes that occurred in the teachers' educational views and practices as a result of their exposure to teaching and learning with the aid of rich technology and their views on factors affecting technology integration. The findings point to two developmental patterns in teachers' views on the factors affecting technology use in the classroom: the first is concerned with the *source of influence* on technology adoption, and focuses mainly on the human factor; the second is concerned with the *nature of the influence* when using technology in the classroom, ranging from technical to cognitive transformation. The three case studies reveal three different profiles of change and demonstrate the complex relations between teachers' orientations concerning the conditions affecting technology use, and the changes that occur in teachers' views and practices.

This study explores teacher views on factors affecting their use of information and communication technologies (ICT) in the classroom and how these views reflect changes in teachers' educational beliefs and actual classroom practice. It is based on the recognition that teachers are the key players in changing the educational world, and in particular the learning and teaching processes in their own classrooms. Therefore the study focuses on the teachers' voice. It does this in the context of a classroom, which integrates technology-based information rich tasks with the school curriculum. Believing that teachers' beliefs, knowledge and classroom practices are multivariate and interrelated, and relying on the important role that teachers play in restructuring technology-based classroom learning processes, the study examines how their views and practices are developed and transformed by 3 years of experience of using ICT in their classes. The study focuses not only on explicit statements from teachers concerning their views, but also on observing their actual practices in the classroom.

Information and communication technologies (ICT) have grown increasingly universal, powerful, and adaptable. They change the world we live in and how we learn to live. Since the introduction of ICT in education, schools now face new social, cultural, and pedagogical phenomena, which challenge teachers in terms of their technical ability, knowledge, and expertise. ICT creates new possibilities, dilemmas, and directions and encourages teachers to harness the new opportunities that ICT offers to make teaching and learning more meaningful and rewarding. The ability to utilize information and communication technology has become the new literacy for the 21st century. As such, new technologies call into question many of our long-held assumptions about education. In other words, ICT can change teaching and learning by being a source of knowledge, a medium for transmitting content, and an interactive resource furthering dialogue and creative exploration.

The reconceptualization of teaching and learning together with the individual school's educational vision, policies, and strategies present a new challenge to the traditional use of information technology in the classroom. No wonder then that the goal of transforming teaching and learning through increased access to and use of technology in schools has been near the top of most educational reform agendas since the early 1980s (Cuban, 2001). ICT is thus considered to be both the cause of change and a major means of achieving it. However, a wide gulf exists between the promises of ICT and the reality of its use in schools. Despite considerable investment, ICT implementation advances at a slower rate than expected in the educational systems of many countries (National Center for Education Statistics, 2005). Furthermore, despite the growing body of evidence supporting the influence of ICT

on learning processes and its impact on teachers and students, tapping this tremendous resource largely depends on how the actual teachers use ICT. As the evidence shows, changing teachers' practices is proving a complex task (Mills & Tincher, 2003).

Indeed, teachers are only slowly incorporating a smattering of technologies into their repertoire (Yildirim, 2000), even though we are witnessing continuous change in the use of computers as technology advances and new applications become available. The use of the powerful technologies is often limited to sustaining rather than transforming educational practice (Akker, Keursten, & Plomp, 1992). In other words, ICT is mostly used when it fits in well with traditional practices. Thus, classroom practice focuses on computer skills rather than integrated learning intentions, and often teachers' practices relate more to issues of management and organization than to learning and assessment. Teachers still lack the confidence to exploit ICT for new teaching approaches. While techno reformers are calling on teachers to encourage inquiry, collaboration, and transform the teacher-student relationship, teachers are mundanely using ICT for presentation, information delivery, and as management tools.

The significant gap between today's digital ICT and teachers' desire and ability to integrate technology into their classrooms is not a result of a lack of access to technological tools in the classroom nor to issues regarding software and hardware. Rather, it is due to incompatibility between the goals of education and interactions between teachers, students, educational and information resources, and curricular goals and materials (Voogt & Pelgrum, 2005). One serious problem for example is that ICT applications are often poorly attuned to the curriculum and educational software is generally unrelated to and not integrated with the textbooks many teachers use. However, there is also a gulf between desired and actual ICT use mainly because the use of ICT in the classroom is an innovation not only in technological terms but from the point of view of teaching as well. This means that teachers must be involved in at least two radical changes—they must learn to use technology and they must fundamentally change how they teach (Scrimshaw, 2004).

To learn how to use ICT in schools, we must pay more attention to the conditions affecting the culture and profession of teaching as viewed by teachers themselves. More specifically, accurate insights are needed into teachers' beliefs regarding the use of ICT in their classrooms, and a deeper understanding of the complexity involved in teachers' learning to teach with ICT, while appreciating and respecting the need to bridge multiple cultures of teaching and learning environments (Geertz, 1983).

Based on the assumption that understanding change involves dialogue between "insiders" and "outsiders," guardians of the old and proponents of the new, this study sees teachers as professionals who are not only knowledgeable about learning theories, methods of teaching, and the potential uses of ICT, but also critical thinkers and active constructors of knowledge. This contrast with the view of teachers, which sees them as technicians or experts in applying prescribed methods and technologies

Teachers, techno reformers, and researchers all admit that despite the research accumulated over the past three decades, many questions regarding the effective use of information technologies still remain unanswered. The present study addresses this gap by investigating teachers' views regarding what supports / hinders their use of technology in the classroom, by examining how teachers conceptualize learning, teaching, and technology, and by exploring the development of teachers' views on these factors during three years of classroom experiences using ICT.

THEORETICAL RATIONALE

Numerous research studies provide a long list of factors that can potentially affect the use of technology in schools. These factors include lack of convenient access to computers, inadequate infrastructure, poor planning for the use of technology (Smerdon et al., 2000), and teachers' inexperience in using technology as a productivity tool (Hope, 1998). Other relevant factors pertain to information and innovation overload and burnout; limited and/or inadequate staff development versus properly planned staff development (Weikart, & Marrapodi, 1999); lack of time for preparing ICT resources for lessons (Preston, Cox, & Cox, 2000); lack of ongoing support, fragmented knowledge, ignorance of school needs, and poor leadership knowledge and support (Hardy, 1998). Also affecting the use of technology in schools is the availability of guidance from specialist mentors and online resources (Sherry, Billig, Tavalin, & Gibson, 2000); compatibility of technology-related innovation with the school's philosophy, and finally, the changing nature of technology itself (Zhao & Frank, 2003).

