Teachers' Beliefs and Practices in Technology-based Classrooms: A Developmental View

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Abstract

This paper reports on an exploratory, longitudinal study that analyzes and interprets the evolution of teachers' beliefs regarding learning, teaching, and technology, and their instructional practices, in the context of integrating technology-based information-rich tasks in six 4th–6th grade classrooms. The study used multiple research tools, interviews, questionnaires and observations, focusing on both teachers' beliefs and classroom practices. The findings reveal that following multi-year experiences in technology-based classrooms, teachers' educational beliefs had changed quite substantively, demonstrating multiple views rather than pure beliefs. The study argues that teachers' beliefs form a mosaic of complementary visions, even conflicting ones. It also shows that it is easier to change classroom practices than educational beliefs. (Keywords: teacher beliefs, technology integration, information-rich tasks, teacher cognition, multiple beliefs.)

INTRODUCTION

This study explores the evolution of teachers' beliefs on learning and teaching in the context of a technology-based classroom environment, integrating technology-based information-rich tasks (IRT) in the school curriculum. It examines whether, how, and why teachers' use of information-rich tasks in an information-rich classroom environment influences their views on learning and teaching and their actual teaching practices. The study assumes that when planning and experiencing teaching and learning using information-rich tasks we must take a fresh look at teachers' beliefs and educational practices. It also assumes that beliefs and classroom practices are multivariate and interrelated. The three-year study focused not only on teachers' explicit statements but on observations of classroom practice as well.

Although for several decades, information and communication technologies (ICT) have strongly affected all aspects of our society and culture (Sproull & Kiesler, 1991), the educational system has largely remained unchanged (Abrami 2001; Albion, 2003; Mann, 2000). ICT has not been widely integrated into education. Where it has been integrated, clear evidence that it can affect teaching or improve desired learning modes is still lacking (Alexander, 1999). Moreover, teachers only superficially accept technology into their work, even when technology is available to their students (Cuban, et al., 2001; Leach & Moon, 2000). Typically, teachers use linear, authoritative, teacher-centered methods, they disregard computers, and resist efforts to move the dominant paradigm

away from teacher-centered teaching to a more student-centered classroom (Cuban, 2001; Semple, 2000).

A major cause of this disappointment has been attributed to teachers' educational beliefs and to their personal theories concerning teaching and learning, since these beliefs strongly influence classroom practices (Albion, 1999; Albion & Ertmer, 2002; Ertmer, Addison, Lane, Ross, & Woods, 1999; Ertmer, Gopalakrishnan, & Ross, 2001; Lim & Khine, 2006; Mumtaz, 2000; Pelgrum, 2001; Scrimshaw, 2004). Beliefs are filters that guide teachers during instructional and curricular decision-making (Pajares, 1992; Prawat, 1992). Beliefs thus affect how teachers implement innovations. Beliefs largely determine how and why teachers adopt new teaching methods (Golombek, 1998), or adapt to new classroom environments, processes, and goals. Indeed, as early as 1984, Munby argued "...teachers' beliefs and principles are contextually significant to the implementation of innovations" (p.28). Cuban (1990) also maintained that educational reforms remain a perennial agenda item since policy makers ignore the belief factors involved in change. More specifically, Fullan (1992) claimed that educators' visions of the potential for educational change with new educational technologies underestimate how difficult it is for teachers to implement the changes that will be required in their practices and skills, as well as in their educational beliefs.

According to Fishbein and Ajzen (1975), the strength of a belief is indicated by the person's subjective probability that he or she will perform the behavior in question. This suggests that it is worthwhile to investigate teachers' beliefs, and also to explore the implicit link between teachers' views on learning and teaching and their actual classroom practices. Without teachers' skilled pedagogical application of educational technology, technology in and of itself cannot provide innovative school practice and educational change (Cox, Abbott, Webb, Blakeley, Beauchamp, & Rhodes, 2004). Studying the link between teachers' beliefs and classroom practices can therefore shed light on the correspondence between classroom practices and stated beliefs, which may reflect on teachers' convictions relating to educational processes and goals involving information technology in the classroom. It may also help us to probe issues associated with technology-based educational change deeper.

However, whereas it is generally agreed that teachers' educational beliefs tend to shape the nature of their instructional practices (Pajares, 1992; Richardson, 1996), some studies suggest that the challenges of classroom teaching often limit teachers' ability to provide instruction congruent with their beliefs (Davis et al., 1993). It therefore seems that we still have much to learn regarding the relationship between teachers' beliefs about learning and teaching and their actual instructional practices.

Specific to the relationship between technology integration practices and teacher beliefs, research is limited. Research results that exist show a strong correlation between computer use and a constructivist view of learning. In Becker and Ravitz's (2001) study, for example, the results show that computer use among teachers is related to more constructivist views and practices and to changes in practice in a more constructivist- compatible direction. In addition,

more recent research suggests that there is a parallel between a teacher's student-centered beliefs about instruction and the nature of the teacher's technology-integrated experiences (Judson, 2006; Totter, Stutz, & Grote, 2006). That is, teachers who adopt a student-oriented constructivist teaching style are more likely to make use of new technology in classrooms, and vice versa: Teachers who readily integrate technology into their instruction are more likely to possess constructivist' teaching styles. This connection between the use of technology and constructivist pedagogy implies that constructivist-minded teachers maintain dynamic student-centered classrooms where technology is a powerful learning tool.

