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"I'm The Same Teacher": The Attitudes of Science and Computer Literacy Teachers Regarding Integrating ICT in Instruction to Advance Meaningful Learning

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ABSTRACT
The communications revolution reaches all sectors of the population and makes information accessible to all. This development presents complex challenges which require changes in the education system, teaching methods and learning environment. The integration of ICT (Information and Communications Technology) and science teaching requires innovative teaching methods based on a constructivist approach. This study examines the extent to which science teachers in Israel who identify themselves as using ICT in their classrooms, actually integrate ICT in their practice, and use ICT to promote higher order thinking. The findings indicate that most teachers in this study use ICT tools primarily for visual aspects of their teaching, such as upgrading classroom demonstrations. Further, they are unaware of the need to change their teaching methods by adopting sophisticated computer applications relevant to science teaching. Even the minority who felt the need to change teaching methods do not know how to achieve this end.
Keywords: science teaching, ICT, cognitive development, teaching methods

INTRODUCTION

Keeping up with the knowledge revolution

The pedagogic potential offered by ICT to improve science teaching has been well documented. Recent research has found that science teachers view the use of technology as beneficial and empowering. However, they claim that they do not use these tools regularly. When used, ICT is used mainly as a teaching aide and less commonly for changing pedagogic paradigms (Graham et. al, 2009; Guzey & Roehrig, 2009; McCrory, 2008). These studies highlight the importance of the choices that teachers make in using these methods in their daily teaching. The presence of ICT in the schools does not ensure their prudent use, and in fact, traditional teaching methods often prevail even in the presence of classrooms with the

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State of the literature

- Recent research has found that science teachers view the use of technology as beneficial and empowering. However, they claim that they do not use these tools regularly.
- When used, ICT is used mainly as a teaching aide and less commonly for changing pedagogic paradigms (Graham et. al, 2009; Guzey & Roehrig, 2009; McCrory, 2008).
- These studies highlight the importance of the choices that teachers make in using these methods in their daily teaching.

Contribution of this paper to the literature

- Our findings strengthen previous research showing how science teachers limit their use of ICT to concrete illustrations and simulations.
- This research suggests the need for a change in pedagogic paradigms of science teachers toward viewing the learner as an active constructor of knowledge and changing the role of teacher from instruction to supporting and guiding students.
- In addition to this paradigm shift, the research suggests the need of science teachers to broaden their repertoire of teaching strategies based on technology.

most advanced technological equipment and with teachers who have been trained to use such tools. This question occupies researchers engaged in examining the effects of globalization on education (Ram, 2005; Harpaz, 2007; Resnik, 2008) as well as those who investigate the difficulties which educators encounter when trying to integrate into today's dynamic reality (Suarez-Orozco, 2004).

When educators fail to engage in the knowledge revolution, they become prisoner to the classic paradigms that have shaped the traditional school. Thus, a situation has been created in which reality continues to change, and schools, which are supposed to prepare their graduates for a new, open age, continue to operate as closed systems. To be at the educational forefront requires significant change in the concept of the role of the teacher and the teacher's function (Shaner, 2010). While virtual learning environments are becoming more widespread, teachers continue to encounter serious difficulties integrating them into their teaching, as they continue to deal with obstacles along the way (Eitan, 2006).

The global communications revolution that changed the face of the world economy, scientific research, cultural endeavors, and everyday life, also intends to bring about change in the educational system (Avni & Rotem, 2009). In Israel, technological innovation in the schools began in the 1990's with building infrastructure and continued into the 21st century with curriculum and teacher training endeavors across the country (Mioduser, Nachmias, Forkosh-Baruch, & Turbin, 2004). Assessment of these initiatives has revealed a strong connection between intensity of factors such as infrastructure, school climate and educational policy with implementation criteria including teacher roles, instructional change and teaching methods (Nachmias, Miodusre, Cohen, Tubin, and Forkosh-Baruch, 2004).

Tubin (2006) claims that "what counts is not the ICT type but its implementation process." She describes the four models of implementation found in Israeli schools: *traditional*, where the basic ICT infrastructure comprises of computers in a lab, designated computer lessons and little effect on everyday teaching; *jet carriage*, where advanced technology is purchased but no pedagogic training is given (likened to attaching a jet engine to a horse drawn carriage); *emergence*, where significant changes in methodology and goals accompany the ICT; and *exploitation,* where the once advanced technology is outdated but nevertheless supports innovative pedagogic methods.

In the last decade, the Israeli Ministry of Education (2009) adopted a national ICT program, whose aims include relevant content for a changing reality, skills for the 21st century, differential instruction based on students' abilities, and breaking down barriers between school and society. This initiative requires that teachers use information and communications technology tools in their instruction to promote learning processes at all grade levels. In a study of teachers who participated in the program, Berenstok (2014) found positive correlations between five measures of readiness for computer literacy and acquisition of computer skills namely; change efficacy, appropriateness, personally beneficial, management support, and organizational value.