Organizational factors also play key roles: for example, funding and equipment issues, lack of time to experiment and develop lessons and units or develop rubrics for assessment (Lam, 2000); planning the technology, support from the school and wider community, and training and implementation by the school administrators (Gray, 2001).

According to some researchers, teachers have the most impact on the quality of technology use in schools and therefore, factors relating to teachers are most frequently cited as influencing technology use in schools. For example, Hardy's (1998) review of studies on teacher attitudes revealed that teacher confidence affects the use of technology more than variables such as access to equipment, administrative support, and time. Other researchers have noted various important, teacher-related variables that influence the effective adoption or implementation of information technology. For example, whether teachers are positive about technology (Becker & Ravitz, 2000); whether they realize the advantages of integrating technology in their teaching (Scrimshaw, 2004); teachers' beliefs and views on information technologies (Norton, McRobbie, & Cooper, 2000); teachers' resistance to change in general (Jones, 2004) and their willingness to change their long-standing pedagogical practices (Snoeyink & Ertmer, 2001) and classroom role (Hardy, 1998); teachers' confidence to incorporate innovation and their commitment to the innovation (Dawson & Rakes, 2003); teachers ability to integrate technology (Kent & McNergney, 1999); prior negative experiences of using technology as a productivity tool (Snoeyink & Ertmer); feelings of intimidation if they sense students know more than them (Fryer, 2003); teachers' extrinsic and intrinsic motivation, and their need to improve computer technology skills and knowledge (Papa, 2003).

If we conceptualize the adoption of technology as a learning process for individuals and organizations, and if we acknowledge that the multiple factors affecting the adoption of technology reflect both individual and organizational variables as well as pedagogical and technology-related variables, then it becomes clear that simply examining isolated factors or variable lists and typologies will not further our understanding of technology use in the school. Moreover, the factors influencing the adoption of technology are often examined separately from one another and from the system in which they interact, whereas classroom technology usage illustrates a combination or network of factors within a particular environment. Zhao and Frank (2003) called this "the ecological system." In other words, a systemic perspective is needed to help us reach a better understanding of why teachers adopt or do not adopt classroom technologies.

According to Sherry and Gibson (2002), we should examine a system containing technological, individual, organizational, and instructional factors. Honey, Culp, and Carrigg (2000), on the other hand, have suggested a different network of constructs, believing that in order to successfully implement information technologies in schools, it is necessary to understand the complex classroom interactions between teachers, students, and technology.

Szabo (2002) took a different, more general view, asserting that the main consideration when introducing an innovation is not the actual technology but ensuring that the social context, people, technology, and purposive action involved are compatible with the proposed introduction of technology.

However, although researchers have suggested numerous system-based conceptual frameworks of constructs that explain ICT use, not many studies have in fact explored the relationship between the factors that promote and detract from the quality of technology use in the classroom. Moreover, although the process of adopting technology is conceived as evolutionary (Zhao & Frank, 2003), and although it is acknowledged that teachers' pedagogical philosophies and practices are not constant but rather affected by their classroom experiences (Becker & Ravitz, 2001; Levin & Wadmany, 2005), little research has longitudinally examined the introduction of technology. With the exception of the ACOT studies (Sandholtz, Ringstaff, & Dwyer, 1997) and Pierson and McLachlan's (2004) study on prospective teachers, most research has either investigated large survey groups of teachers or smaller samples, and they based their analysis on existing models of change.

The present study addresses the gap in this regard. First, it documents teachers' opinions regarding the factors that supported and hampered their use of technology in the three consecutive years of experiencing teaching in a technology-rich environment. Secondly, it describes the interrelationship between the various aspects of the teacher's experience with technology: the teachers' views of the factors affecting their use of technology, the changes in their educational beliefs during their classroom experiences, their views on the technology they used, and the constituents of their classroom practices. The interrelationship between these different factors is graphically presented, using three case studies of teachers.

METHODOLOGY

The research encompassed a longitudinal study that lasted three years. It is a case study of one school with multiple case studies of teachers at the school. It mainly utilized qualitative methodology principles (Lincoln & Guba, 2000). The methodology consists of a combined exploratory case study approach and a collective case study approach. It relates to each teacher as a separate case study, while simultaneously relating to all the teachers, holistically, as a group. Six teachers, in grades four to six, participated in the study.

Three data sources were examined: open questionnaires, interviews, and classroom observation. The open questionnaires and interviews were mainly used to study explicit educational beliefs and knowledge; the classroom observations and weekly meetings with participating teachers enabled the researchers to study the teachers' practices in real life teaching and learning situations and provided indirect or implicit measures of the teachers' beliefs. The open questionnaires were administered annually to teachers and the interviews followed researchers' observation of teachers in their classrooms and in the course of inservice training. The questionnaires and interviews probed teachers' opinions of the differences they had observed both in themselves and their professional environment and examined what they thought had assisted or impeded their classroom work.

RESEARCH DESIGN

Prior to the study, preparations were made in the school to support the needs of a technology-based teaching and learning environment and instruments for the implementation phase were developed and tested. The preparation phase lasted about six months during which (a) technological equipment including computers, multimedia, and a variety of software were introduced into classrooms to create the communication network "Akavish" (Hebrew: Spider); (b) professional development strategies, contents and workshops were tentatively planned and also a plan for mentoring teachers' classroom practices; (c) student and teacher learning activities, demonstrations, and research tools were developed and tested on samples of teachers; (d) advisory teams ("mentors") of educational technology experts and curriculum subject specialists were trained to assist teachers with their classroom work. These teams included school personnel, experts from the university, and a software development company's personnel. A group of students was trained to function as "computer assistants" in their own classrooms. They were taught to select technology tools that would enable information to be found quickly and to analyze and synthesize information and present it professionally.

In the next school year, following a brief workshop before the school year began, teachers started applying new concepts of student learning. They also received ongoing assistance on request and attended weekly, in-school workshops as a group. These workshops discussed two kinds of activities: (a) those initiated by the teachers based on their experiences with their own students in the classroom, (b) activities planned by the project leaders, dealing with the basic concepts and structure of information rich tasks, different

uses of information technology, introduction to general software capabilities, and examples of problem-based learning situations simulating learning by the teachers as a learning group. That is, the workshops contained activities, planned prior to the study, but also incorporated activities exploring teachers' queries, interests, dilemmas, and specific needs relating to classroom experiences pertinent to the study.