Nevertheless, most of these studies have relied upon surveys and on self-reported data from teachers (Judson 2006; Willis, Thompson, & Sadera, 1999). Much less knowledge is available on the extent to which teachers' actual classroom practices are aligned with their educational beliefs on teaching and learning. Such knowledge may help to distinguish between strongly and less strongly held beliefs, and this might explain why some beliefs may be resistant to change (Zeidler, 1997). Furthermore, relatively few studies have examined these effects in the longitudinal context of a technology-enhanced learning environment. The present study seeks to fill this gap. Particularly, it seeks to learn: (1) Whether and how teachers' beliefs on teaching and learning change during their longitudinal teaching experiences with educational technologies in rich technology-based classrooms. (2) How do teacher views on learning and teaching relate to the practice of integrating technology and how do they incorporate technology into new pedagogical patterns based on new or modified educational beliefs? (3) Whether and how teachers' views on technology change during their longitudinal teaching experiences with educational technologies in rich-technology based classroom and how these views could be characterized.

THEORETICAL BACKGROUND

Teachers' beliefs and classroom practices

Teachers' beliefs are usually conceptualised as a tacit set of often unconsciously held assumptions regarding educational issues and processes such as teaching, learning, curriculum, schooling, and knowledge (Elen & Lowyck, 1999). Beliefs can be *inferred* from what people say, intend and do (Pajares, 1992), and thus they can give insight into the reasons teachers act the way they do. It is suggested that teachers' educational beliefs are considered a filter for teachers' instructional and curricular decisions and actions and therefore can either promote or impede change (Prawat, 1992).

For almost two decades, research has documented the influence of teacher beliefs on teacher instructional practice (Clark & Peterson, 1986; Fang, 1996) demonstrating that personal belief systems have a powerful effect on what teachers learn from educational reform schemes and professional development programs, as well as on the teachers' curricular decision-making and teaching practices. The studies demonstrate that teachers tend to adopt new classroom practices based on whether the assumptions underlying the new practices are

consistent with their personal epistemological beliefs (Yocum, 1996). Therefore, since teachers' knowledge and beliefs about teaching and learning forms an "intuitive screen" through which they interpret professional development and teaching reforms (Buchanan et al., 1998), these beliefs can either further or impede change (Prawat, 1992). If teacher beliefs do not match the goals and assumptions of educational innovation, resistance is likely (Burkhardt, Fraser, & Ridgeway, 1990). In contrast, if teachers' beliefs are compatible with educational reform, it is highly likely that the new ideas will be accepted and adopted in the classroom.

In the context of technology use in the classroom, studies have also shown that teacher beliefs and attitudes influence teachers' use of computers in the classroom (Ertmer & Hruskocy, 1999; Marcinkiewicz, 1994; Tearle, 2004), and there is a relationship between teachers' beliefs and their instructional decisions (Haney, Czerniak, & Lumpe, 1996; Mumtaz, 2000). Veen (1993), for example, found that teachers are more likely to adopt new technology if they can use it in accordance with their existing beliefs and practices. Furthermore, research suggests that teachers with student-centered pedagogical beliefs, who adopt student-oriented constructivist teaching, are successful at integrating technology except in cases where anxiety about computers prevented them from appropriating the technology. In contrast, teachers with more traditional beliefs are likely to face much greater change in their practices in order to integrate technology (Honey & Moeller, 1990; Judson, 2006; Totter et al., 2006).

Conceptually, research exploring teachers' beliefs in the context of technology-based classrooms include views on how ICT enhances the learning process (Greenberg, Raphael, Keller, & Tobias, 1998), views on student learning and the meaning of "good teaching," as well as perceptions concerning the role of ICT in student lives (Windschitl & Sahl, 2002; Zhao, Pugh, & Sheldon, 2002). Gobbo and Girardi (2002), and Maor and Taylor (1995) referred to teachers' epistemological beliefs and found that teachers' use of new technology varied according to their epistemological orientation.

Of the various facets of teacher beliefs, beliefs regarding the nature of technology and its role in teaching and learning can form a major barrier to incorporating technology into the classroom (Ertmer & Hruskocy, 1999). Indeed, Ertmer et al., (1999) found that teacher perceptions of the role of technology are closely linked to how technology is used. For example, it is argued that a view of technology as something unstable and always changing (Slough & Chamblee, 2000), presents a major barrier to its use in the classroom. Therefore, in this study, when exploring teachers' educational beliefs, we also examine their views on the role of information technology and their use of it in the classroom.

Most research that studies the relationships between teachers' educational beliefs and the use of technology in the classroom focuses on how teachers' beliefs shape their implementation of school reform initiatives and show that the way teachers use technology is consistent with their personal views/beliefs on curriculum and instructional practices (Cohen, 1987; Cuban, 1986). Thus, the teachers who hold a traditional teaching philosophy and believe their role is to transmit an extremely rigid curriculum through highly controlled pedagogy

are the teachers who may avoid computers. In contrast, teachers who believe in constructivist learning principles tend to use computers more frequently (Becker & Ravitz, 2001). In Fulton and Torney-Purta's (2000) study, for example, the teachers all stated that they used technology to support their teaching in ways that they thought appropriate, yet none felt that using technology had changed their educational beliefs.