Teachers' positions regarding ICT integration in instruction

Teachers' approaches toward digital environments and their influence on instruction, constitute a primary factor in implementing the process of change in methods of instruction in schools. Three positions regarding ICT among teachers have been found in the literature. The first approach is characterized by teachers rejecting the integration of information technologies in instruction, based on the notion that such technologies are not beneficial (Mioduser, Nachmias, Tubin & Forkosh-Baruch, 2006; Najar, 2006). The second approach accepts integrating ICT in instruction as an aid in processing information and data, but not as an accompanying tool in the classroom (Collis, Peters, & Pals, 2001; Abou-Dagga & Huba, 1997). The third approach is an espousal of full integration of ICT, which is viewed as a tool to promote instruction and achieve varied learning strategies (Mioduser, 2006; Preston, Cox & Cox, 2000). The implementation of learning programs and reforms rises and falls according to these positions and teachers' attitudes regarding change (Darlig-Hammond, 2005 in Klieger, Ben Hur & Bar Yosef, 2008). There are those who maintain that the major block preventing ICT's success in instruction is the negative position of teachers toward ICT. Changing these positions may help overcome the obstacles in implementing the technology. Teachers' willingness to cope with professional change in methods of instruction shape their positions toward integrating ICT in the instructional process (Anderson & Maninger, 2007; Bitner & Bitner, 2002; Hew & Brush, 2007). Therefore, the transition to virtual learning requires adaptation (Eitan, 2006) and training.

Factors influencing teachers' positions toward ICT integration in instruction

Difficulties in integrating ICT in classrooms are related to teacher's perceptions and beliefs (Yocum, 1996; Semple, 2000). Another factor related to teachers' willingness to integrate ICT is age and seniority (Hung & Hsu, 2007). Older teachers with more seniority are generally less positive about the use of computers and about the use of information technologies in classrooms in particular.

Teachers' willingness to use ICT technologies is dependent upon their knowledge of and fluency in computer skills. As early as 1999, it was found that those who connect regularly to the internet tend to use ICT in their classroom more than those who do not use internet in their daily life (Beck, 1999). Furthermore, a command of computer skills and ICT, has been found to correlate with advanced technological-pedagogical content knowledge. This complex knowledge which involves the smart integration of information technologies also reduces fear of change and is thought to be an ability that improves through practice (Magen-Nagar & Peled, 2012).

Training in the use of computers in teaching has been found to correlate with a more positive approach to ICT integration in instruction and coping with technical difficulties arising during the lesson (Sanders & Morrison, 2001).

ICT integration in instruction – a pedagogical change

The central challenge to teachers is to move from traditional instruction integrating computers to instruction integrating ICT. Effective use of technology entails an intelligent and critical attitude toward this pedagogy. Many educators have claimed that integrating ICT in instruction will lead to a techno-pedagogical revolution.

ICT requires changes in the professional role of the teacher, from transmitting content and explanations to fostering collaboration and dialogue between teacher and student (Fullan & Langworthy, 2014). Furthermore, the teacher supports the development of the student's ability to direct her own learning in digital environments, emphasizing the roles of mentor and coach, (Feinmesser, 2000 in Eitan, 2006). Today's teacher is required to mediate between the student consumer of knowledge and sources of information appropriate to him, while identifying prior knowledge and constructing new learning experiences (Arak, Dori, 2009 in Nissim, Barak & Ben Tzvi, 2012). These new ICT pedagogies necessitate different teacher preparation. The teacher needs a command of tools for sharing information, which include developing and administering social network groups. Furthermore, he must be familiar with programs for mapping concepts, systems for administering learning, advanced tools for searching, organizing, and processing information (Barak, Carson & Zoller, 2007 in Nissim, Barak & Ben Tzvi, 2012). Furthermore, continued and intensive training of teachers in tools for information sharing, administration of social media groups, and programs for conceptual mapping and promoting higher order thinking has been found to significantly influence the use of these tools in the classroom (Magen-Nagar & Peled, 2012).

Teachers believe that their increased use of ICT contributes to learning and enhances their capability (McCrory, 2008). Professional development programs focusing on technical integration were found to positively impact science teachers' development of TPACK (Technological Pedagogical and Content Knowledge, Guzey & Roehrig, 2009). Furthermore, it has been shown that the acquisition of this pedagogic knowledge develops gradually over time with continued experience (Graham et. al, 2009). However, the prevalent perception among teachers is still that the role of technology focuses on variety, enrichment, and expanding instruction through use of multimedia tools that raise student attention and motivation (Prensky, 2008). In their study of Israeli teachers, Shamir and Kali (2007) found that teachers make use of ICT principally as a visual tool without significant pedagogic change. Introducing technology has not been accompanied by a change of school culture, and the definition of teacher's role and methods. Therefore, although schools have received equipment and have made advances in the area of technology, school structure, classroom dynamics, instructional methods and students' learning behaviors have largely remained unchanged (Salomon, 2006; Handal, 2004).