The study's approach to teacher professional development follows Putnam and Borko's (2000) situative perspective approach to professional development, which emphasizes four essential features of effective teacher learning: (a) teachers must be treated as active learners who construct their own understanding; (b) teachers must be treated as professionals; (c) teacher learning must be situated in classroom practice, and, (d) the teachers must be treated as they are expected to treat their students, emphasizing social-constructivist learning principles.

More specifically, the teachers were exposed to the following learning experiences:

1. Designing learning activities characterized as ill or loosely-structured which were definable as "information-rich tasks."
2. Providing inquiry-based learning processes using information technology.
3. Learning new concepts, procedures, and skills for operating information technologies and for presenting information-rich, **interdisciplinary** tasks.
4. Learning in cooperative teams and analyzing these learning practices to demonstrate the feasibility and usefulness of such learning experiences in the classroom.
5. Planning and evaluating inter-disciplinary learning activities for students inside and outside the school.
6. Discussion and reflection on classroom experiences while focusing on difficulties and problems, solutions and accomplishments.

After presenting the plans for implementing the new teaching, learning, and curricular experiences to the school staff, and after explaining the anticipated impact on the school, the school principal selected six teachers for the study: Initially four were chosen from the fourth and fifth grades, and two more teachers from fifth grades were added in the second year. Thus, six teachers and 164 of their students participated in the study: four teachers were studied for three years and two teachers for two years.

Teachers attended the weekly workshops for two consecutive years and received personal tutoring on request. Teachers involved in the study for three years, received personal tutoring upon request in the third year and also met with their colleagues whenever they felt the need to discuss issues, mostly regarding their classroom experiences. Students chosen as "technology assistants" did not attend the teachers' workshops, but received their own training in workshops outside the school. The aim of the workshops was to prepare the "assistants" for their classroom role, namely to operate the computers and be responsible for technology maintenance; to assist teachers and students with technical problems; and to assist students with their projects.

The teachers' classes were observed several times a year throughout the project. Altogether, 73 observations of the six teachers were carried out. A further 43 observations were also carried out during the workshops, to observe the teachers' learning processes. Open questionnaires were administered to the teachers at the beginning of each year, and personal interviews were conducted at the end of each year.

Data Analysis

The data were analyzed in two stages: first, the researchers used the responses to the teachers' questionnaire to create a portrait of the individual teacher's views with regard to the factors that supported or hampered their teaching in a technology-rich environment. The analysis of the changes in each teacher's views at three points in time: the first, second, and third years of the study, allowed the researchers to identify critical dimensions in the professional development of the teachers as a group and pinpoint a developmental pattern in their views.

Stage two of the data analysis focused on the teachers. The aim was to reach a deeper understanding of the relation between the individual teacher's profile of change in educational beliefs and practices during the study and her views on the factors fostering and inhibiting her efforts. Of the six teachers explored, three were chosen for presentation in this article, because they had distinct and highly divergent change profiles in terms of their beliefs, knowledge restructuring, classroom practice, and views on technology. We realized that the distinct developmental pattern of the three teachers adequately represented the profiles established for their colleagues (Wadmany & Levin, 2004).

The teachers were Zipi, who only changed superficially, and whose pedagogical and epistemological views were mostly realist and behaviorist-based. Zipi believed that knowledge, as a compilation of empirical data, is

given and absolute, and that it is acquired by adopting an objective distance from the world; Hadasa who showed the most significant change by moving away from a combined view of knowledge as transmitted and cognitively constructed, toward a relativist, social, and radical constructivist educational ideology, which posits that a person (teacher or student) is indistinguishable from his/her roles, culture and relationships, and that knowledge is always negotiated within a context of culturally informed relationships and experiences, and evolves through dialogue, language, and other systems of symbolic representation; and finally Zipora, who changed most, and held both realist and relativist beliefs, in other words, she viewed knowledge as both transmitted and cognitively constructed.

RESULTS

Teachers' Views on Enhancing ICT Use: Two Developmental Factors

On examining the teachers' views as a group in terms of the factors that enhanced their experiences in a technology-based learning environment, the study found two developmental patterns: the first concerns the source of influence on technology adoption, which focuses mainly on the human-learning factor, namely, in what way and under what learning conditions did teachers embrace technology; the second concerns the nature of influence occurring when using technology in the classroom. It focuses mainly on the different types of knowledge and knowledge change involved in adopting information technology.

1. During the three years of their classroom experiences, the teachers' developmental patterns relating to the source of influence on technology adoption point to a move away from external authoritative influences and towards personal, self-organized learning experiences associated with ongoing learning and professional support. Specifically, during their years of integrating technology rich tasks in a technology rich environment, the teachers' views on factors affecting their technology integration shifted:

Away from factors reflecting a need for external legitimacy, reinforcement, encouragement, power, and emotional support from authority figures such as superintendents and principals. The following statements show examples of this:

> I needed the school principal to support the new educational ideas and encourage me through the difficulties; The school superintendent's view affects the success of the change in the classroom—her participation in the workshops shows that she thinks the project is important; Regular assistance from the tutors was very helpful.

Through factors emphasizing the benefit of dialogical learning with partners, colleagues, and students, as seen in the following statements:

> Interacting with my colleagues, who were very supportive and important, helped me to understand things better; I became friendlier with my colleagues; working with them gave me the courage and confidence to try out new ideas; I worked hand in hand with the students, which made it easier to change my approach; The fact that I learned from the students while working with them certainly taught me a lot, and made the project even more successful.

To factors involving the teachers' own learning from their teaching experiences, their need for ongoing professional learning support, and the learning opportunities they encountered, as reflected in their impressions:

> My new experiences in the classroom allowed me to see that my views on teaching had changed and that I had made a success of the project; The new experiences made me reflect on my own development as a result of using the new teaching approach, and helped me to capitalize on the change.

In other words, the development pattern of the teachers' views defines a continuum, at one end of which lies the external influences on the teacher, and at the other end the teacher's internal behaviors; that is, their self-regulated, reflective behaviors. Between the two extremes lies the teachers' dialogue with colleagues and students, which the teachers' perceive as an important factor in helping them to implement the considerable innovation required by the project. This pattern expresses the teachers' orientation towards technology integration as part of a continuum ranging from external control and regulation to autonomous and collaborative regulation.

