

Teachers in a World of Change: Teachers' Knowledge and Attitudes towards the Implementation of Innovative Technologies in Schools

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Abstract

The implementation of innovative technologies in school is a complex process that enquires creating a pedagogical, technological, and managerial systemic change in the school-culture – a process that usually fails to meet the high expectations and to create the systemic change.

In light of the many recent studies, which indicate that teachers' perception and attitudes play a pivotal role of in the success or the failure of technology-implementation projects, the present study explores the teachers' perceptions and attitudes towards the implementation of an innovative technology (smart class) in school by analyzing the inter-relationships between the major pedagogical factors that act in a technology-implementation process: (1) the teachers' attitudes towards change, (2) the teachers' technological-pedagogical content knowledge, and (3) the teachers' perception of school as a learning organization. Data was gathered using questionnaires that captured the teachers' level of "Technological Pedagogical Content Knowledge" (TPACK), their perception of school as a learning organization, and their attitude towards change. Findings indicate a positive correlation between TPACK and the teachers' attitudes towards change, and a positive correlation between teachers' attitudes towards change and their perception of school as a learning organization. Participants who scored high in TPACK and in perceiving their school as a learning organization also scored high in their positive attitudes towards change.

Key words: TPACK, attitude; teacher's attitudes towards change, school as a learning organization, innovative technology, educational technology, smart class; educational change

Introduction

Recent studies indicate that the implementation of innovative technologies in schools demand a systemic change in the school-culture (H. Becker, 2001; Eshet, 2007; Coffman, 2009; Cuban,

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1988; Kent & MacNergney, 1999; Wallace, 2004) and involves a wide range of pedagogical, technological, and managerial factors, whose inter-relationships are not fully understood (Cunningham, 2009; Darling-Hammond, 2000; Day & Smethem, 2009; Fullan & Smith, 1999; Halverson & Smith, 2009). Most studies of technology-implementation in school systems report on disappointment from the projects' outcomes (Avidov-Ungar,

Editor: Alex Koohang

An earlier, shorter version of this paper was presented at the Chais conference 2011, in Raanana, Israel, and included in Y. Eshet-Alkalai, A. Caspi, S. Eden, N. Geri, & Y. Yair (Eds.), *Proceedings of the Chais conference on instructional technologies research 2011: Learning in the technological era*. Raanana: The Open University of Israel. http://www.openu.ac.il/research_center/chais2011/papers.html

2010; Day & Smethem, 2009; De Val & Fuentes, 2003; Halverson & Smith, 2009; Mioduser, Nachmias, Forkosh, & Tubin, 2004) and emphasize the pivotal role of the teachers' pedagogical perspectives and beliefs in its success (De Freitas & Oliver, 2005; Selwyn, 2010). This claim was illustrated in the meta-analysis of thousands of technology-integration projects (Hattie, 2009), which found that the best predictors of students' achievements are related to teachers' activities and not to the technology itself. This emphasizes the importance of studying the teachers' perspectives and beliefs in the context of a technology-implementation project and the inter-relationships between teacher-related variables that affect the project's success (Levin & Fullan, 2008).

Studies of the factors that affect the success of implementing change in school in general and innovative technologies in particular (Fullan, 2000; Kontoghiorghe, Awbre, & Feurig, 2005; Sandy, 2010) indicate that the three major success factors are: (1) the teachers' attitudes towards change, (2) the teachers' contextual pedagogic and technological knowledge, and (3) the teachers' perception of school as a learning organization. This study explores the correlation between these three factors, in the context of a systemic change, related to the implementation of innovative "smart classes" in school. Below is a brief description of each of the three factors.

