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Ina Blau[a], Yehuda Peled[b] & Anat Nusan[c]

[a] Department of Education and Psychology, The Open University of Israel, Ra'anana, Israel

[b] Department of Information Studies, Western Galilee Academic College, Akko, Israel

[c] Department of Advanced Studies, Oranim Academic College of Education, Tiv'on, Israel

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Technological, pedagogical and content knowledge in one-to-one classroom: teachers developing "digital wisdom"

Ina Blau[a]*, Yehuda Peled[b] and Anat Nusan[c]

[a]*Department of Education and Psychology, The Open University of Israel, Ra'anana, Israel;* [b]*Department of Information Studies, Western Galilee Academic College, Akko, Israel;* [c]*Department of Advanced Studies, Oranim Academic College of Education, Tiv'on, Israel*

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One-to-one (1X1) laptop initiatives become prevalent in schools aiming to enhance active learning and assist students in developing twenty-first-century skills. This paper reports a qualitative investigation of all 7th graders and their 15 teachers in a junior high-school in Northern Israel gradually implementing 1X1 model. The research was conducted during a second year of 1X1 implementation at the school level, which was a first year of teaching and learning with laptops for all study participants. The study triangulates non-participant lessons' observations and semi-structured interviews with 15 teachers. The data were collected twice: at the beginning and toward the end of the 2011–2012 academic year – in total, 30 observations and 30 interviews were conducted. The results were examined through phenomenological research techniques and discussed in terms of the technological, pedagogical and content knowledge (TPACK) and "digital wisdom" approaches. The teachers showed significant increase of technological knowledge. However, only moderate connections between technology and pedagogy as well as between technology and content were found. Some of the teachers functioned as moderators, scaffolding students and supporting their individual or collaborative learning. However, many teachers struggled with effective management of 1X1 classroom. Neither conjunction of teacher TPACK nor facilitation of student digital skills was observed. The paper suggests an overlap of the TPACK framework and the digital wisdom approach and provides implications for curriculum developers and educational policy-makers.

Keywords: one-to-one laptop classroom; the TPACK framework; digital wisdom; student digital literacy skills; qualitative research

Introduction

Advocates and opponents of educational technology agree that the impact of implementing computers in school cannot be fully realized until the technology continues as being a shared resource (Oppenheimer, 2003; Papert, 1996). As part of this global tendency of implementing one-to-one (1X1) technology, the past decade has seen a new educational reality emerging in Israeli schools, where thousands of teachers and students have been provided with their own laptop in school (Blau & Peled, 2012).

*Corresponding author. Email: inabl@openu.ac.il

The idea underlining the transition to teaching in a digital environment based on the personal laptop in the form of 1X1 model is to develop among students skills relevant to successful functioning in the twenty-first century. The term "ubiquitous computing" addresses the availability of the technology embedded within the environment of daily life. In educational settings ubiquitous computing refers to "learning environments in which all students have access to a variety of digital devices and services, whenever and wherever they need them" (van't Hooft, Swan, Cook, & Lin, 2007, p. 6).

Previous studies showed that 1X1 model can improve learning process and outcomes. Personal laptops enable active learning that promotes learning motivation and improves students' achievement in math and language literacy (Grimes & Warschauer, 2008; Silvernail, 2011; Washuk, 2011). In addition, 1X1 learning model develops critical thinking and inquiry skills of students (Bebell & Kay, 2010; Bebell & O'Dwyer, 2010; Solhaug, 2009), and allows differential learning for students in different levels (Zucker & King, 2009).

However, research literature shows that the impact of the 1X1 model can differ significantly, according to the way in which teachers promote the use of computers by students. 1X1 technologies present new demands on teachers as a delivery model (Storz & Hoffman, 2013), change the style of class management, influence teaching and learning, and modify the roles of teacher and students (Addis & Falk, 2010). Since students can easily be distracted by gaming and chatting opportunities, effective 1X1 class management includes the need to control the device so it can be used as a learning tool rather than a distraction (Storz & Hoffman, 2013).

The role of teacher in 1X1 classroom can change from teacher as a "sage on the stage" transferring knowledge to students – to teacher acting as a "guide on the side" (King, 1993), facilitating independent or collaborative learning by students. 1X1 technologies change the information itself – the degree of its up-to-date and diversity – and the way a teacher and students can access, process and represent information sources (Buckingham, 2013; Watson, 2001). Thus, in 1X1 classrooms teachers function as one of many information sources for their students.