2. The second developmental pattern exhibited by the teachers describes the kind of influences required for technology adoption. It represents a shift:

Away from technical and organizational aspects related to change and to introducing a new approach, such as the nature of courseware used, alignment to curriculum, and so forth.

> There are inevitably technical hitches when working with computers, and this interferes with teaching and learning; The school didn't always have the right courseware for the curriculum; I needed more time to cover it all—the regular curriculum and the new stuff.

Through personal and individual capabilities reflecting readiness to confront changes. It represents the interplay that occurs between the teacher's personal strengths and weaknesses when adopting an innovation. For example, the ability to deal with the unexpected; a sense of confidence or feelings of anxiety, level of reflectivity, sensitivity to the teacher's own needs or difficulties, as the following statements demonstrate:

> I found it hard to plan lessons whose course was unpredictable; I had some difficulty understanding the sequence of the instructional design; I couldn't decide what to do first and what follows; I can't handle open situations where you don't know what's going to happen or where it will lead; I get anxious about new things.

To reconceptualizing and transforming views concerning the meaning of curriculum, teaching, and learning and their manifestations in actual classroom practices as reflected in their impressions:

> It required me to change my ideas about teaching and learning, which was difficult; It is hard to accept the notion that a teacher no longer supplies knowledge, and that you are supposed to learn from your students; It is hard to learn new ideas at the same time as practicing them in the classroom.

This dimension of change is concerned with the transformations in conceptual thinking as a result of practicing teaching in a technology-rich classroom, and how these changes affected the regular school curriculum and teaching practices. The developmental pattern exhibited by the teachers concerning the nature of change required for technology adoption is: From concentrating on specific and technical issues of technology use, to becoming aware of and transforming one's own educational views (i.e., being involved in conceptual change or knowledge restructuring). In between the two extremes poles lies the teachers' awareness of their personal difficulties, needs

and capabilities to cope with the changes required when using information technology, which the teachers' perceived as an important factor in helping them to use information technology in their classrooms. This pattern reflects the nature of the teachers' engagement with technology—from technical, shallow engagement through engagement with reflection on personal skills and capabilities, and finally to cognitive transformation.

The two dimensions identified with regard to the conditions that influence technology integration in the school, in terms of both the positive and negative aspects associated with technology, reflect the teachers' self-conceived vision of technology use (Figure 1).

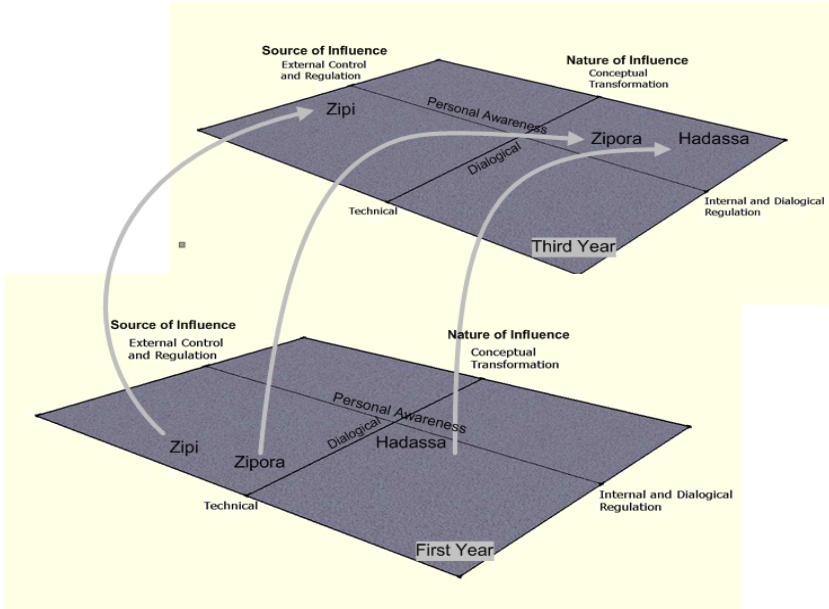

Figure 1. The development pattern of three teachers

The teachers manifest a two-dimensional vision reflecting their various orientations towards the processes of integrating technology into the classroom: the controlled/external dimension, which implies that initiation and regulation depend on the demand of others, and the autonomous/internal dimension, which reflects the idea that the initiation and regulation of teacher's behaviors are self-determined. This vision also expresses the nature of the teacher's engagement with the change: technical/superficial versus cognitive/deep and is used here to describe the profiles of teachers' changes

through the years. It portrays the relationship between changes in teachers' beliefs and practices, the factors that teachers believe affect the use of technology in teaching, namely, their vision of technology use, and teachers' learning patterns.

Interestingly, teachers' answers with respect to inhibiting factors they encountered during the three-year study show no definitive development pattern. Most of the teachers' views expressing difficulties are included in the two dimensions described, and focus mainly on the difficulty caused by the need to restructure their knowledge and alter their conceptions of teaching and learning. Most of the teachers expressed this idea, though only in the third year of the study, and even in the third year, not all believed that the need for them to change their conceptions had inhibited their success in integrating technology. On the subject of personal capabilities, only some teachers indicated that their difficulty with teaching using technology stemmed from their lack of confidence and anxiety.

Three Teachers: Three Different Profiles of Development

The study identified three profiles to describe the relation between teachers' vision of technology use in teaching and the change in their educational beliefs and practice:

The first profile reflects superficial change in educational beliefs, peripheral knowledge restructuring, a technical view of information technology, and regular use of direct instruction. According to this profile, traditional professional development and support from authorities are the main factors responsible for encouraging teaching in a technology-based classroom. Interaction with students is also an important factor that develops in this profile, although it only appears in the teacher's second or third year of experience. In this profile, the changes are mainly technical and only a limited degree of self-awareness is involved in the actual integration of technology in the classroom.