1. Teachers' Attitudes towards Change

The teachers' attitudes towards change and their readiness to become active partners is considered a critical success factor (Avidov-Ungar, 2010; Coffman, 2009; Day & Gu, 2007; Fullan & Smith, 1999). Similarly, resistance to change is considered one of the main reasons for failure of processes that involve change in organizations in general and in the educational systems in particular (Fullan & Hargreaves, 1996; Zimmerman, 2006). In the case of innovative technology implementation in schools, teachers' resistance is reported by some studies to be the most important factor in the project's success (Del Val & Fuentes, 2003), mainly because the technology doesn't fit to their pedagogical practices and beliefs (Halverson & Smith, 2009; Harris & Hofer 2009). According to Del Val and Fuentes (2003), resistance to change is divided into cognitive resistance (focused on identifying and presenting weaknesses of the change and enlisting claims and reasons for maintaining the existing situation) and emotional resistance (focused on expressing negative feelings towards the change, such as anger, disdain, hostility or sadness). Emotional resistance is also accompanied by psychological symptoms such as tension, impatience, pessimism, apathy and disinterest. In many cases, resistance to change becomes active resistance, in which participants actively sabotage the process of change (Zimmerman, 2006).

2. Teachers' Technological Pedagogical Content Knowledge (TPACK)

Teaching in a technological environment faces teachers with a wide range of pedagogical, cognitive and ergonomic challenges (Eshet, 2004; 2007; Koehler & Mishra, 2009, 2008; Mishra & Koehler, 2006). Unfortunately, most teachers are not trained to teach in technological environments (Day & Smethem, 2009), and many of them report on difficulties in effective integration of technologies in their teaching (De Freitas & Oliver, 2005).

Following Shulman's (1987) definitions of good teaching, in educational projects the teachers' perception of their knowledge is considered a critical success factor (Polly & Mims 2009). In technology-implementation projects this knowledge is described as a blend of Technology, Pedagogy, and Content Knowledge (TPACK) (Harris, Mishra & Koehler, 2009; Mishra & Koehler, 2006) – knowledge that teachers must master in order to use the technology effectively (Doering, Veletsianos, Scharber, & Miller, 2009; Polly, & Mims, 2009). According to Cunningham (2009), the interaction between the three TPACK components (i.e., technology, pedagogy, and content knowledge) creates seven types of knowledge (Table 1) and can be regarded as a measure of

teachers' ability to integrate innovative technologies effectively into their teaching. These seven types of knowledge are derived from the three major topics (i.e. pedagogy, technology, and content, or PK, TK and CK respectively), three interactions between the three topics (Pedagogical Technological Knowledge, Technological Content Knowledge and Technological Pedagogical Knowledge – or PCK, TCK and TPK respectively), and the seventh type of knowledge – TPACK – results from the interaction between all the six types of knowledge (Table 1).

Table 1: The seven types of knowledge included in TPACK (modified from Mishra & Koehler (2006))

Type of knowledge	Description
Content knowledge CK	Knowledge of facts and proofs in a specific domain; knowledge bases of the subject taught
Pedagogical knowledge PK	Extensive knowledge of the teaching and learning processes and methods that includes educational goals, values and targets. A teacher with thorough pedagogic knowledge understands how students construct their knowledge, acquire skills and develop learning habits, and thus knows which methods to use so that the student understands
Technological knowledge TK	This knowledge includes cognitive methods and working with technology, familiarity with the technological potential, and with the technical and pedagogical principles of the technology
Pedagogical content knowledge PCK	This knowledge embraces the core of teaching, learning, curriculum, evaluation and reporting and demands flexible lesson planning and implementation
Technological content knowledge TCK	This knowledge is the understanding of the way in which technology and the content influence, and are influenced by, each other. Teachers should know which technologies are suitable for the topic studied and how the content is influenced or changes due to the technology, and vice versa
Technological pedagogical knowledge TPK	This knowledge is the teacher's ability to see the pedagogic possibilities embodied in the technological tools originally developed for purposes other than educational, and to explore how they can be used to advance students. This is the understanding of how the use of technology can change learning and teaching
Technological pedagogical content knowledge TPACK	This knowledge is the basis for effective teaching using technology. It is the understanding of the overt interaction between the contextual, the pedagogical and the technological knowledge when "the sum is greater than the parts" and differs from the knowledge of each part individually. Thus every teaching situation using technology presents the teacher with the combination of the three factors.

Archambault & Crippen (2009) used TPACK to measure teachers' perception of their teaching in a technology-based environment. Based on their findings, they argue that TPACK can be used as a reliable measure of teaching quality in such environments.