Positions of science teachers

Science teachers are not exempt from the expectation of pedagogic change related to ICT adaptation in the schools. Recent research on this group has revealed a discrepancy between high levels of ICT confidence and low levels of classroom implementation (Hsu, 2013). This phenomenon has been addressed in several studies examining factors that impede implementation. In the personal domain, a Turkish study showed generally positive attitudes towards ICT, with no gender differences. However, age was negatively correlated (Cavas, Cavas, Karaoglan, & Kisla, 2009). In his meta-analysis of relevant literature, Bingimlas (2009) found a contrast between the strong desire of science teachers to integrate ICT and their lack of confidence, competence and access to resources. A later review of the literature confirmed that general lack of confidence towards ICT use among science teachers, and suggested that additional barriers to implementation include institutional factors such as lack of suitable software, limited access to ICT, and rigid school structures (Buabeng-Andoh, 2012). Hechter and Vermette (2013) identified institutional barriers including inadequate access, time, resources, training, budget, and support. Evidence for low levels of ICT training among science teachers around the world was found in a review of current literature on the topic (Buabeng-Andoh, ibid), and this factor was related to teachers' inability to integrate ICT in their teaching. Thus, both motivational and institutional factors can impede implementation.

As in Hsu's (2013) study mentioned above, Israeli researchers found a discrepancy between science teachers' positive attitudes towards ICT and their actual implementation (Nachmias, Mioduser, & Forkosh-Baruch, 2009). While teachers claimed that ICT contributes to learning and empowers abilities, they reported that their use of ICT was limited largely to preserving instructional methods instead of advancing new pedagogic paradigms. Those who integrate ICT in instruction primarily use traditional teaching models such as presentation of information, demonstration, instructions for classroom work, and assessment of learning.

Simulations and production of multimedia were less common. On the other hand, Sendag (2014) found a correlation between positive attitudes and self-efficacy regarding ICT with internet use, reported ICT skills, and interest in the science teaching profession. An example of such positive effects is found in Klieger's (2008) study of science teachers who introduced laptop computers to make learning more efficient. They reported satisfaction in their ability to deal with relevant content using ICT. In addition, these teachers reported personal empowerment, innovation, renewal, autonomy, and a rise in self-esteem.

Attitudes of science teachers toward the use of ICT can change. Peled, Kali and Dori (2011) note four types of positioning of science teachers towards the use of ICT: the independent and initiating teacher, the teacher who toes the line, the avoidant teacher, and the oppositional teacher. One example of the initiating teacher who changed his practice is found in Davidson's (2012) self-study about the integration of online forums as a solution to low student participation and the inability of the teacher to respond to each student in a traditional science class. Some science teachers reported that they integrate ICT in their instructional methods (Luft & Roehrig) as a result of courses and training programs. However, in the same study non implementation was also found among other participants in the same courses. The desire for professional advancement through the use of ICT in their teaching was ranked as a secondary need by science teachers (Nimben & Nazuki, 2014). These studies shed light on the complexity of factors that hinder and foster ICT implementation in science teaching.

RESEARCH AIMS AND DESIGN

While previous studies have dealt with science teachers' perceptions about integrating ICT into their practice, they included teachers with different levels of ICT knowledge and skills. This study focuses on a population of science teachers who claim a high level of ICT knowledge and also report integrating ICT in their teaching. The objective of the present study was to examine whether this group of teachers, uses ICT as an aid for pedagogical innovation such as new teaching strategies or do they use it for embellishing the visual aspect of teaching. In addition, we examined the teachers' self-perception of their disposition to use ICT in their teaching. Furthermore, we examine the extent to which these teachers claim to use ICT for developing students' independent thinking and exposure to available universal information for learning.

The study examined three interdependent questions:

1. What are the perceptions of science teachers who possess technological-pedagogical knowledge and who report that they hold a favorable position toward ICT, regarding its use as a smart instructional tool (developing thinking, communication, and collaborative social learning)? What are their attitudes toward the need for ICT and how do they understand the strengths and weakness of its use in the classroom.

2. How do these teachers understand the contribution of ICT to students' learning in the areas of the construction of knowledge, visualization, and direction of learning, knowledge skills development, and problem solving?
3. What is the awareness of the teacher using ICT regarding its purpose for changing teaching methods, the place of the student, and the role of the online teacher?

METHODOLOGY

This study is based on qualitative methodology using a descriptive-interpretive approach, relying on personal interviews and analysis of their findings. This type of study allows the researcher to understand the participants' perceptions, positions, and actions (Rubin & Rubin, 2012). In the present study, this methodology has allowed for the examination of the subjective perceptions of the participants. The interviews also elicited descriptions of the teachers' use of ICT including its integration in their teaching. The semi-structured interviews invited the participants to express their perceptions vis-à-vis their use of CT as a learning solution.

The Participants

Teachers were selected from participants in a computer course for science and technology teachers in elementary and middle schools in a large city in Israel. Participants in the course had studied in a previous ICT course and were considered to have acquired a high level of ICT literacy in science subjects as well as medium to good command of computer skills. Twelve teachers from this group of 50 were chosen through a screening interview to identify those who preferred teaching science lessons using ICT rather than traditional frontal teaching. Those chosen claimed to use ICT at least three times a week in their teaching. These selected teachers agreed with the statement that integrating ICT technologies can advance the quality of instruction. The age of the participants ranged between 24 and 45, with an average of 33.7. Their seniority ranged between 4 and18 years, with an average of 11.1. Eleven of the twelve were women, reflecting a gender imbalance in the profession of science teaching.