Zipi was an example of a teacher with this profile (Table 1 and Figure 1). In her first year of the program, as Zipi began her experience of using information rich tasks in a technology-based classroom, she had an authoritative view of teaching, which she viewed as "knowledge transmission." She mainly focused on curriculum coverage and described teaching as "a funnel–the teacher pours substance and knowledge into the students' brain." By the end of her classroom experiences, she still viewed teaching as "knowledge transmission," although her emphasis had changed slightly from a focus on content coverage to a focus on student understanding. Nevertheless,

Table 1

Teachers' Profiles Describing Changes in Educational Beliefs and Practice Between the First and the Third Years

	Zipi		Zipora		Hadassa	
	1st Year	**3rd Year**	**1st Year**	**3rd Year**	**1st Year**	**3rd Year**
Views on Learning	Imitation and practice	Imitation and practice + cognitive process	Imitation and practice	Imitation and practice and cognitive process	Cognitive constructivism	Radical constructivism
Views on Teaching	Knowledge transmission + syllabus coverage	Knowledge transmission + student understanding	Knowledge transmission + syllabus coverage	Knowledge transmission + student understanding	Knowledge Transmission + student understanding	Facilitation of learning + individual growth
Views on Technology	Computers are used for practice	Computers enrich instruction	Computers are source of information and tools for communication	Computers are intellectual partners, which help expand human capabilities	Computers are learning aids	Computers are partners for learning
Classroom Practices	Direct instruction	Direct instruction + collaborative learning	Direct instruction	Cognitive apprenticeship	Direct instruction + caring	Discovery learning + reflection

she still retained a positivist epistemology (conceiving a well-structured reality, separated from the human "knower," assuming regularity and predictability, and, viewing knowledge as given and absolute, acquired by adopting an objective distance from the world): "I plan lessons around problems with a single, clear, easy to find answer."

From an initial view of learning as "sucking up information / a tool / soaking up like a sponge" at the beginning of the study, Zipi's perspective only shifted slightly to a viewing learning as a process in which the learner "obtains and absorbs information from outside resources." Complementary data reflecting Zipi's beliefs was also obtained from the metaphors she used to describe teaching and learning. Zipi's metaphor for learning was "drinking from a fountain," and her metaphor for teaching was "continuous water dropping"—both of which reflect passivity in learning and transmission in teaching. Her views on technology had not changed either: after three years, she still perceived computers in technical terms, as either a practical tool or an instructional and enrichment tool.

Zipi was also an example of a teacher whose knowledge restructuring process only changed superficially. Superficiality here encapsulates a low level of reflective behavior, low tolerance for ambiguous situations, and high tolerance for dissonance. Meaningful interaction is mainly with formal authorities, such as the principal or researcher. Indeed, Zipi expressed a low or shallow level of reflection: "I am aware of the change process and think about it during the workshops." She also presented low tolerance for ambiguous situations: "The new approach offers no fixed, clearly-defined curriculum. I expect a clear curriculum....It is hard, having to plan the curriculum myself," and high tolerance for dissonance: "It is hard to learn new material and teach it at the same time." She judged her professional progress in terms of relevant or meaningful interaction with others, both authorities and colleagues, and was satisfied that: "The school Inspector came to explain the rationale for the new teaching approach."

Zipi did not revise her classroom practices and throughout the study used mainly direct instruction strategies. Nevertheless, despite maintaining her direct instruction practices throughout, towards the end of the study, Zipi added supplementary practices and the occasional session of cooperative learning.

Thus, we have placed Zipi in two different locations in the third quarter of the two-dimensional representation of the teachers' vision of technology use (Figure 1), which reflects an external and technical orientation towards technology integration and a limited positivist-based change profile during the study.

The second profile involves significant change in the teacher's educational beliefs and considerable knowledge restructuring. This is combined with a shift away from a view of technology as an instrument that supports learning, towards a view of technology as a partner that empowers students and teachers. If the teacher is positive about learning from students and colleagues, then the above factors, along with a focus on collaborative learning can successfully support the use of technology in teaching and learning. These views also correlate with the teachers' strong awareness of the need for conceptual change regarding school learning. The teachers also believed in the importance of learning from personal experience, but only in the third year of the study.

The change that took place in Zipora's view illustrates this category. Zipora (Table 1) changed her view of learning from knowledge accumulation to learning as knowledge accumulation and knowledge change in response to students' needs, active engagement in real-life situations, and working with cooperative groups. At the outset of the study, she noted that: "Learning is experimental–you are mindful of what you are doing. You try to discover what is right and what is wrong." At the end of the study, however, Zipora said: "Learning is an experiential process that takes time and is powered by internal motives and interests." Retaining her initial view of teaching as "knowledge telling," this teacher came to see teaching as a support system for guiding student thinking and facilitating their self-efficacy. In other words, compared to the beginning of the study, her focus by the end of the study was more on understanding her students and less on curricular content.

This notwithstanding Zipora's metaphors continued to express a passive view of learning and a transmissionist perception of teaching. At the beginning of the study she associated learning with conditioning and "Pavlov's dog," and metaphorically described teaching as: "a train, pulling wagons that can't go forward without it," thus reflecting passivity and an objectivist-determinist view. Towards the end of the study, she regarded teaching as involving: "the capacity to provide students with a comfortable, meaningful, and guided learning environment." In the course of the study, Zipora's perception of the value of interdisciplinary learning tasks changed. She developed a deeper appreciation of her students, conceiving them as partners in planning instruction, and revised her teaching practices from a primary focus on direct instruction at the beginning of the study, to modeling, coaching, articulating, reflecting, and exploring behaviors, towards the end of the study.

Her views on technology changed: whereas at the beginning of the study, she perceived technology as an instrument supporting learning, at the end of the study, she perceived it as a partner for empowering student and

teacher capabilities. However, her view of the curriculum had an extremely traditional-positivist hue, in that she believed that only academic experts should devise the curriculum, and that teachers lacked the authority to make curricular decisions—suggesting a view of the curriculum as a system of control.

Zipora is also an example of a teacher who changed significantly in terms of her knowledge restructuring process. This was characterized by a relatively high level of reflective behavior accompanied by high tolerance for ambiguous situations, a low tolerance for dissonance, and by her most valued interactions being with other teachers (peers) and students. Indeed, Zipora demonstrated a high level of reflective behavior: "I am constantly aware of the processes we are experiencing. I typically think of this before class and after class so I can tell you what I think when we meet." In the second year, Zipora expressed a personal need for reflection:"I think about and analyze the processes I experience, which helps me to make decisions. It is absolutely crucial for my professional growth and for me to be able to evaluate the change process."