3. School as a Learning Organization

The constant introduction of innovative educational technologies requires that schools develop an organizational learning culture, a culture which helps maintain transfer of knowledge, creativity, flexibility, and support, which are critical for coping effectively with the never-ending changes in educational technologies (Collinson, 2010; Coppieters, 2005; Fauske & Raybould, 2005; Giles & Hargreaves, 2006; Senge, Cambron-McCabe, Lucas, Smith, Dutton & Kleiner, 2000; Zhao & Ordonez de Pablos, 2009; Weldy & Gillis, 2010). This issue is also discussed in Negroponte's "Being Digital" thesis (1995) in which he emphasized cooperation and cooperative learning as characteristic elements in schools which maintain a learning organizational culture. Research shows that schools which maintain a learning organizational culture are able to cope more successfully with systemic changes dictated by technological innovation (Giles & Hargreaves, 2006; Kontoghionghes et al., 2005; Tas, 2005; Yu-Lin & Ellinger, 2008; Zhao & Ordonez de Pablos, 2009). Some researchers even claim that there is no point in integrating technologies in schools that don't maintain a learning organizational culture (Weldy & Gillis, 2010; Lieberman, 1995; Tatnall & Davey, 2003).

In recent years, there is a growing amount of evidence that the perception of teachers of their school as a learning organization affects their readiness to become active partners in technology-integration projects, and consequently, affects the project's success (Levin & Fullan, 2008; Ogo-bonna & Harris, 2003; Vaillant, 2005; Zimmerman, 2006).

The Research Background

During the year 2009, the Israeli's Ministry of Education introduced the "smart classrooms" project in 100 schools in southern Israel. The project's goal was to provide a unique innovative technological platform that will lead to a technological educational reform in teaching methods and in student-teacher relationships (C. Becker & Lee, 2009). Smart classes consist of a variety of technological devices, such as Internet connectivity, computers, projectors, and interactive boards. They enable teachers to prepare, project and share learning materials, and create a new kind of teacher-student dialogue (Way, Lilley, Ruster, Johnco, Mauric, & Ochs, 2009). This study explores the perceptions, attitudes, and knowledge of teachers who participated in the project.

Methodology

Goals

This study explored the inter-relationships between the 3 major factors that involve change in a technology-integration project: teachers' Technological Pedagogical Content Knowledge (TPACK), teachers' perception of school as a learning organization, and teachers' attitudes towards change. It examined the following connections:

- Connection between teachers' technological pedagogical content knowledge (TPACK) and their attitudes towards change.
- Connection between teachers' perception of school as a learning organization and their attitudes towards change.

Research Population

Participants were one hundred teachers from eight elementary schools in southern Israel. For all of them it was the first year of participating in the "smart class" project. 74.2% of the participants had more than ten years of teaching experience, 5.4% had 7-9 years, 14% had 4-6 years, and 6.5% had 1-3 years of experience. 66.3% had a B.A., 22.8% a M.A. and 10.9% lacked an aca-

demic degree. 55.7% of the participants reported that they are in an expert stage of their career, 32.9% reported of an Intermediate stage ("moderate-to-high level"), 8.9% reported that they are at a "preliminary level" and 2.5% reported that they are at a beginners stage of their career. 66.2% of the participants taught three or more subjects at school, 15.6% taught two subjects, and 18.2% taught one subject.

Research Tools

Data was gathered, using a self-report 1-7 Leichert Scale questionnaire, which consisted of the following three components:

Technological Pedagogical Content Knowledge (TPACK) questionnaire (Archambult & Crippen, 2009; Cox & Graham, 2009)

This 24-item questionnaire is divided into the following seven types of knowledge that teachers should master in order to effectively implement and use innovative technologies in teaching: Pedagogical Knowledge (PK), Technological Knowledge (TK), Content Knowledge (CK), Technological Content Knowledge (TCK), Pedagogical Content Knowledge (PCK), Technological Pedagogical Knowledge (TPK), and Technological Pedagogical Content Knowledge (TPACK). The questionnaire has a high level of reliability: $\alpha=0.97$.