Instruments

To examine the research questions, use was made of a semi-structured interview, according to Sabar Ben Yehoshua's model (1990). In this method, the interviewee is requested to relate to questions established in advance regarding their stance about different points while encouraging conversation to develop other in directions. This allowed the participant to express her position on the subject under examination and to relate her experience.

The interview consisted of 15 questions, some of which were closed and others were open. The respondent was asked to answer the question and explain by giving an example. The questionnaire was prepared for the purpose of this study and was checked for validity and reliability. The interview consisted of three parts. The first part revealed the frequency and purposes of ICT use. The second part examined the teacher's pedagogic considerations in

using ICT as a solution for promoting learning. The teacher was asked to give examples showing her preference for ICT use over frontal teaching without ICT, as well as to express her personal outlook regarding the advantages and disadvantages of using ICT instruments in teaching. In the third part, the teacher was asked questions examining her awareness of the need for changing instructional methods, and the student's position and teacher's role in online instruction. In addition to open questions, the teachers were asked to indicate their level of agreement with statements regarding the smart use of ICT instruments.

(See **Appendix 1**, Questionnaire for teacher interviews).

Procedure

After their initial selection, the twelve participants were given an in-depth interview using the questionnaire mentioned above. After hearing an explanation of the study and its significance, all participants agreed to the interview procedure and the anonymous use of their data. Each participant was given a numerical code and a fictitious name. The interviewees demonstrated openness and willingness to cooperate. The interviews were transcribed and recorded. The interviews were conducted during breaks at a summer in-service training for science teachers.

Qualitative Data Analysis

The interview protocols were broken down into components and organized into relevant constructs (Kassen & Krumer-Nevo, 2010). The initial analysis began with close reading of each interview. In the second stage, the teachers' responses were categorized according to their perceptions regarding: the need to use ICT as an instructional tool, the advantages and disadvantages of its use, and the need to change their teaching methods. In addition, their self-reported use of ICT methods was categorized according to manner of use. The third stage involved searching for connections and relationships between their attitudes about ICT with their self-reported use of these methods in their practice. Data analysis was performed according to Rubin and Rubin's (2012) method in which the participants' comments from the field are used to interpret and understand the field itself.

FINDINGS

The findings are presented through the viewpoints and self-reported behaviors of the teachers regarding the use of ICT in their teaching. We found that participants agreed on a number of benefits as well as weaknesses. However, there were characteristics of ICT learning about which there was controversy among the teachers. We begin with the points of strength on which the teachers mostly agreed. Then we present those issues about which the participants expressed concerns. These attitudes are then juxtaposed against their reported classroom practice in using ICT for science instruction.

Expressions of instructional strengths in integrating ICT

Participants in the study elaborated on the strengths of integrating ICT in their teaching. First, teachers perceive ICT as promoting relevance and stimulating learning. As such, it is a tool for creating relationships and for connecting to the student. In this context, Dina said: "I prefer to use ICT during the lesson because the children are automatically attracted by the computer; the computer speaks to today's children." Sima added: "When we teach without ICT, we are not talking with the children in the language they're used to and have been exposed to. In order to interest the children and give them motivation for learning, there is a need to speak in a language familiar to children."

Second, ICT tools enable the teacher to vary instruction and are perceived as a welcome change from frontal methods. Dina noted this advantage: "We have introduced more life into learning, more possibilities. The material studied is the same material, but the ability for variation has increased immensely. I easily integrate a film, a video clip, a game, a text, ICT tasks, etc."

A third advantage noted by many teachers is the visual aspect common in ICT instruction which makes phenomena accessible to the learner. In this regard, ICT enables teachers to make concrete illustration available, such as complex processes and experiments that could not be conducted in school laboratory conditions. This visual aspect of the use of technology allows the investigation of events both from distant environments and those on a micro level which would require advanced technology unavailable in a school classroom. This is apparent in the words of Shlomit, a middle school teacher:

> *In frontal teaching, it's difficult to describe processes. The computer helps the teacher because with the computer simulation there is no need to describe how a red blood cell contains iron. I simply show it, and that does the job.*

Lior also describes how technology is used to illustrate processes, promote learning, and internalizing material: "The use of technology brings phenomena closer to the learner and explains processes in a clearer manner. The graphic representation of processes and phenomena facilitate internalization by the learners."

A fourth argument in favor of the use of ICT is instrumental. There are teachers who instead of conducting an experiment in class, show films of experiments or use animation. These teachers describe the virtual experiment as time-saving. "In order to conduct an experiment in the classroom, time is needed for organizing the groups, handing out the equipment, collecting it, etc. With today's existing technology, it's possible to shorten the process and save time."

A fifth benefit noted by half of the study participants its effectiveness in promoting student concentration during the lesson. For example, Ayelet maintained: "When I use ICT in instruction, I don't have to focus the students. The moment the projector is turned on, all eyes

are immediately on me." Related to concentration is the enhancement of memory and assimilation of the material. Teachers claimed that ICT provides a sensory stimulus that increases the ability to incorporate the concepts into their existing schema. Leah stresses this point: "By using the computer, the material studied is absorbed better because the children see, hear, and remember better. Sound, image, and emotion will lead to longer term remembering." Lior added his views on the benefits of ICT for assimilation of ideas:

> *Photosynthesis is very hard for children to understand. When children see a picture of the process, they don't always understand it. When I show them a simulation of the process, they see what happens at every stage. This allows the student to understand it much better.*

Shlomit adds to these statements by emphasizing meaningful learning.