However, changing the role of teacher and transferring the responsibility for learning to the students occur only if teachers recognize this as necessary for successful technology implementation and receive acceptable level of training and support (Johnson, 2008; Silvernail, 2011; Storz & Hoffman, 2013; Washuk, 2011). Four out of five key themes that emerged from interviews in a recent study that investigated 1X1 initiative in a middle school (Storz & Hoffman, 2013) were teacher-related: changes in teacher pedagogy, impact on classroom management, potential for improved teacher-students communications, and suggestions to address teacher professional development needs.

In addition to these changes in pedagogy and class management, in order to effectively integrate technology in the classroom, teachers need to develop inter-connections between their knowledge regarding technology, pedagogy, and learning content. Technological, pedagogical and content knowledge (TPACK) model (Mishra & Koehler, 2009) emphasizes the importance of the combination of TPACK in order to successfully implement technologies in educational institutions. The TPACK model integrates technological component into Shulman's (1986) concept of pedagogical content knowledge in order to address the growing implementation of digital technologies in educational settings and to explore the potential of these technologies (Mishra & Koehler, 2006). The TPACK model includes three primary types of knowledge (pedagogy, content, and technology), three intersections of the primary types (pedagogical & content knowledge, technological & pedagogical

knowledge, and technological & content knowledge), as well as the intersection of all three primary types (technological & pedagogical & content knowledge types).

According to the TPACK model, the use of educational technology shifts over time from focusing on primary knowledge types toward their integration. This argument received empirical evidence in Koehler, Mishra, and Yahya's (2007) study in which online course participants, who initially approached three primary knowledge types as separate concepts, demonstrated a more integrated approach after being engaged over time in instructional design activities.

The TPACK model is primary explored on pre-service teachers or among students in educational technology academic courses (for review, see Abbitt, 2011) and was only occasionally used to investigate technology integration in K-12 settings (Hofer & Swan, 2008). Technology implementation by experienced educators does not start from scratch – through time, experienced teachers have developed pedagogical and content knowledge. Thus, when a new technology is introduced, experienced teachers enrich their technological knowledge (TK) and afterwards incorporate it into the pedagogical and content knowledge they already have. This may raise additional difficulties, since technology may not "fit" pedagogical practices that these educators have developed over years of teaching. Similarly, they are expected to incorporate digital content available for their teaching subject, instead of printed content that they have successfully used for teaching the same curriculum. In other words, developing new habits and inter-connections between the new technological component and existing pedagogical practices and between the new technology and learning content in real classroom among experienced educators may be a more difficult process than linkages among the same three components developed in the same period of time by pre-service teachers or students in academic courses, as presented by most of the previous studies.

Another possible way to described teacher-led technological changes is based on the differences between the generations of teachers and students. According to Prensky's (2001) approach, teachers are largely "digital immigrants," while students are "digital natives" born into the world of digital technologies. Although this claim is widely cited in the research literature, it has received little empirical support (for review, see Bennett, 2012; Bennett, Maton, & Kervin, 2008). The similar is true for less widely used epithets attempting to capture the essence of the same phenomenon, for example, "Google Generation" (Rowlands et al., 2008), "Millenials" (Howe & Strauss, 2000), or "the Net Generation" (Tapscott, 1998). Later Prensky (2009) expanded this approach and proposed the term "digital wisdom" that relates to the wise use of technology, which is important to develop *regardless* of a user's generation.

Consistent with this approach, several studies have found that students had much to learn about using laptops effectively for learning purposes (for review, see Storz & Hoffman, 2013). For example, research by Lee and Spires (2009) revealed differences between in-school and out-of-school computer use. Thus, students may be proficient with personal and social uses of technology that they widely use outside classroom, but lack essential technological skills relevant for learning purposes. In terms of digital literacy skills (for review, see Eshet, 2012), we can presume that students may naturally develop digital socio-emotional skills (e.g. the ability of communicate effectively, share emotions, manage privacy in cyberspace) by interacting through social media, or naturally promote their real-time thinking (e.g. the ability of execute different tasks simultaneously, switch attention from one task to the other, rapidly change their angle of view and perspective of the digital environment, and respond to feedback in real-time) by playing digital games. However, many students may lack information digital skills (e.g. the ability to

assess effectively the quality and reliability of online information), and what Eshet described as reproduction digital skills (e.g. the ability to create new meanings or new interpretations by creatively combining preexisting, independent pieces of information – text, graphic, or sound). Lee and Spires (2009) suggested that teachers need to bridge this gap in order to build the learning-relevant technological competences of their students. It seems that 1X1 classroom setting is an appropriate learning environment in which teachers can help students practice school-relevant uses of technology and gradually develop their digital wisdom.

In professional settings we can refer to teachers' "digital wisdom" as a wise use of technology in order to promote and improve the quality of teaching and learning. It therefore seems that in the contexts of technology implementation in the classroom and teacher professional development, the development of "digital wisdom" by educators overlaps the integration of technological, pedagogical and content knowledge as described by the TPACK model. Both of them refer to the wise use of technological tools and digital content to improve pedagogical processes and the development of digital literacy of students.