Perception of school as a learning organization questionnaire

This 44-item questionnaire explored the teachers' perceived level of organizational learning in school (Korland, 2000), examining two aspects: (1) whether the processes that characterize a learning organization actually exist in school; (2) whether these processes are actually important for the effectiveness of the school's functioning. The questionnaire referred to four of the following major organizational learning processes at school:

1. Learning processes
2. Evaluation and drawing conclusions
3. Disseminating information and knowledge
4. Gathering and preserving information and knowledge

The questionnaire has a high level of reliability: $\alpha=0.82$

Attitudes towards change questionnaire

This 16-item questionnaire examined attitudes and resistance to change among the participants – cognitive, emotional, and behavioral. The questionnaire has a high level of reliability: $\alpha=0.94$

Findings

A. Teachers' Attitudes towards Changes

Table 2 presents the cognitive, emotional, and behavioral attitudes of teachers towards change that were gathered by the Attitudes towards Change questionnaire. From the table, it is evident that the participants, in general, show a very positive attitude towards change, with the behavioral attitudes being the highest (5.70) and the emotional attitudes being the lowest (4.92). The Cognitive attitudes are ranked in the middle (5.03).

Table 2: Teachers' attitudes towards change (N =100)

	Average	SD
Cognitive attitudes	5.03	0.75
Emotional attitudes	4.92	0.90
Behavioral attitudes	5.70	0.68

B. Teachers' Technological Pedagogical Content Knowledge (TPACK)

TPACK findings are summarized in Table 3 according to the seven types of knowledge it consists of.

Table 3: Technological pedagogical content knowledge (TPACK) according to its components

	Average	SD
Pedagogical knowledge PK	3.92	0.74
Technological knowledge TK	3.00	1.17
Content knowledge of the subject CK	4.00	0.78
Technological content knowledge TCK	3.63	0.94
Pedagogical content knowledge PCK	4.07	0.71
Technological pedagogical knowledge TPK	3.53	0.96
Technological pedagogical content knowledge TPACK	3.41	0.87

Table 3 indicates that the self-reported level of teachers' knowledge for all seven TPACK components is moderate to high. The highest score was obtained for the Pedagogical Content Knowledge (PCK) (4.07), indicating the high self-confidence of teachers in the subject-matter they teach. In contrast, the lowest score (3.0) was found in the Technological Knowledge (TK), representing the low self-confidence of teachers in using technology for teaching. The high standard deviation found for Technological Knowledge (1.17) indicates the co-existence of two teachers' groups: One with a high and one with a low mastery level of technology for teaching.

C. Teachers' Attitudes towards School as a Learning Organization

The Table 4 depicts the teachers' perception of school as a learning organization for four the major learning processes of organizational learning (Korland, 2000). Findings illustrate the importance that teachers assign to the organizational learning processes in school. On the other hand, the significant differences between the two columns in Table 4 reveal a large gap between the level of organizational processes that the teachers would expect to have in their schools, and the level that actually exist there.

Table 4: Teachers' perception of school as a learning organization

Organizational learning processes	To what extent do behaviors of a learning organization exist in school?		How important are behaviors of a learning organization in school?	
	M	SD	M	SD
Learning processes	4.07	0.80	4.43	0.56
Evaluating & drawing conclusions	3.99	0.86	4.51	0.67
Disseminating information & knowledge	4.09	0.73	4.43	0.59
Gathering and preserving information & knowledge	3.91	0.88	4.44	0.69

A weak, negative and significant correlation ($r_{(87)}=-0.227$, $p<0.05$) was found between teaching seniority and the reported level of evaluation and drawing conclusions processes at school. A weak, negative and significant correlation ($r_{(87)}=-0.270$, $p<0.05$) was found between teaching seniority and the scores for gathering and preserving information and knowledge processes at school.

D. Correlation between TPACK and Attitudes towards Change

Examination of the correlation between the teachers' attitudes towards change and the indices of the TPACK questionnaire was conducted, using Pearson tests, as shown in Table 5.