> *In my opinion, instruction with the help of ICT is much more meaningful for the student. In ICT instruction, the student receives information and understands it more easily. Therefore, because his understanding is greater, the student's learning is more meaningful.*

A sixth benefit of ICT use is its ability to promote active learning. Reut explained that when she gives ICT tasks, she chooses those that activate the students rather than provide only a visual experience. Sarit shares this view:

> *I am talking to you from my experience in the classroom. When there is a lesson with laptops and they have a task that activates them, the children are happy to work. They ask me to have computers every lesson.*

A seventh advantage relates to meeting the needs of different learners. Many of the study participants mentioned that instruction integrating ICT technologies deals effectively with the problem of student heterogeneity. ICT tools can be adjusted for differential paces and ability level, thus suiting the learning to each student's needs. Rina noted: "When I give ICT tasks, I essentially allow each student to work at a task suited to his level, ability, and individual pace. That's something I could never do in a frontal lesson with an entire class." Teachers also referred to the issue of adapting instruction to a student's learning style. Some remarked that the use of ICT promotes the inclusion of children with learning difficulties because it provides them with a learning channel that is friendlier and more comfortable than a conventional classroom. Rina suggested that problem solving in an ICT environment is particularly beneficial for children with learning disorders as well as those with ADHD.

Different views on strengths and concerns about weaknesses of ICT use

Although there was widespread agreement about the strengths of many aspects of ICT use in teaching, there were also areas of disagreement, as expressed by the teachers in their interviews. These concerns about possible drawbacks and disadvantages of ICT will be presented below, using quotes as evidence of the differing views.

The first disadvantage according to some teachers, is that ICT destroys the imagination. This argument relates to the wide use of illustration through ICT. Such applications suppress the imagination and thereby stifle the development of creative thinking. Sima adds her opposition to the use of the visual aspect of ICT:

> *It's not magic. In order for learning to be meaningful, the student has to work and internalize, and there are teachers whose use of ICT doesn't activate anything beyond the students' visual sense.*

Regarding their views on ICT as a stimulus for learning, teachers expressed opposing views. Sara was in favor of ICT as a positive stimulus, as shown in her reflective comment:

> *I use ICT when I want to stimulate my students about the subject. For example, when I introduced the subject of electrical energy, I show the children a film about the electrical blackout at Teddy Stadium in the middle of a soccer game. We got into the subject following the film.*

In this quote, Sara explains how ICT enables her to bring an exciting current event to heighten the students' interest in the topic under consideration. Leah, on the other hand, sees these exciting stimuli which are enabled by ICT, as an obstacle to learning because students become used to a high stimulus threshold and become bored when such attractions are absent.

In response to the question as to whether ICT use has led to higher order thinking skills, such as analysis, synthesis and evaluation, different approaches were expressed. Many endorsed ICT as a tool that supports such skills. Lior, a middle school teacher, claimed that ICT invites higher order cognitive skills, such as "analysis, synthesis, and evaluation." He went on to claim that ICT "makes possible broader use of diagrams and drawing conclusions." Osnat elaborated on this notion: "[Higher order thinking] is expressed when the student is asked to organize information in a graphic manner, to draw conclusions and to represent information in a chart." Reut qualifies her opinion about ICT as a tool to promote thinking.

> *I think that ICT use has a possibility for the use of higher order skills, but this depends on the way it is used. If a teacher takes an "ICT activity", develops suitable questions with it, and gives suitable direction, it certainly can be a tool requiring high cognitive skills.*

Despite these positive views about the contribution of ICT to promote higher order thinking, some teachers thought otherwise. Leah's negative views on this aspect are expressed in this excerpt:

ICT use does not provide for the development of higher order thinking skills. It was initially designed for the lower level student who has a need for visual interest in order to illustrate processes. It turns out that because of the weak students, the strong students enjoy the visual quality and receive information already chewed and ready to be swallowed.

In contrast to her colleagues' positive views, Leah understands ICT differently. She claims that ICT is most helpful to weak students who require visual presentations and causes damage to the strong students because of its tendency to oversimplify scientific concepts.

The capabilities of ICT to access information is viewed in different ways by the teachers. Some value this feature for both the teacher and the student. Sarit claimed:

> *Information is much more available. While teaching a subject, the teacher can access available information sources, pictures, articles and show them in real time, the most relevant possible - a tsunami, an earthquake, etc. The students also can find available and relevant information much easier.*

This argument in favor of ICT is seen through a negative lens by other teachers. They argue that accessibility of information and concrete demonstrations of phenomena work against the learning process because they lead to a reduction in live classroom experimentation. Shlomit thus remarked about herself, "I used to bring demonstrations to the classroom such as magnets and various materials, and the children used to discover for themselves the phenomenon that only some metals are attracted to the magnet. Today I'm lazy, and I use a computer simulation instead." Shlomit admits that the availability of digital simulations reduces her need to conduct hands on experiments in class. This pull and push regarding use of ICT technology sometimes leads to teacher ambivalence. Sarit who argued in favor of the use of digital stimuli, also sees the negative side of this practice. She reflected on her own teaching:

> *When I taught the parts of the flower, I took the trouble to pick flowers in order to provide students the experience of taking apart the flower. They felt the pollen clinging to their fingers and thus learned the mechanism of pollination by insects. Today I show them the simulation on the website and from that, we draw our conclusions. I'm also spared cleaning the lab and returning magnifying glasses.*

She looks back with nostalgia about her former teaching which included lively hands-on activities. These practices, while effective for student learning seem to be a thing of the past. Her ambivalence about abandoning the experiential learning is based on an instrumental argument of convenience.