Research goals and questions

This study explores the overlap between teachers' professional development according to the TPACK model (Mishra & Koehler, 2009) and the development of professional "digital wisdom" (Prensky, 2009) by teachers as a result of technology integration in 1X1 classroom. In addition, the study investigates changes in the role of teachers in 1X1 classroom.

The research questions are:

(1) Whether and to what extent 1X1 teaching and learning models promote inter-connection between the components described by the TPACK model, as well as enables teachers to develop "digital wisdom" – wise use of technology in order to promote pedagogy and strengthening learning-relevant digital skills of their students?
(2) Whether and to what extent 1X1 teaching and learning models change the role of teacher – from transmitting information to facilitating knowledge construction by students?

Method

Participants

The study included all 15 teachers of the four classes of seventh graders (12–13 years old), except students with special needs, in a large regional secondary school in Northern Israel. Thirteen of the teachers were women. The age range of the teachers was 30–52; the experience in teaching ranged from 6 to 30 years. The participants teach a variety of subjects: math, Hebrew (native) language and literature, English (second language), science, history, geography and bible. All the participants hold at least a Bachelor in Education (BEd) degree or general Bachelor (BA) degree and Teaching Diploma in their subject; eight of them (53.3%) hold Master degree or were graduate students.

The 1X1 initiative was a top-down decision of the school's principal. The participants of this study did *not* voluntarily choose to join the program – they became a part of 1X1

program because the seventh graders they taught joined this initiative. In order to enhance the teachers' motivation to incorporate laptops in their instruction and to compensate their investment of time and efforts in adapting lesson plans, all the teachers participating in the program received a free of charge laptop from the Ministry of Education. The laptops were designated for teachers' professional needs; thus, teachers dropping out from 1X1 program or leaving the school prior to three years in the program had to return their laptop.

General ICT skills varied significantly among the participants – most of the teachers define themselves as highly technology-oriented, while six (40%) of the participants described their digital skills as basic. All of the teachers stated that they use ICT for personal needs and for preparing their lessons; however none of them had previous experience of teaching in the 1X1 classroom model.

Before the implementation started, during the 2011–2012 academic year, all of the teachers had finished a standard professional development course (30 hours) focused on the implementation of laptops in their classroom. The course was obligatory; the instructor of this course and its syllabus were approved by the Ministry of Education supervision. The instructor holds a MA degree in education and has experience in ICT training and teacher mentoring. The program emphasized the correspondence of technological tools and digital content with pedagogical goals. During the implementation stage, the teachers continue to meet with their instructor every two weeks, individually or in teams of 2–3 teachers of the same subject. These meetings focused on supporting teachers in their use of laptops with students. In addition, the participants received on-demand pedagogical support from the program coordinator – a teacher working at the school that holds MSc degree and has finished an advance course for school coordinators of the 1X1 initiative.

Although the participants in the study were novice in the 1X1 classroom, the data were collected during the second year of the project in the investigated school. Thus, the participants were previously exposed to changes in the organizational learning environment and could learn from the experience of their colleagues already teaching in 1X1 classrooms.

Instruments

Previous studies used different research tools in order to assess development of technological, pedagogical and content knowledge described by TPACK. Quantitative studies used either self-report TPACK questionnaire (The Survey of Preservice Teachers' Knowledge of Teaching and Technology; Schmidt et al., 2009), or indicators to assess TPACK in lesson plans (Harris, Grandgenett, & Hofer, 2010).

Bennett et al. (2008) argued that qualitative research is needed to provide insights into the diversity uncovered by surveys in the discussion about what role the technology can and should play in education. Storz and Hoffman (2013) claimed that the voices of the teachers and their students provide a richness that does not necessarily come from survey data – their insights have the potential to influence in profound ways both the institutions implementing 1X1 initiative and educational policies. Consistent with the claims of these authors, the current study explores 1X1 initiative through phenomenological investigation within the qualitative research paradigm that combined observations of lessons and interviews with teachers.

Previous qualitative study used a coding scheme for lesson scenarios (Graham, Burgoyne, & Borup, 2010) of pre-service teachers, and qualitative content analysis of discourses in online courses (Koehler et al., 2007). Using criteria based on TPACK model in analysis of observation protocols and interviews with in-service teachers allows the exploration of *actual teacher behavior* during the lessons, beyond the self-report or planning instructional design of future lessons. This method adds ecological validity

(Bernard & Bernard, 2013) to the assessment of TPACK during ICT implementation by experienced teachers.

The observation protocol and interview questions were developed by the first and second authors and piloted during the first year of the implementation. See Table 1 for

Table 1. Examples of coding based on TPACK and digital wisdom frameworks.