Other studies, however, explore how the use of educational technology affects teachers' educational beliefs. Here, the results show that when implementing technology-based educational reforms, some teachers find that technology encourages greater student-centeredness, greater openness toward multiple perspectives on problems, and greater willingness to experiment in their teaching (Knapp & Glenn, 1996). One of the findings of the Apple Classrooms of Tomorrow (ACOT) project similarly noted that technology has shifted classrooms toward student-centered teaching rather than curriculum-centered teaching, collaborative tasks rather than individual tasks, and active rather than passive learning (Sandholtz et al., 1997). The classroom shift away from an emphasis on textbooks and teachers to the integration of technology and teachers in the role of facilitators is not merely one of adopting new tools, but in fact a transformation in pedagogy and epistemology (Bruenjes, 2002). Burton (2003) also shows that even professional development experiences involving technology will facilitate a change in teacher beliefs regarding teaching and learning towards a more student-centered focus, reflecting the teacher's belief that her or his role has changed from a more traditional role to that of facilitator and partner in inquiry.

Thus, it has been suggested that where the beliefs that underpin a particular instructional reform are not congruent with the beliefs of the individual teachers, the success of the reform will be limited and the change process slow (Richardson, 1996). Whitworth (1997) takes this argument further, contending that curriculum reforms are most likely to change teachers' knowledge and belief systems mainly because knowledge and beliefs do not change until teachers confront difficulties in their classroom practice. Based on Guskey's (2002) model of teachers' growth, which suggests that change in teachers' beliefs is primarily an experientially-based learning process for teachers, one might assume that when teachers translate the abstract ideas concerning the integration of technology in their teaching practices, they are likely to widen their ideas or views on learning, teaching, and technology.

It is therefore worth exploring whether the relationship between teachers' beliefs and practices is a one-way relationship or a dynamic two-way relationship in which beliefs are also influenced by practical experience (Thompson, 1992). The present study addresses these issues within the context of a technology-based learning environment and the framework of a longitudinal study.

VIEWS ON TEACHING AND LEARNING

Recent studies into teachers' beliefs generally agree that there exist a limited number of views on teaching and learning. Views on teaching range from imparting knowledge or information presentation (teacher centered views) to

encouraging knowledge creation or facilitation of student learning (learner centered view) (Kember & Kwan, 2000; Martin & Ramsden, 1993; Samuelowicz & Bain, 2001). Similarly, a number of views of learning are described in the literature. The most dominant are the six ways of understanding learning identified by Marton, Dall'Alba, & Beaty (1993), which identifies a continuum that includes three views reflecting a quantitative view of learning or a surface approach to learning, conceiving learning as a process of memorizing and reproducing learned materials, and three views of learning as a meaning-making process or reflecting a deep view of learning.

In the data analysis of this study, we will relate mainly to Kember and Kwan's (2000) categories on teaching and Marton et al. (1993) learning categories. Yet, we will also apply a more holistic classification that refers to both teaching and learning, by using a general, more basic categorization, suggested by Doolittle (1999) which defines a continuum of theory-based beliefs, ranging from behaviorist view, through cognitive-constructivism to critical constructivism.

Theoretically, the study builds on three major assumptions:

1. Teachers' beliefs come from a variety of experiences, including their upbringing, life experiences, or schooling processes, yet the exact sources are still unclear (Raths, 2001). Beliefs are tentative constructions and thus subject to revision. As a result, teachers tend to adopt new classroom practices based on whether the principles underlying the new practices are consistent with their personal educational beliefs (Windschitl & Sahl, 2002; Yocum, 1996). Simultaneously, however, the use of educational technology in the classroom and teacher development experiences can change or affect teachers' educational beliefs (Bruenjes, 2002; Burton, 2003).
2. The teacher's view of technology can present a major barrier to the use of technology in the classroom. However, beliefs on the role of technology in the classroom can be modified using technology-based experiences (Slough & Chamblee, 2000).
3. Changing the teacher's paradigm is a complex matter. As Kuhn (1970), indicated, paradigms control the methods, questions, and standards of a community, as well as the broader constellation of its cherished beliefs, values, and techniques. Changing educational views is therefore a gradual process and multiple conceptions co-exist in the transitional stage (Gunstone, 1994).

The above assumptions call for a constructivist approach to studying information technology in schools. This approach emphasizes the importance of studying teachers' educational beliefs and the context in which they occur, using a range of qualitatively different tools, interviews, questionnaires, and observations.

METHODOLOGY

The context of the study

The three-year longitudinal study (1997–2000) was conducted in one school in a city in central Israel. It was initiated by university researchers in collabora-

tion with the local municipality education department and Israeli Ministry of Education. The study, in the form of a case study, mainly employed qualitative methodology (Lincoln & Guba, 2000). Some results were also quantified. Since the study sought to investigate processes affecting teachers' beliefs as well as those affecting classroom practice in a technology-based learning environment, we decided to combine an exploratory case study with a collective case study (Levin & Wadmany, 2005; Yin, 1992). The teachers are treated both as individual case studies and as a group; thus, we could address each of the six teachers who participated in the study separately while relating to them, holistically, as a group.

The school principal selected six teachers for the study; initially four were chosen from the fourth and fifth grades, and two more teachers were added in the second year. Thus, six teachers and 164 of their students participated in the study; four of the teachers were studied for three years, and two teachers for two years. Most of the teachers are highly experienced teachers. Their teaching experiences ranged from three years (Anat) through eight years (Gila) and 14 years (Penina and Hadasa) to 23 (Zipi) and 29 (Zipora) years. Their ages varied from 26 (Anat), through 33-35 (Gila, Penina and Hadasa) to 45 (Zipi) and 52 (Zipora). They all teach the various subject areas taught at the elementary level, although Penina and Zipora teach mainly mathematics, and Zipora serves also as a computer coordinator in the school.