Mixed opinions regarding improvement in student achievement as a result of ICT learning were found. Some teachers indicated that instruction enhanced by ICT results in increased student learning, while, others did not identify any change.

There was only one criticism of ICT that was not contested by any of the teachers. It addresses differences in students' learning preferences. Zahava asks "And what will you do with students who are not connected to the computer? ICT is not appropriate for every child!"

To summarize, participants in this study indicated a number of strengths in the use of ICT in their teaching, including: opportunities for creating interest in and stimulus for

learning, the ability to illustrate, and an increase in students' concentration and level of activity. Teaching supported by ICT is geared to the individual student's level and makes learning easier for students who have difficulties. In addition, information is constantly available and ICT provides for the development of higher order thinking skills.

On the other hand, some of the advantages of ICT were offset by real concerns and a number of disadvantages were noted. Among the criticisms were: a decrease in meaningful learning due to an elevated stimulus threshold, a decrease in the students use of imagination, a decline in the use of higher order thinking, a failure to address student's learning preferences, and a reduction of experimentation in the classroom.

Principal approaches relating to the manner of ICT use in instructional processes

Participants in the study express three principal approaches that differed one from the other regarding ICT use in the instructional process. The first: frontal teaching in which ICT serves as a visual aid; the second: smart integration of ICT in frontal teaching; and the third: the abandonment of frontal teaching.

The first approach presents ICT use as a frontal teaching tool in every way. Information is selected by the teacher and entered into a presentation. Material that was written on the board in a traditional lesson, is now screened through a projector and it is read to the students in the class. Sometimes pictures are added to the presentation, thereby using ICT as instrument for attaining learning aids. Learning continues to occur according to the rules of traditional frontal teaching. As Sima said: "I haven't abandoned and will not abandon the frontal method. For me, ICT is only an aid."

The second approach, which most of the study's participants supported, is the integration of ICT with frontal instruction. These teachers responded negatively to the question that addressed replacing frontal teaching with ICT by explaining that they have combined the two methods. This integration allows them to enjoy the advantages of frontal learning and learning using ICT at the same time. This point was made clear in Zahava's statement:

> *There is a need to cry out against the trend to throw away the past and its methods. We shouldn't abandon the frontal method, which also has advantages. It organizes learning, it helps things fall into line and it is necessary for the opening and conclusion of every lesson. The trick is to integrate and use ICT as a tool in a smart manner within the frontal lesson.*

The third approach abandons the frontal method altogether and views ICT as the focus of pedagogy. Instruction is based on extensive use of computer skills in individual or group work. Students are occupied with gathering information from the internet and processing data in information-sharing programs. The teacher serves as a learning mediator only rather than a source of knowledge. Thus, learning could take place even without a teacher. In Reut's

words: "If ICT is frontal, we haven't done a thing. If it is here for the purpose of dealing with student differences, a smart classroom and a pace suited to each student, the integration of the tool works well." Only one teacher supported this radical approach.

Although most of those interviewed support integrating ICT in instruction, in fact, they primarily endorsed using visual aspects of the tool rather than focusing on its capabilities to promoting student learning. This reliance on ICT for its visual aspects was expressed by statements such as: "I use ICT, primarily as an illustrative tool" or "I show films, clips, and presentations. My presentations are based on pictures. I use a lot of visuals." We found a significant gap between the declarations of teachers who espouse smart use of ICT and the implementation of this concept in the field of instruction.

In the interview, teachers identified internet sites that they customarily use in their lessons. Approximately two-thirds of these sites were characterized solely by their visual possibilities. This evidence reinforces the claim that the primary use of ICT for science teaching is visual.

All those interviewed firmly opposed the statement: "The computer replaces the need for the teacher." They related to the teacher's role as the human aspect of the learning process, as Dina said.

> *The teacher directs, encourages, puts in a good word, listens. She is the human component that the student needs for learning. Without her, there is no change in intonation; there is no caressing hand, and no contact. That's why the teacher is needed in the learning process - in contrast to the cold and alienated computer.*

To the question of the learner's functional role when using ICT, it was noted by those interviewed that today's students lack basic skills for independent learning at elementary school age and sometimes even at middle school age. Teachers maintain that students are exposed to much information, but that information is random and populist. Students, for their part, tend to be connected to the internet, but not for the purpose of accumulating information for learning. They are adept at posting on Facebook and playing games and less amenable to engaging in learning activities.