Only towards the end of the third year did Zipora express high tolerance for ambiguous situations: "Although things were not so clear cut, and although I found lots of the ideas ambivalent, I still managed to overcome these difficulties, both alone and together with other teachers and my students." Interestingly, Zipora's tolerance to dissonance can only be assessed indirectly, from the data. Thus, we find that she was highly aware of the changes the teachers needed to make: "The new learning environment requires teachers to significantly change their approach to teaching. All of the teachers need to make this change including those who resist any change." However, at the same time, she says: "It is impossible to keep the old values and strategies and be involved in this kind of teaching. Even though it is difficult, I still do it–even if I can't see the connection between the stated curriculum and the actual classroom practices."

Zipora believes that all relevant parties in the school should be involved in such a far-reaching type of change: the school superintendent, the principal, the teachers, and the students. Despite this, she states that her most meaningful interactions were with colleagues and students: "The students turned out to be my partners—I learned with them and from them." "My discussions with my colleagues were highly significant and mainly our collaborative thinking processes."

Thus, Zipora's change profile may be placed in the first and third quarters of the two-dimensional representation of technology use (Figure 1, Table 1), reflecting a high degree of awareness of her needs as a teacher to implement such a change. This marks a move away from external control to a

more autonomous orientation in her use of technology, coupled with a high level of engagement in cognitive and rational change in her educational beliefs. In sum, her change represents a move away from positivist educational views (reflected in the third quarter) towards a more constructivist orientation (reflected in the first quarter).

The third and most remarkable change in the teachers' educational beliefs involved radical knowledge restructuring; a realization that technology is a partner in teaching and learning, and the use of classroom practices that promote discovery learning. In this case, the teacher perceives her students as highly capable, not only of seizing open-ended, creative learning opportunities and employing diversified modes of learning, but of offering curriculum-related suggestions, helping with planning classroom activities, and supporting the teacher's experiences within an innovative environment. According to this profile, a teacher's own learning and transformation in educational beliefs and practices are the main factors responsible for encouraging a positive approach to teaching in a technology-based classroom. Radical change of this nature also correlates with a desire to continue learning "with and from colleagues" and "with and from" the professional authorities. In this change scenario, the teacher is aware of the difficulty of changing conceptions and beliefs and overcoming anxiety.

Hadassa (Table 1) is an example of this kind of teacher. In her first year, when she began her experience in using information rich tasks in a technology-based classroom, Hadassa held an authoritative view of teaching, which she saw as "knowledge transmission." By the end of her classroom experiences, she had arrived at a constructivist view of teaching as a collaborative process of restructuring knowledge for both teachers and students, and a view of learning as an active, meaning making, authentic process concerned with real-life issues. Her metaphoric view of learning is one of "infinite renewal—the wind that blows from young, lively, and healthy fountains."

At the start of her experience, Hadassa seemed aware of the importance of her students' knowledge and curiosity. However, over the years, she became a great believer in her students' self-regulatory capabilities, their sense of responsibility and ability to be partners in instructional planning. She also changed her view of technology and began to see it not as a technical-functional tool, but as a partner in the processes of learning and teaching. Her actual teaching strategies also changed: from direct instruction and much care for her students at the beginning of her experience with technology, to using discovery learning strategies and reflection on her actions in her third year of experience. Hadassa noted:

> My students and I learn experientially, therefore we understand what we do; My teaching practices have changed. Now teaching is what happens when I work together with my students using understanding and experimentation; My students offer curricular suggestions and help plan activities; I try to provide opportunities and resources for my students to discover or /and construct concepts for themselves.

Hadassa is also an example of a teacher whose knowledge restructuring process has changed radically. Radical change is characterized by high level of reflective behavior, high tolerance for ambiguous situations, low tolerance for dissonance, and by developing knowledge and practices through interaction with students and colleagues.

Hadassa's profile indeed demonstrates a high level of reflection: "I can't stop thinking about the new learning and teaching processes. This type of thinking improves our understanding of what happens in the classroom"; high tolerance towards ambiguous situations: "I am open to change because I believe in change"; and low tolerance for dissonance: "I am scared of new things, but I believe that this is the direction education and teaching should take, therefore I keep battling with my fears and going along with the change." Her interactions with others are mainly with colleagues and students: "It is important for me to meet with my colleagues. They come to observe my class because it is important for me to get feedback….The students are my partners in the learning process…I learn from my students."

Based on these statements, we can place Hadassa's change profile (see Figure 1) in the fourth (in the first year) and first quarter (in the third year) of the two-dimensional representation of technology use, reflecting autonomous control over the use of technology and high engagement in cognitively and rationally changing her educational beliefs. Her change represents a move away from a slightly positivist educational view (edge of the fourth) to a constructivist orientation (fully in the first quarter).

The case studies illustrate the complex relation between the teachers' views on technology usage and the changes they experienced when working in a rich technology classroom. They also reflect the complex, internal, cognitive and emotional dialogue underlying teachers' perceptions of pedagogical innovation as a professional learning process. This suggests that it is important to tolerate uncertainty and reflect (both during and concerning action) on personal beliefs during the activities and thinking required for technology-based classroom reform. The case studies also showed that tolerance of uncertainty and intolerance of dissonance (the gap between the desired and actual classroom processes and products), and appreciating the positive aspects of learning in a community of learners—colleagues or students—assists teachers

in overcoming negative and discouraging emotions, such as anxiety and indecision.

DISCUSSION

This research is important for understanding the way teachers view and experience educational practices when technology is introduced into their classrooms. It shows how information technology can change the way teachers' function, think, and feel in their classrooms. It also shows that both the conditions teachers believe will facilitate the use of technology in teaching and the changes that occur in their beliefs and practices are linked to the different patterns of teachers' learning. The study thus emphasizes the importance of formally learning from experts, contextual and dialogical learning with colleagues and students, and self-learning based on one's classroom practices.

The teachers' views of the factors inhibiting and encouraging learning and teaching in a rich technology-based climate demonstrate that perceptions arise as a result of activities involving other people and situations, and are not simply confined to the individual's mind. This supports Engestrom's (1999) activity theory, according to which humans learn through their actions and use what they have learned to plan and carry out other actions, which ultimately affect their beliefs and behaviors. It also supports the activity theory conception that internal-mental activities cannot be understood when analyzed in isolation from external activities due to mutual transformation between the two activities: internalization and externalization. Rather, the context of the activity determines when and why external activities become internal and vice versa, while the social context and interaction between actors and agents in the environment activates the internalization / externalization mechanisms.