Table 5: Correlation between TPACK and teachers' attitudes towards change

Technological pedagogical content knowledge (TPACK)	Technological Pedagogical knowledge (TPK)	Pedagogical Content knowledge (PCK)	Technological content knowledge (TCK)	Content knowledge (CK)	Technological knowledge (TK)	Pedagogical knowledge (PK)	
0.229*	0.272**	0.146	0.188	0.345**	0.176	0.283**	Attitudes towards change general
0.247*	0.239*	0.170	0.191	0.271**	0.178	0.288**	Cognitive attitudes
0.237*	0.263*	0.171	0.222**	0.372**	0.175	0.297**	Emotional attitudes
-0.044	0.061	-0.34	-0.044	0.102	-0.034	0.036	Behavioral attitudes

* Significant at the level of $p<0.05$

** Significant at the level of $p<0.01$

It is evident from Table 5 that Pedagogical Knowledge (PK) has a significant, weak, positive connection with the attitude towards change ($r_{(96)}= 0.283, p<0.05$), both with the cognitive attitudes ($r_{(96)}= 0.288, p<0.05$) and the emotional attitudes ($r_{(96)}= 0.297, p<0.05$). Content Knowledge (CK) was found to have a significant positive correlation with the attitudes towards change ($r_{(94)}= 0.345, p<0.01$), both to the cognitive attitudes ($r_{(94)}= 0.271, p<0.01$) and to the emotional attitudes ($r_{(94)}= 0.372, p<0.01$). A significant, positive weak correlation ($r_{(94)}= 0.222, p<0.05$) was found between Technological Content Knowledge (TCK) and emotional attitudes towards change. A significant weak correlation was found between Technological Pedagogical Knowledge (TPK) and the average attitudes towards change ($r_{(94)}= 0.272, p<0.01$) – both with the cognitive attitudes ($r_{(94)}= 0.239, p<0.05$) and to the emotional attitudes ($r_{(94)}= 0.263, p< 0.05$). A significant weak correlation was found between Technological Pedagogical Content, Knowledge (TPACK) and the average attitudes towards change ($r_{(94)}= 0.229, p<0.05$), both with the cognitive ($r_{(94)}= 0.247, p<0.05$) and the emotional attitudes ($r_{(94)}= 0.237, p<0.05$).

In summary, findings revealed a significant weak-to-moderate positive correlation between the TPACK components and the emotional and cognitive attitudes towards change: The higher the teachers scored on TPACK, the more positive their emotional and cognitive attitudes towards change are.

E. Correlation between Attitudes towards Change and the Perception of School as a Learning Organization

The correlation between the participants' attitudes towards change and their perception of school as a learning organization was examined, using a Pearson test. (Table 6).

Table 6: Correlation between attitudes towards change and the perception of school as a learning organization

	Attitudes towards change – general	Cognitive attitudes	Emotional attitudes	Behavioral attitudes
Learning processes	0.104	0.037	0.145	0.073
Evaluation and drawing conclusions	0.135	0.055	0.202*	0.065
Disseminating information and knowledge	0.153	0.108	0.192	0.066
Gathering and preserving information and knowledge	0.181	0.137	0.242*	0.049

* Significant at the level of $p<0.05$

Table 6 shows two significant correlations – a significant positive, weak, correlation between emotional attitudes towards change and the perception of school as an organization that maintains processes of evaluation and drawing conclusions ($r_{(95)}=0.202, p< 0.05$), and a weak, positive significant correlation between emotional attitudes towards change and the perception of school as an organization that maintains processes of gathering and preserving information and knowledge ($r_{(95)}=0.242, p<0.05$).

The finding that the higher the teachers' perception of school as maintaining processes of evaluation and drawing conclusions and processes of gathering and preserving information and knowl-

edge the more positive are their emotional attitudes towards change clearly indicates the importance of organizational learning processes in improving teachers' solidarity with school.

Discussion and Conclusions

This study investigated the inter-relationships between the three major factors that affect leading a change in organizations in general and in the context of innovation technology implementation in schools in particular (Archambault & Crippen, 2009; Cox & Graham, 2009): (1) the Technological Knowledge, Pedagogical Knowledge, and Content Knowledge of teachers (TPACK), (2) Teachers' attitudes towards change, and (3) teachers' perception of school as a learning organization.