The need for changing instructional methods in ICT

Although teachers largely endorsed ICT use, they varied in their views on the need to change their practice. In response to the question "Did you feel a need to change the method of teaching over the course of ICT use?" teachers were divided into three categories. Some felt no need for change, others felt a need for change in the visual-external area, and only one expressed a need for significant change in instructional methods. The first view claiming no need for change was expressed by Sarah: "ICT for me is an additional assistive tool in the lesson. It does not change anything for me." Ayelet said: "When I use ICT, I don't feel a

significant change, but I certainly feel a need to take advantage of it as a tool for opening or concluding a lesson."

The second category included teachers who expressed a need for change, but in their explanations, they referred to changes that related to visualization of the material taught rather than changes in instructional methods. Shlomit explained this approach: "The changes [I made] involve lesson preparation and structuring its progression for integrating different websites in order to make the experience more concrete." Another teacher expressed a similar view: "The change is that today I show them the simulation on the website 'Kal v'homer' and we draw conclusions based on the simulation instead of bringing the experiment itself to each group of students." These teachers talk about themselves as having undergone change; however, this change only touches upon the visual area and is not a change in the concept of the instructional method.

Teachers in the third category expressed transition to new teaching methods as a result of ICT tools. Rina focused on significant changes in how she organizes classroom instruction to meet the needs of different learners: "ITC makes it possible to meet the needs of different learners. It made me understand that there are groups of children who require different work methods, and that created a change for me." Another teacher, Lior, feels driven to change his entire instructional approach in response to ICT:

> *The more time that passes during which I enjoy the charms of ICT, the sharper the need for changing my methods of instruction. I feel that I lack tools for how to do this. It's true that I integrate ICT in my teaching. On the surface, I'm a teacher in the new, modern, computerized world. But in fact, I'm the same as my teachers from years ago, only with more innovative means. I feel that I really need to change, but I am not exactly sure how.*

Lior's frustration stems from his realization of the potential of ICT to enable significant learning, while realizing his own limitations to make this transformation. For him, using ICT in class does not automatically turn it into a smart learning tool.

Summary of findings

Our major finding addresses science teachers' willingness to use ICT in a limited fashion.

Although the participants were all computer-literate and shared positive attitudes toward ICT, they primarily directed its utilization towards concrete illustration through films and simulations. Although there is evidence of active ICT instruction, very few participants reported teaching strategies directed toward the independent learner. Furthermore, agreement among these computer-literate science teachers regarding ICT use was found for a majority of factors, while disagreement was found for a few others. In addition, most of the teachers did not express a need for change or transition to a different style of instruction. Regarding pedagogic change, three approaches were identified ranging from no change,

through minor changes to allow ICT to aid traditional lessons, to a realization that change is necessary in pedagogical approaches. In general, the participants stressed that ICT cannot replace the teacher, who is critical for learning to take place.

DISCUSSION AND CONCLUSIONS

The study group constituted those teachers, who based on their self-descriptions, could be expected to use advanced technological resources as a smart instructional tool. These were teachers who had training in technology, indicated positive positions regarding its use in instruction, and used this tool frequently. This pro-ICT profile among participants could explain our findings that a preponderance of agreed upon attitudes were positive. Seven benefits of ICT were noted, although a small number of these benefits were opposed and seen as possible drawbacks by some of the teachers. However, the results of the study indicate that their positive perception has not led them to implement the technology as a smart teaching tool. ICT has made the visual aspect very efficient although it has not been turned into a tool for meaningful learning.

Traditional instruction has persisted and teachers, despite computer-literate bias, do not feel a need for pedagogical change. This study reinforces Avni and Rotem's (2009) finding that the introduction of technology in Israeli classrooms has not been accompanied by appropriate changes in pedagogy. On the one hand, smart ICT use requires an integration of the construction of knowledge and interaction and a transfer of the center of gravity from the teacher as the source of knowledge to collaboration and dialogue between teacher and students (Fullan & Langworthy, 2014). On the other hand, ICT use as a smart instructional tool can provide challenging opportunities in which the learner is actively engaged independently or in a social and collaborative process. Use of tools such as social networks, WIKI, forums, and blogs can make possible social learning that goes beyond geographical boundaries. Based on their self-reported profiles, the interviewees could be expected to be familiar with these tools. However, none mentioned using these various methods in their instruction. This finding warrants attention and explanation.

These findings indicate that Israeli science teachers who claim a positive attitude towards ICT are still not open to preparing the learner for active, independent learning and for navigating the class in what Resnick (2008) refers to as "a knowledge-rich world". Furthermore, our participants failed to mention those aspects of technology-based learning deemed crucial by Salomon (2006): allowing the learner to choose activities according to their areas of interest, investigating questions that arise from these activities, and engaging in individual or group explorations in accordance with their skills.

These findings are an expression of a broader phenomenon regarding the adaptation of technology into the classroom context. As such, today's preoccupation with technology in the schools fails to address the instructional-learning process, nor does it reframe the image and role of the teacher and learner (Magen-Nagar & Peled, 2012). While science teachers, such as

those who participated in this study, have learned to use the technology itself, they have not taken full advantage of the potential of these tools to change the learning process by making it more meaningful for the students. This change requires viewing the teacher as a facilitator to the learning process instead of serving as the major source of knowledge. In addition, it presumes a different definition of the learner, from passive to active involvement in the process. Thus, our findings strengthen the call for educational reform that focuses on issues of the instructional-learning process instead of looking solely at technology for its own sake.