Prior to the beginning of the study, the school infrastructure prepared itself to cater for a technology-based teaching and learning environment, and the requisite instruments for the implementation phase were developed and tested. The preparatory phase took six months, during which (1) technological equipment including computers, multimedia, and a variety of software were placed in classrooms to form a communication network called "Akavish" (Hebrew: "Spider"); (2) professional development strategies, contents, and workshops were tentatively planned and a plan for mentoring teachers' classroom practices developed; (3) learning activities for both students and teachers, demonstrations, and research tools were developed and tested on samples of teachers; and (4) advisory teams of mentors who were both experts in educational technology and subject specialists were trained to assist teachers with their classroom work. The teams included school personnel and experts from Tel Aviv University and "Svivot" (a software development company). A group of students was also trained to function as "computer assistants" in their classrooms.

During the school year, teachers began to introduce new ideas relating to student learning. This followed a brief workshop before the school year. They also received ongoing assistance on request and attended weekly, in-school workshops (learning sessions that the teachers held with the university people while discussing issues that came out in their classroom experiences. They also worked together on problems they were facing either conceptually or practically as a group). These workshops addressed two kinds of activities (1) activities initiated by the teachers based on their own experiences with students, and (2) activities planned by project leaders on the subjects of the basic concepts and structure of information-rich tasks, the uses of information technology, and general software

capabilities. The teachers were also exposed to problem-based learning situations, simulating learning by the teachers as a group. The workshops therefore provided teachers with activities, which had been planned ahead of the study, and incorporated activities that examined teachers' queries, interests, dilemmas, and needs relating to classroom experiences relevant to the study.

More specifically, the teachers undertook the following:

1. Design of learning activities definable as "information-rich tasks."
2. Inquiry-based learning using information technology.
3. Learning of new concepts, procedures, and skills for operating computers; presentation of information-rich, interdisciplinary tasks.
4. Learning in cooperative teams to encourage cooperative learning in the classroom; analysis of these learning processes.
5. Planning and evaluation of inter-disciplinary learning activities for students inside and outside school.
6. Discussion and reflection on classroom experiences, with focus on difficulties, problems, solutions, and accomplishments.

INSTRUMENTS AND DATA ANALYSIS

Various research tools were used to obtain a rich and comprehensive description of the processes experienced by each of the teachers. The tools were open-ended and developed especially for the study. They comprised personal, partially structured, interviews with teachers; open questionnaires for teachers, and classroom observations. Questionnaires and interviews were used mainly to examine explicit educational beliefs and knowledge. Classroom observation and weekly meetings with teaching staff were used to study practices in teaching and learning situations. During each year of the study, a number of observations were made of each of the teachers' classes. The total observations of the six teachers were 73 (Zipi 13; Zipora 12; Gila 9; Anat 10; Penina 14; Hadasa 15) for the whole study. A further 43 observations were also carried out during the workshops to observe the teachers' learning processes.

The open-ended questionnaires for exploring teachers' beliefs consisted of eight questions on the meaning of six concepts: teaching, learning, role of student, role of teacher, curriculum, and technology. Questionnaires were administered annually for three years and teachers were also asked to write two metaphors on the concepts of teaching and learning. Teachers were interviewed following observations of the teachers at work in class or during inservice training. The interviews examined teachers' views on the changes in their professional environment and themselves and their beliefs regarding teaching and learning.

The study used the phenomenographic (Marton, 1986) approach to data analysis, which classified expressions used by subjects according to similarities, differences, and complementaries. Teachers' responses to the open questions were cumulatively analyzed for commonalities throughout the study (Levin & Wadmany, 2006), and the categories obtained were interpreted with reference to educational orientations concerning learning, teaching, and knowledge

(see Table 1). Table 1 delineates the categories that were used in the analysis of teachers' beliefs. These categories distinguish between objectivist and constructivist educational orientations, and are based on Kember and Kwan's (2000) categories on teaching and teaching modes; Doolittle (1999) and von Glasersfeld (1998) categories on learning; and Habermas' (1987) three knowledge constitutive interests, which we applied to teachers' views on technology's role in the classroom. The characteristics of each category are described in the following sections.

Table 1: Categories for interpreting teachers' views on learning, teaching, and technology and their actual teaching practices

Conceptions of Learning	Conceptions of Teaching	Teaching Models	Views on technology
Behaviorist orientation(1)	Passing information (1)	Direct Instruction (1)	Technical Interest
Cognitive Constructivism (2)	Transmission of knowledge (2)	Collaborative learning (2)	Communicative or practical interests
Social constructivism (3)	Meeting students' needs (3)	Cognitive Apprenticeship (3)	Emancipatory knowledge interests
Radical Constructivism (4)	Helping students become independent learners (4)	Discovery learning (4)	

Note that in Table 1, the numbers in parenthesis indicate the weight assigned to a category after quantification of results. The categories come from theory. The actual analysis used these categories to characterize, first, the teachers' statements concerning what teaching is, what learning is, what is the role of technology, and second, the teachers' classroom practices (based on the data gathered through the observations). This enabled comparison of the changes to and from the various dimensions examined in the teachers' orientations. If a teacher appeared in more than one category, the value of the lower category in the hierarchy appears, plus half a point to indicate a midway position.