The fact that the highest TPACK score was found for Pedagogic Content Knowledge (PCK) and the lowest score for Technological Knowledge (TK) indicates the well-reported gap between teachers' feelings of control in the content they teach, as opposed to feelings of helplessness and loss of control when they implement technology in their teaching. Similar findings were reported by Archambault and Crippen (2009), who explored factors that affect the implementation of innovative technologies in schools.

In general, the teachers' attitudes towards change were found to be positive, and the fact that the highest scores in the Attitudes towards Change index were found for the behavioral attitudes clearly indicates the readiness of teachers who participated in the implementation project to actively work for creating change. On the other hand, the great variance that was found with respect to their emotional attitudes towards change indicates an inconsistency among the participants concerning the need for change, which may result from heterogeneity in the participating group that consisted of technology-literate and technology illiterate participants.

The importance that teachers assign to maintaining processes and characteristics of a learning organization in their school is evident from the research findings, in which the participants reported of a strong will to be active in making their school a learning organization that enables cooperative learning, consistent feedback, and control. On the other hand, the teachers reported an unsatisfactory preparation of their schools for the implementation of the innovative smart class technology. It is reported from many recent studies that dialogue, cooperation, knowledge-transfer, and knowledge conservation, which are characteristic elements of school as a learning organization, lead to positive attitudes towards change and are important factors in implementing innovative technologies (Cibulka Nakayama, Price, & Stewart, 2000; Zhao & Ordóñez de Pablos, 2009). This illustrates the crucial importance of teachers' participation in the leadership of a change and in decision-making processes in order to strengthen teachers' positive attitudes towards the change (Fullan, 2000; Harris & Hofer, 2009; Selwyn, 2010; Vaillant, 2005).

Examining the correlation between the three factors (i.e. TPACK, attitudes towards change, and perception of school as a learning organization) revealed two significant correlations:

1. Positive correlation between TPACK (especially Pedagogical and Content Knowledge – PK and CK respectively) and attitudes towards change (especially the cognitive and behavioral attitudes).
2. Positive correlation between teachers' attitudes towards change and their perception of school as a learning organization (especially when it maintains processes of evaluation and drawing conclusions and processes of gathering and preserving information and knowledge).

In other words, participants who scored high in TPACK and in perceiving their school as a learning organization also scored high in their positive attitudes towards change. These findings reinforce the claims that the adoption and implementation of change that involves innovation tech-

nologies is a personal process (Ogobonna, & Harris, 2009), unique to every teacher and related to his or her personal beliefs and motivations (Darling Hammond, 2000). On the other hand, it is a process of change in the organizational culture (Koehler & Mishra, 2009) that requires special organizational preparations in order to reduce resistance (Avidov-Ungar, 2010; Mioduser, Nachmias, Lahav, & Oren, 2000).

The research findings concerning TPACK, attitudes toward change, and perception of school as a learning organization allow employing three perspectives in the analysis of change which takes place in schools that implement innovation technologies: (1) the **systemic perspective**, as expressed by the School as a Learning Organization index, (2) the **professional-personal perspective**, as expressed by the TPACK index, and (3) the **procedural perspective**, as expressed by the teachers' attitudes towards change. The TPACK index consists of elements from the three perspectives (Archambault & Crippen, 2009; Cox & Graham, 2009) and, therefore, can be used as a predictor for the potential of teachers to implement innovative technologies effectively in their teaching.

Findings of this research clearly indicate the pivotal role of the co-existence of a learning organizational culture in school, side by side with a high level of teachers' technological-content-pedagogical knowledge, in generating positive attitudes towards the changes that innovative technologies bring and in improving the implementation's success. Future research is required, in order to investigate the actual effect of the TPACK index on the success of innovative technologies implementation in schools.

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Yoram has a diverse academic and professional background: He holds a B.A in Archeology, M.Sc. in Geology and PhD in Earth & Environmental Sciences. For a decade, he was the Head of the Instructional Design Program in the Tel Hai Academic College and a senior researcher in the Geological Survey of Israel.

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