The dissonance between the positive attitudes of the science teachers in this study and their limited use of technology in their teaching, points to the need for supporting these teachers to broaden their repertoire of teaching strategies based on technology. Magen-Nagar & Peled's (2012) comparison of teachers from technologically rich schools to those in regular schools revealed the importance of adequate professional development efforts for the assimilation of these tools in daily teaching. Although the teachers in this study were exposed to technological tools, they had not undergone systematic training and did not receive ongoing guidance and support. Thus, their positive attitudes towards ICT without adequately training and support resulted in a superficial practice in technological pedagogy.

This study points to the need for effective training of science teachers in the use of ICT in their teaching. Such training needs to go beyond exposure to discrete tools, and needs to focus on technology as a central path for learning. This approach includes re-visualizing the role of the teacher, from a model of source of knowledge to a paradigm of mediation between the student and the universe of knowledge available to the student through technological means (Fullan & Langworthy, 2014). For example, students of all ages regularly use ICT tools such as smartphones and tablets in their everyday engagement with the world. However, when they bring them to schools, their teachers often see them as distractions to learning, rather than useful tools that can be harnessed through planning and supervision. Shaner (2010) claims that teachers must learn to fully integrate these tools into the learning process in order to move beyond their limited use of ICT as a visual tool.

The study's results are based on the data of 12 science teachers. Due to the modest size of the group, it is not possible to claim the validity of the findings for the entire population of computer-literate science teachers. Nevertheless, this study indicates that there has been no significant change in ICT implementation as a smart tool, as least among some Israeli science teachers. It is recommended to increase the number of participants in the study in order to validate the results. Further, an intervention model would expand our understanding of the utility of professional development by examining the effects of in-service training and continued pedagogical technological guidance and support for the teachers. Such research should pay close attention to the goals of in-service training in terms of implementing change in practice rather than solely familiarizing the teachers with ICT tools. Another potentially fruitful avenue for further research would be a focus on those teachers who expressed a need for pedagogical change regarding the perception of their instruction by examining motivational factors in changing their pedagogy.

This study as well as those that follow will point the way to preparing teachers to support the student as an independent learner through the use of technology. By nurturing this goal through assimilation of ICT in science learning, the teacher advances the student on the path of independent learning. By supporting the student's construction of knowledge, and promoting higher order thinking through technology, the teacher of the 21st century prepares her students for the challenges ahead.

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APPENDICES

Appendix 1

Questionnaire for teachers' interview- Instruction integrating ICT

Personal information: Age _____ Seniority in years _____

Elementary school teacher/Middle school teacher

Male/Female

1. Do you use ICT in your teaching?
2. Does the possibility for using it exist? Would you prefer teaching an ICT lesson instead of a lesson that isn't an ICT lesson? Explain.
3. Many teachers are aided by ICT for illustration. Are you also aided by ICT in that way? What is the extent of your use of ICT as a tool for illustration?
4. Below are statements dealing with the extent of your ICT use. Rank each statement according to your degree of agreement with it.

Statement	Strongly Agree	Agree	Unclear to me	Disagree	Strongly Disagree	Comments or explanation
I am aided by ICT technology to a great degree (3–5 lessons a week)						
I use ICT to a great degree to present films						
I use ICT to a great degree to present simulations						
I use ICT in the classroom to gather encyclopedia information during instruction						

5. Mention names of films/simulations/sources of encyclopedia information that you have used.
6. In your opinion, is there a difference between instruction prior to computerization and instruction using it? How are the differences/similarities expressed?

7. Below are statements dealing with your degree of ICT use. Rank each statement according to your degree of agreement with it.

Statement	Strongly Agree	Agree	Unclear to me	Disagree	Strongly Disagree	Comments or explanation
Integrating ICT technology can promote quality instruction to a great degree						
Integrating ICT prepares the students well for a technological world and provides them with 21st century skills						

8. Does the use of ICT create more meaningful learning in your opinion? Explain.

9. Below are statements dealing with your degree of ICT use. Rank each statement according to your degree of agreement with it.

Statement	Strongly Agree	Agree	Unclear to me	Disagree	Strongly Disagree	Comments or explanation
The use of ICT makes learning interesting for most students						
The use of ICT makes learning comprehensible for most students						
The use of ICT allows for the understanding of complex processes						
The use of ICT allows for long-term memory						
The use of ICT creates the internalization of scientific concepts						
There are students who prefer being instructed by the teacher without ICT						

10. In your opinion, does ICT replace the need for a teacher? Explain.

11. In your opinion, does the use of ICT provide for the development of higher order skills (analysis, synthesis, evaluation) more than instruction without it? How is this expressed?

12. In your opinion, does the use of ICT increase student achievements more than learning without it? Explain.

13. When you use ICT, do you abandon the frontal teaching method? Explain.

14. Does using ICT mean relinquishing traditional instruction? Are there advantages to traditional instruction that are missed by using ICT? What is your opinion?

15. Does the use of ICT during instruction cause you to change/feel the need for a change in the method of instruction?