A. Behaviorist orientation (1) learning produces immediate, recognizable changes in the learner's behavior. Learning concerns entities, attributes, and relationships in an objective reality (reality is independent of learners and knowledge is acquired exclusively through the senses. Learning functions like a switchboard and takes place when one person conveys the universal characteristics of reality to another.)

B. Cognitive Constructivism (2) learning involves the internalization and (re) construction of external reality. This is a weak form of constructivism, and emphasizes knowledge acquisition as an adaptive process resulting from active

cognizing by the learner. It also argues the *external* nature of knowledge and the existence of an independent reality, which is knowable to the individual;

C. Social Constructivism (3) learning involves the co-construction of meaning within a social activity (it argues the *social* nature of knowledge, and the belief that knowledge, as a shared experience occurring within a socio-cultural context, is a consequence of social interaction and language usage (Prawat & Floden, 1994). Knowledge is bound to time and place (Vygotsky, 1978);

D. Radical Constructivism (4) – learning is knowledge construction. It is influenced by the context in which an activity is experienced and is relative to the accomplishment of a goal; mental structures and personal meaning are constructed (knowledge is internal, and although external reality may exist, it is unknowable to the individual (Glasersfeld, 1996).

When analyzing teacher conceptions of *teaching*, we used the four categories developed by Kember and Kwan (2000):

A. Teaching as transmission of knowledge—teaching is a teacher-centered activity. Its main aim is to transmit knowledge to students, who are passive recipients of information;

B. Teaching as the facilitation of learning—teaching is student-centered. Its main aim is to facilitate student learning.

Each category was further sub-divided into:

A. A(1) Teaching as passing information (1) emphasis on syllabus coverage and meeting exam requirements without over concern for student understanding;

B. A(2) Teaching as the transmission of knowledge with concern for students' understanding (2) emphasis on structuring knowledge and organizing teaching to help students understand, remember, and apply knowledge;

C. B(1) Teaching as meeting students' learning needs (3)—teaching is informed by a sense of responsibility about meeting student learning needs;

D. B(2) Teaching as helping students become independent learners (4) focusing on growth rather than knowledge and skills. Teaching is a process of helping learners to develop intellectually and become autonomous lifelong learners.

The categories relating to *teaching models* included the following four models or approaches:

Direct Instruction (1)—an instructional method based on the transmission paradigm employs learning theories of behaviorism. This involves a rigorously developed, highly scripted method, rich in structure, drilling, and content. Teaching is fast-paced with constant teacher-student interaction.

Collaborative Learning (2)—instruction method in which students of differing levels work in small groups towards a common goal. Students are responsible for one another's learning and their own.

Cognitive Apprenticeship (3)—involves socializing students in new behavioral norms and professional ways of working. A model of instruction,

which seeks to make thinking visibly situated within the social constructivist paradigm. Students work in teams on projects or problems with close teacher scaffolding. Cognitive apprenticeship involves Vygotskian "zones of proximal development," i.e., students require aid from their peers and teacher in order to succeed. Typical teacher behaviors are modeling, coaching, articulating, reflecting and exploring.

Discovery Learning (4)—this is an inquiry-based learning method, which takes place most notably in problem solving situations in which the learner draws on personal experience and prior knowledge to discover the truths to be learned. Seeks a personal, internal, constructivist-based learning environment.

The categories for *views on technology* relate to knowledge interests, and follow Habermas' idea that knowledge is shaped by the needs and desires of human beings and that different kinds of knowledge express different "knowledge constitutive interests" (Habermas 1987). The view on the role of technology lie within one or other of Habermas's three knowledge constitutive interests:

A. ***Technical interest*** is based on an instrumental rationality; the goal is control. A technical knowledge interest is being served when technology is perceived as a means of practicing knowledge, skills, understanding, or competency, and when the context is not considered particularly relevant. The emphasis is on technology controlling and predicting student or teacher behavior and learning so that they conform to predetermined ends.
B. ***Communicative or practical interests*** have a more subjective perspective and the goal of developing understanding. Here, there is "a fundamental interest in understanding the environment through interaction based upon a consensual interpretation of meaning" (Grundy, 1987, p.14). Technology serves a practical interest when its role is communication and interpretation, e.g., negotiating meaning or discussing the relationship between learning task components.
C. ***Emancipatory knowledge interests*** contain an action component and are based on critical theory. They reflect "a fundamental interest in emancipation and empowerment to engage in autonomous action arising from authentic, critical insights into the social construction of human society" (Grundy, 1987, p.19). Emancipatory interests also involve concern for the moral and ethical considerations underlying human action (Gore & Zeichner, 1991). The emancipatory view of technology's role involves the pursuit of knowledge or capacity to become conscious of the ways in which knowledge is constructed. Technology not only helps students and teachers to construct meaning for them, but to achieve a critical understanding of how this is done. Also, as an intellectual partner, technology use engages in a critique and judgment about the student or teacher's learning/work and fosters critical analysis directed at transforming the educational practices, educational understandings, and educational values of those involved in the learning process.

A 90% agreement was obtained between the three evaluators concerning the interpretation of the data and the categories obtained. After discussing minor divergences, the evaluators reached consensus.