The study thus demonstrates that not only computer technology is required to ensure that computer technology is successfully introduced into the classroom with the desired effect, but a complex web of interrelated factors and expectations within a didactic and pedagogical task structure and an organizational and educational mindset. These findings support other findings, which suggest that in order to use technology, teachers must have diverse teaching experiences so that they enter the classroom with wide ranging abilities and an associated positive belief system (Russell, Bebell, O'Dwyer, & O'Connor, 2003).

These findings highlight the fact that teachers' beliefs are shaped by everyday classroom and school experiences, and that people in their environment (their colleagues, students) and artifacts mediate the teachers' relationship with reality (Nardi, 1996). Referring to this conclusion, Nardi wrote that: "you are what you do, and what you do is firmly and inextricably embedded in the social matrix of which every person is an organic part of" (p. 7). This social matrix is composed of people and artifacts. Though the term "people" refers to individuals associated with the teachers' daily context/environment (students and colleagues), it also refers to such authorities as the principle, school superintendents, and experts. "Artifacts" refers to physical tools such as computers, courseware, software, and curriculum materials, and to the norms, vision, expectations, and language of the school.

The study also supports the notion that these mediating activities with people and artifacts continually change and evolve and can provide a historical, personal profile of how a teacher develops in a given situation. Therefore it also supports the view that schools and classrooms can become learning communities of teachers, students, and experts. It also recommends the use of tools (ICT and other artifacts) as a means of promoting the accumulation and transmission of social knowledge. These tools not only influence teachers' outward behavior, but also their mental performance. In practical terms the study suggests that when planning professional development for teachers, learning from experts, colleagues and self and experiencing different learning settings should be encouraged, planned, and supported.

Furthermore, longitudinal case study research like this, which reveals the multi-layered developmental process of teachers' educational views based on their classroom experiences, their identity when teaching with technology, and their views on the place of technology use in the vision of teaching, question the stage-like structure suggested by many innovation adoption/diffusion models, and Concern-based Adoption Model. Neither the differences in teachers' change patterns, nor the different classification patterns of their views regarding the vision of technology use suggest a stage-like development in teachers' views concerning the use of ICT in schools. Rather the study seems to suggest a developmental model that is cyclic or helical, wherein classroom practice and dialogue with others and with new artifacts affect the depth of the teachers' learning, their cognitive views, and feelings, and their behaviors in a wide range of change dimensions.

This study therefore challenges the idea that teacher appreciation and use of information technology in the classroom develops in stages and suggests that we should further explore the question of whether one can claim that the development occurs in purely hierarchical and invariant sequences.

In other words, this study suggests that we question the assumption that teachers' use or concerns about using information technology in the school are likely to reflect a linear sequence of development. Based on the fact that teachers hold multifarious and multidimensional views on technology use, including seemingly discrepant views or practices that co-exist and interact, the study proposes that the evolution of teachers' views on the use of technology in their school and their actual practices with information technology are adaptive and dynamic, and involve variation and selection of views and practices. In other words, the development of views and practices concerning the effective use of information technology might have stage-like properties, but does not evolve in a one-stage-at-a time fashion.

In addition, the results support the idea that when viewed within the teacher's broader belief profile and knowledge restructuring processes, doubts, uncertainty, and lack of confidence can be regarded as an acceptable and normal part of a teacher's professional development. The results also endorse Saye's (1997) finding that for both students and teachers, comfort with uncertainty strongly relates to the ability to use technology innovatively. It also supports Dudley-Marling and Fine's (1997) conclusions that for teachers who are learners "uncertainty is what keeps the inquiry process going" (p. 252), and therefore uncertainty encourages growth and renewal.

The findings regarding the three case studies imply that the "one size fits all" metaphor is inappropriate if we are to meaningfully influence teachers' use of technology in the classroom and develop their capabilities to work in technology-based environments. In fact, the study calls for technology-based and school-based reformers to reach the right balance between working with teachers individually and working with meaningful groups/communities of teachers. Moreover, with reference to Cuban (2001), who claimed that factors inside and outside the school affect the ability of ICT-based innovation to diffuse into and improve the school, this study also adds that there is a need to consider personal variables. It demonstrates that not only should we consider the fit of technology use within the localized classroom setting of each teacher, but we should also consider the broader profile of teachers' educational beliefs, their cognitive and emotional disposition to face novel, uncertain, situations, their actual teaching practices, and their views on technology and its supportive and restrictive nature.

IMPLICATIONS

The present study has multiple significance and relevance:

First, it offers new insight into the exploration of teacher change when integrating ICT into the school curriculum in the context of a technology-enriched learning environment. In particular, it offers a more holistic perspective of the factors that facilitate or interfere with teachers' use of classroom technology. Its importance lies in its identification of several **developmental** patterns, which appear in teachers during ICT use in the classroom, as explored and observed during three years of research. These developmental patterns reflect teachers' views on the use of information technology in school, the meaning of learning, teaching, and technology, and the characteristics of actual classroom practices.

Researchers often divide the barriers affecting teachers' integration of ICT in their teaching into several categories: for example: institutional and personal barriers, or first-order and second-order barriers (Ertmer, 1999); inside and outside school barriers (Cuban, 2001), or teacher-level, school-level, and system-level barriers identified by Balanskat, Blamire, and Kefalla (2007), where each category includes a set of more specific distinct factors affecting technology use.

However, this longitudinal study suggests that sometimes a combination of external and internal or personal and institutional factors really matters most. In other words, after analyzing the teachers' beliefs, the study argues that technology integration is affected by multidimensional characteristics and the synergy between two types of epistemic influences: the **source** of the processes as well as the **nature** of the processes and knowledge involved in ICT adoption, which represent two **developmental** continuums.

The first continuum describes the human learning dimension that ranges from external authoritative influences, through dialogical processes, towards personal need and self-learning. The second continuum represents the knowledge involved in ICT adoption, which ranges from technical and organizational knowledge, through knowledge concerning the process of change, to knowledge restructuring processes involved in conceptual transformation. The study also shows that the conditions teachers believe will facilitate the use of technology in teaching, and the changes that occur in their beliefs and in their actual classroom practices, are linked to different patterns in their learning.