RESULTS

The results section describes the nature of change in both teachers' educational beliefs and classroom practices. More specifically it characterizes teachers' statements in the interviews and questionnaires as well as their classroom practices using the categories described above at two points in time: at the beginning of the study and at its end, three years later. The results present change profiles of each teacher and the profile of the teachers as a group.

1. Beliefs on Learning and Teaching

Table 2 indicates that during the three-year period of teaching and learning in a technology-based environment, changes occurred in the beliefs and educational practices of all six teachers. More specifically, the findings show that, whereas at the beginning of the study most teachers expressed behaviorist and transmissionist views on learning and teaching, respectively, after the study, teachers expressed more varied views.

At the start of the study, complementary data reflecting teachers' beliefs were also obtained from metaphors describing teaching and learning. These metaphors confirmed the positivist views expressed in most teachers' statements. For example, Zipi's metaphor on learning was *"drinking from a fountain,"* and her metaphor for teaching was *"dropping"*—both reflecting passivity in learning and transmission in teaching. Zipora's metaphors expressed similar ideas. She associated learning with *"Pavlov's dog"* and described teaching as a *"train, pulling wagons that can't go forward without it."* Anat's learning metaphor of a "container" was consistent with her metaphor of teaching as *"handing-over."* Both reflected an objectivist-determinist view. Similarly, Penina's learning metaphor of the *"sponge"* was consistent with her *"funnel"* teaching metaphor. The only different perspective at the beginning of the study was found in Hadasa's metaphor. She described learning as *"infinite renewal—the wind that blows from young, lively and healthy fountains."*

A very different picture emerged at the end of the third year of the study however. Although a varied pattern of educational beliefs was found, almost all teachers expressed more than one category of belief regarding at least one concept. For example, even after three years of exposure to a technology-rich environment, Zipi still saw learning as a process of knowledge acquisition. However, she also saw the student as an active learner. This indicates both a behaviorist ideology and a weak constructivist (cognitive constructivist) ideology. Zipi wrote, *"We learn experientially through understanding. Active involvement in the learning is what actually promotes understanding. We must activate deep-level thinking to perform as expected."*

According to the findings, after three years of experience in a technology-rich classroom, teachers exhibited considerably fewer positivist beliefs, i.e., fewer behaviorist views on learning, and even when they expressed a transmissionist orientation, they focused more on student understanding than covering content (see profiles for Zipi, Zipora, Gila, and Anat in Table 2). Only one teacher (Penina) continued to regard teaching as a process of knowledge transmission in which external norms dictate the teaching process (a process she indicated

Table 2: Patterns of change in teachers' views on learning, teaching, and classroom practices according to number of years in the study

	Conception of Learning		Conception of Teaching		Actual Teaching Practices	
	1st year	3rd year	1st year	3rd year	1st year	3rd year
Zipi Change=2.0	Behaviorist	Behaviorist + Cognitive Constructivist	Knowledge Transmission— *Syllabus Coverage*	Knowledge Transmission *Student Understanding*	Direct Instruction	Direct Instruction + Collaborative Learning
Zipora Change=4.5	Behaviorist	Behaviorist + Cognitive Constructivist	Knowledge Transmission— *Syllabus Coverage*	Knowledge Transmission — *Student Understanding*	Direct Instruction	Cognitive Apprenticeship
Gila Change=4.0	Behaviorist	Cognitive Constructivist	*Knowledge Transmission*— Syllabus Coverage	*Facilitation of Learning—Meeting Student Needs*	Direct Instruction	Collaborative Learning
Anat Change=3.0	Behaviorist	Cognitive Constructivist	Knowledge Transmission— *Syllabus Coverage*	Knowledge Transmission— *Student Understanding*	Direct Instruction	Collaborative Learning
Penina Change=1.0	Behaviorist	Behaviorist + Cognitive Constructivist	Knowledge Transmission— Syllabus Coverage	Knowledge Transmission— Syllabus Coverage	Direct Instruction	Direct Instruction + Cooperative Setting
Hadasa Change=7.0	Cognitive. Constructivist	Radical Constructivist	*Knowledge Transmission— Student Understanding*	Facilitation of Learning *—Individual Growth*	Direct Instruction + Caring	Discovery Learning + Reflection
Mean change	6.5:6=1.08		7:6 =1.07	10:6=1.66		

whose main focus was on content coverage or meeting exam requirements, though without much concern for student understanding).

Interestingly, however, the results point to different profiles of change in views for all the teachers, as reflected in their conceptions during the study. The only exception was Penina whose view of teaching as knowledge transmission guided by external standards failed to change, and view of learning and classroom practices changed only slightly.

2. Evolving Classroom Practices

A similar pattern of change emerged for teachers' actual classroom practices (Table 2). At the beginning of the study, all teachers used direct instruction and predetermined sequences of instruction to reach predetermined goals; after three years in a technology-rich classroom, wide divergences emerged between the teaching models teachers used. Most teachers significantly changed their classroom practices, discarding direct instruction and adopting practices focusing on facilitating collaborative learning processes, where most emphasis was on coaching, modeling, reflection and exploration. Even when direct instruction was still used, as in Zipi and Penina's cases, supplementary practices were introduced (Zipi) or were performed in a cooperative setting. In only one case (Hadasa) discovery learning was used.

Quantitative analysis of the changes made by the teachers as a group shows that the largest mean change was in teachers' classroom practices (1.66). This compares with the smaller, similar size changes in their views on learning and teaching (1.07 and 1.08 respectively). As individuals, Hadasa was clearly the teacher who changed most, Zipora and Gila changed somewhat, and Penina and Zipi, hardly at all.

3. Views on Technology

Table 3 presents the changes in the six teachers' views on the role of technology, showing the pattern of change for each one. The results show that technology is not a unitary concept: It means different things to different teachers, and the practices associated with each conception lead to quite different outcomes.

The results also show that not all teachers significantly changed their views regarding the role of technology in the classroom. In fact, only three teachers changed their views significantly. Penina's change pattern was unique and significant. She changed from a technical view initially, to a view indicating technical and practical integration. Thus, Penina changed from viewing information technology as a tool for supporting traditional teaching, to a view of information technology as a tool for supporting teaching, which also provides a communicative tool for enlarging the conceptual world of teachers and students alike. Zipora's change profile reflects a shift away from viewing technology as an instrument supporting learning, to viewing technology as a partner in individual learning and development: a partner that empowers students' and teachers' capabilities. Hadasa also changed her view of technology, and towards the conclusion of the study came to see it not as a technical-functional tool, but as a partner in the learning and teaching processes.

Table 3: Patterns of change in teachers' views on technology role in the classroom

	View on technology—1st year		View on technology—3rd year	
	Typology	**Example – Teacher Citation**	**Typology**	**Example– Teacher Citation**
Zipi	Technical	*The computer is for practice*	Technical	*The computer enriches instruction*
Zipora	Practical	*The computer is a source of information and a tool for communication*	Emancipatory	*The computer is an intellectual partner, which helps to expand human capabilities and the computer challenges the thinking in the environment*
Gila	Practical	*The computer helps develop our thinking*	Practical	*Using computers changes our thinking*
Anat	Technical	*The computer, which is difficult to operate, has other purposes, not just playing games*	Technical	*There are technical difficulties involved with computer use in the classroom*
Penina	Technical	*The computer helps us to learn*	Tech+Practic	*The computer helps to develop our thinking and introduces a new conceptual world into a subject domain*
Hadasa	Technical	*A learning aid*	Emancipatory	*An important partner for learning and teaching*

DISCUSSION AND IMPLICATIONS

The study explores the processes of change in teachers' learning and teaching ideologies and actual educational practices. It addresses the quality and uniqueness of the changes in each teacher, using a longitudinal analysis of an innovative approach to learning and teaching focusing on information- rich tasks in a technology-rich environment.

The nature of change in educational beliefs and practices

The study demonstrates that spending three years in a technology-rich learning environment produces substantive change in teachers' educational beliefs and classroom practices. These findings support the view that teachers' beliefs can be changed (Fullan, 1991; Leung, Watters, & Ginns, 2005; Tillema, 1995), even though they are often thought of as permanent and difficult to alter (Pajares, 1992). It also confirms that belief systems are dynamic, changing and can be restructured if individuals are open and interested in evaluating their beliefs in light of new experiences (Thompson, 1992) and in a context of consensual goals. According to Jacobsen (2002) change depends on the teacher's capacity to "build new bridges" through constructivist learning experiences. It seems that the learning processes that take place when teachers are exposed to new goals, practices, types of problems, and instructional tools function as a discourse, and encourage or pressure teachers to modify their teaching styles and even their underlying beliefs regarding effective teaching. The study therefore supports the distinction between the mechanistic-functional use of technology and the use of information technology as enhancing a learning culture that both affects and is affected by teachers' expectations, beliefs, and experiences.

More specifically, regarding technology, and supporting Becker and Ravitz's (2001) findings, the results show that teachers' views on teaching and classroom practices in a technology-based environment are located along a continuum in which "teaching as transmission" lies at one pole and "teaching as facilitating knowledge restructuring" lies at the opposite pole. The study refines these categories, however, and adds additional facets of beliefs concerning views on learning and on the role of technology in the school. These aspects of teachers' beliefs were also described on a continuum characterized from positivist or transmissionist to constructivist-based views.

The study also demonstrates that educational change involving information technology is an individual process, unique to each teacher. It indicates that even when working with groups in a supportive and dynamic learning community, which has a guiding culture, teachers respond differently to similar educationally innovative ideas relating to information technology in a technology-rich school. The results support findings in other studies, which attest to the diversified experiences of teachers and difficulty in meaningfully changing beliefs about teaching and learning processes and classroom skills, even when teachers firmly believed change is necessary and positively seek to change their professional performance (Bell & Gilbert, 1994; Clandinin & Connely, 1996; Fullan, 1991; Soter, 1995). 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 (Levin, 1999).

Furthermore, although a belief system is built on interconnections between specific beliefs, there are indications in this study that some beliefs are easier to change than others (Levin & Wadmany, 2006; Wadmany, 2004). Specifically, it shows that in a technology-rich environment where students are constantly challenged by open-ended rich-information tasks and resources, and where they assume the role of tutors to their peers and teachers in operating and communicating with computers, it is easier for teachers to change their views of students and the student's role in the learning process. They perceive students as capable, self-regulated learners whose voice in the teaching process should be heard and whose mastery of the computer, appreciated.

In contrast, it is harder for most teachers to conceive of learning as knowledge transformation rather than knowledge accumulation, and to regard technology as a dialogical tool that empowers both students, teachers, and the learning process, instead of as a technical instrument that supports practice and enhances students' and teachers' thinking. The reported results suggest that it is not just technology, but the overall learning environment and its emphasis on non-structured tasks, rich sets of technology-based information resources, and exposing teachers to new visions, that ultimately changes teachers' beliefs and practices. It also concurs with Rokeach (1968) who argued that beliefs differ in intensity and power and vary along a central-peripheral dimension. The more central this dimension, the greater will be its resistance to change.