These results support the importance identified by various researchers of adopting a systemic, ecological, or holistic view when studying change processes in teachers in order to understand why teachers adopt or do not

adopt classroom technologies (Zhao & Frank, 2003). They also supported the claim that most of the factors believed to be meaningful in facilitating teachers' use of technology do not directly encourage a linear use of technology, but rather their influence is filtered by teachers' views. The present results show that teachers' strongly believe that using ICT in the classroom is a process ultimately founded on their own internal learning processes and their knowledge transformation and commitment to professional growth, although at the initial stages of their experiences they are more heavily supported by external authoritative influences, and some of them are almost totally dependent on extrinsic factors, such as authority approval, and intensive technical support.

In this respect, the study encourages educators and teacher educators to be aware and sensitive to the important influences that teachers' educational views (on learning, teaching, and technology) have on teachers' practices and on their capabilities and need to interact with others (authority figures and colleagues), and that teachers also reflect on their own beliefs, knowledge, and experiences. Researchers and teacher educators could incorporate experiential practices and strategies into their professional development programs, which address such beliefs, skills, and knowledge, and in this way help to improve teachers' awareness and insights into the change process that lies ahead. This could be achieved by relating directly to the teachers' explicit knowledge and beliefs. Asking teachers to share their stories and reflect on their ICT integration experiences is another potential method for highlighting, understanding, and appropriately shaping personal beliefs regarding desired ICT practices. However, in view of the individual patterns found in this study, we highly recommend that such professional development experiences should consider providing both individual and group learning opportunities, which show respect and appreciation for teachers' unique interpretations of using ICT and their analysis of their own beliefs and knowledge.

Second, although the study only presents the profiles of views and practices of three teachers, each teacher demonstrates a unique developmental pattern across the three years of ICT practice in the classroom. The results support the findings of other, larger studies that attest to the diversified experiences of teachers and the complexity of trying to meaningfully change teachers' beliefs about teaching and learning processes and classroom skills even when teachers firmly believe that change is necessary and positively seek to change their professional performance.

This implies that the constructivist approach to learning, which conceives learning as complex, interactive, changing, active, and situated, and

which allows learners to individually construct their knowledge in a unique and meaningful way while confronting challenges and dilemmas, fears and excitement is not only applicable to students, but to teachers as well. We therefore strongly recommend that professional development experiences apply personal and social constructivist-based learning principles even if this requires a slower pace and more heterogeneous patterns of professional development.

Third, the study demonstrates that the use of technology-oriented learning tasks is not enough to ensure successful integration of technology into teaching. Ideas for adjustments and mindful changes must be weighed in terms of the teachers who ultimately determine how technologies are utilized in the classroom. More specifically, the study shows that during three years of classroom practice with ICT, some teachers went beyond just knowing how to use computers and adding this knowledge to their repertoire. In the classroom process that emerged, teachers' views on learning teaching and technology were modified and transformed and steered in a new direction. Teachers' views evolved from an authoritative transmissionist view to a perception which sees teaching and learning with technology as an interactive, interpretive, and constructive process, a meaningful and engaging experience that can affect others and be affected by its own process.

Developments in teachers' views on teaching and learning occurred on several levels and reflected changes on a continuum stretching from teacher-centered teaching and learning to student-centered teaching and learning with a new appreciation for student interpretation of knowledge; from relating mainly to the individual student to relating mainly to groups or learning communities; from relating to externally imposed knowledge to appreciating authentic issues; from relying on disciplinary-based learning goals to acknowledging the value of inter-disciplinarity, and from viewing technology as a technical tool to seeing it as a partner that can empower the student, teachers and the learning environment.

Taking the premise that belief change is a consequence of teachers' continuous inquiry into their instructional decisions and practices, the study suggests that in terms of professional development experiences, be this conferences, workshops, personal or online mentoring opportunities, teachers should be exposed to the potential inter-dependent multidimensional characteristics associated with their beliefs and practices. Learning opportunities that incorporate technology-supported practices, which are coherent with teachers' routine classroom activities can be a source of inspiration and professional renewal. Experiences of this nature could raise teachers' awareness of desirable constructivist-based multidisciplinary learning and teaching

processes. It could also produce desired changes in teachers' knowledge and skills regarding meaningful teaching and learning processes using ICT.

Finally, there is a large body of literature that supports the idea that the main obstacle that prevents teachers' using technology in their classrooms is lack of adequate preparation. Yet, studies also show that despite training some teachers are hesitant and unwilling to embrace technology. In other words, according to the research, even though trained teachers use technology more than teachers with no training, the frequency of technology use and of implementing student-centered learning does not improve significantly with training (Di Benedetto, 2005).

The present study describes teachers' needs in terms of professional growth. It shows that training by authorities is only one component of an effective professional development plan. The views elicited from teachers highlight their need for formal training by experts at an earlier stage of their new classroom experiences with ICT. At subsequent stages in their professional growth they will require educational opportunities that facilitate collaboration with colleagues on authentic routine classroom issues as well as personal and self-inquiry accompanied by mentorship, sometimes in addition to, but mainly instead of, authoritative training. The present results support arguments by researchers that follow-up professional growth programs and mentoring systems are necessary after technology integration training in order to foster collaboration and support, address daily challenges, and ultimately increase effective technology usage in the classroom (Di Benedetto, 2005). It also strengthens the importance of self-study and collegial interaction as an informal professional communication method to be use in teachers' professional growth (Sahin & Thompson, 2007).

In this respect, the present study highlights the need for long–term, continuous, professional development experiences for teachers in their schools, which should be dynamic and adaptive to differentials in teachers' needs, skills, views, and commitments to learning and to experience innovative classroom practices. Long-term professional development programs, not just learning events are vital for technology integration to succeed. Since teachers learning opportunities are often plagued by fragmentation, teachers' training courses, workshops, and support session monitoring should be coordinated and sustained over time to empower teachers and show them what they need to know and what they can achieve.

The study also highlights the importance of focusing on the individual teacher's professional development as suggested by the traditional cognitive approach to teacher learning and of providing opportunities for interaction between participants in the new educational experience: interaction with educational specialists; student experts, learning resources (materials), and

representational systems (Greeno, 1997). Thus, the learning and change processes these teachers should experience throughout their professional growth can be viewed as much as a matter of enculturation into their community's thinking dispositions as a question of explicit practice with ICT. In this respect, we support Balanskat et al.'s claim (2007) that teachers' professional development should be conceived as part of a culture of lifelong learning, knowledge sharing, and peer learning.

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