Furthermore, in this study teachers' beliefs could not always be classified simply and dichotomously as either constructivist or behaviourist/functionalist. Most teachers could not therefore be classified as consistently holding any one particular orientation. Instead they seemed to change educational lenses, demonstrating multiple views rather than pure beliefs. Thus, although teachers expressed some form of constructivist orientation, or cognitive, social or radical belief either directly or through their metaphors, they did not reject the behaviourist view or even hold two seemingly conflicting orientations at the same time. In more general terms, it was found that some teachers' beliefs changed although they remained within a certain belief paradigm (beliefs on the constructivist continuum). For others, however, the changes shifted them into a new paradigm (behaviourist to constructivist). In most teachers' cases, both types of changes were observed.

We make no claim that the teachers in this study experienced either a universal or general shift in their approach to learning, teaching or technology. Rather, in the context of thinking about their own experiences in rich technology-based classrooms, they acquired both conscious and unconscious insights into the meaning of teaching, learning and technology through powerful and rich actions and through their reflections on these actions.

IMPLICATIONS

The present study is significant and relevant for several reasons. First, it offers an important contribution to the exploration of teachers' change when integrat-

ing information-rich tasks into school curriculum in the context of a rich, technology-based environment. Its theoretical importance lies in the finding that real change occurs in classroom practices, even before the teacher can consciously conceptualize newly established educational beliefs. This supports Guskey (2002) and Fullan (1993), who suggest that change in beliefs follows (but does not precede) change in practice. Additionally, the findings endorse Becker and Ravitz's (1999) "Trojan Horse" theory, which implies that computers encourage and may require changes in practice that subsequently do in fact change the pedagogical beliefs of teachers. They also support Argyris and Schon's theory of action (1974), which maintains that humans learn from their actions, and use what they learn to plan and carry out future actions, which all ultimately affect their beliefs (Kane, et al., 2002).

Second, the study supports Gunstone's (1994) idea of "multiple conceptions" by arguing that educational beliefs change gradually and that multiple conceptions co-exist during the transition. However, with an eye to the growing body of literature on the importance of versatility and flexibility in learning (Cantwell & Beamish, 1994; Purdie & Hattie, 1999), the present results may also mean that during professional growth, there is no need for teachers to relinquish old conceptual ideas in favor of new ones, but rather extend their repertoire of ideological ideas and refine their organization and coherence (Caravita & Hallden, 1994). Thus, the coexistence of contrasting views of learning and teaching, in the individual teacher's thinking and within a group of teachers, may reflect differences in the dimensions of beliefs which teachers simultaneously discern and focus upon. Rather than regard such beliefs as inconsistent, we should see them as complementary. This interpretation of the multiple-conception perspective confirms that learning and teaching are complex and multifaceted phenomena just like the environment with which learning individuals and communities interact.

Third, the study demonstrates that the adoption and 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 developments in teachers' beliefs regarding teaching and learning occur on several different dimensions and reflect changes on a continuum, which stretches from teacher centered teaching and learning to student centered teaching and learning; from relating mainly to the individual student to referring 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-disciplinarily, and from viewing technology as a technical tool to seeing it as a partner that can empower the student, teachers and the learning environment.

Finally, the study shows that we cannot, and should not, simply rely on teachers' explicit statements regarding their beliefs or practices. In a period of transition, with teachers facing new educational ideologies and goals, they may not be aware of their own emergent beliefs. Alternatively, they may nurture multiple

conceptions caused by feelings of insecurity at the prospect of relinquishing long-held beliefs, even if these are irrelevant in an era when information technology assumes its place as a well-respected part of our educational repertoire.

It is therefore highly recommended that, in order to learn about teachers' beliefs, a variety of tools should be used besides teachers' statements. Particularly spontaneous and planned metaphors, since these are a rich instrument, which if recognized and used mindfully and in a multidimensional way, will help augment our understanding of teachers thoughts and feelings (Blair & Banaji, 1996). Moreover, a metaphor is a dynamic, constructive, and context-sensitive conceptual phenomenon, which reflects the latent views and beliefs of teachers in an authentic and rich fashion (Lakoff & Johnson, 1980). We further highly recommended that classroom observation should accompany our studies since, as we found, teacher's actual classroom practices cannot be predicted from a teacher's expressed beliefs about learning and teaching.

If we accept that belief change is a consequence of teachers' continuous inquiry into their instructional decisions and practices, and that it is an integral aspect of teachers' lives, then exploring teachers' beliefs through both metaphors and direct statements offers a powerful vehicle that can enrich our comprehension of technology-based classrooms, and may help us understand the implications of this learning context with respect to classroom processes and teachers' professional growth. Moreover, demonstrating that teachers can hold compound educational beliefs concerning learning and teaching has important implications for teachers' professional growth, technology integration and instructional flexibility. A multifarious viewpoint with simultaneous, seemingly discrepant views, means that teachers can adapt their own instruction to different students' or classroom needs, or to teach different subject areas assuming that more than one didactical approach is instructionally appropriate. It also allows teachers to survive in a pluralistic educational world in which teachers are exposed to divergent views on the definition of learning and what constitutes effective teaching in a technology-driven world.

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