Categories	Citations from observation protocols and interviews
TPACK framework	
TK	Observation: "The teacher asks students to open a word file she previously uploaded to the class website. She uses power point and the overhead projector to explain the task"
Technological–pedagogical knowledge	Interview: "I plan my lessons with laptops differently, since students have tools that enable them learn more actively" Observation: "Students use their laptops for the task and progress each one in his or her own rate. The teacher moves from one student to another, sees their progress, ask questions to monitor understanding and assist when her help is needed"
Technological–content knowledge	Interview: "Laptops make learning materials more perceptible. I often use illustration and simulations from digital textbooks. Sometimes I include in my lessons tasks based on virtual museum tours, authentic documents or maps"
TPACK	Observation: "Students enter via the link in the class website onto the online learning activity prepared by teacher … The activity is interesting and very well designed. It has two levels of difficulty, therefore less-advanced students are able to complete the obligatory level without feeling frustrated, while more advanced students continue to more challenging optional part of the activity"
Digital wisdom framework	
Developing digital wisdom by teachers	Interview: "As you could see during the observation, I could not open the video clip which I planned for the explanation part of the lesson. But this time I did not panic – I have changed the browser and the problem was fixed. Next time, if possible, I will download a clip and present it from the file" Observation: "The teacher uses overhead projector for explanations. This part is too long and most of the students lose attention and not listen to her. Since laptops are opened, some of them start playing; others search the internet; many communicate through Facebook" (R)
Developing digital wisdom by students	Observation: "One group of students explores another function of the application and explains to the teacher how it works. The teacher founds this function interesting and asks them to present it to the class. She promotes a short whole-class discussion about how this function can be used for improving students' projects. The presentation and discussion lasted in total 7 min; the group of students that discovered this new function looks motivated and empowered" Observation: "Students work on the collaborative task in small groups through shared documents on Google Drive. One of the students erases some sentences written by another student. The teacher unsuccessfully tries to deal with their anger and disappointment. One student from other group suggests using the history function, declining the change and letting the group to decide which of these sentences should be kept, edited or erased. Instead the teacher asks all the students to close their laptops" (R)

examples of citations from observation protocols and interviews transcriptions that represent different types of knowledge based on the TPACK model (Koehler & Mishra, 2009) and manifestation of digital wisdom based on Prensky's (2009) framework.

Non-participatory observations of the participants' lessons were conducted at the beginning and toward the end of the academic year. The observations focused on ways of teaching and learning during lessons, modes of using technological tools and digital content, pedagogical strategies and interaction modes between teachers and students and among peers. The purpose of the observations was to determine whether and to what extent teachers integrated the three components of the TPACK model – technological, pedagogical, and content knowledge in their teaching, as well as the way in which teachers develop "digital wisdom," that is, use the technology and digital content effectively, in order to promote pedagogy and strengthen students' learning-relevant digital skills.

Observation protocols were coded based on the elements of TPACK model. The criteria are based on:

(1) The appropriateness of technological tool/application selection and its use to achieve the lesson goals and the academic level of the students (TK),
(2) The appropriateness of instructional strategies to the characteristics of the selected technological tool (technological and pedagogical knowledge (TPK)),
(3) The appropriateness of digital content selection and use (technological and content knowledge (TCK)),
(4) The "fit" of technology, pedagogy and content (TPACK).

Semi-structured retrospective interviews were conducted immediately after the observations. Semi-structured interviews were chosen as a research tool in order to provide the opportunity for teacher's voices, as well as to triangulate the observation data, which shows *actual* changes in pedagogy, with *teachers' perceptions* of changes in teaching and learning in 1X1 classrooms and on factors that promote or inhibit these changes.

The interview goal was to learn what are the teachers' perspectives about their use of the laptop in the classrooms, their perceptions of how having the laptops affected student learning, and how their pedagogical practices may have changed as a result of the 1X1 initiative. The interviews contained eight main questions focused on the teacher's point of view regarding (1) changes in teaching and learning processes in 1X1 classroom, (2) changes in the role of teacher and learners and in ways of classroom management, (3) the role of technology and integration of TPACK types in the lesson observed, and (4) the ability of the teacher to promote and develop students' digital wisdom. In order to explore changes over time the same questions were used in the interviews in both periods of data collection.

Procedure

The research was conducted during the 2011–2012 academic year in a large regional secondary school (7th–12th grades) in northern Israel, which had four classes of seven graders, during the second year of the 1X1 implementation at the school level and the first year of implementation by the study participants.

Each of the 15 teachers was observed twice: once at the beginning of the first term (October–November) and a second time toward the end of the second term (April–May). Thus there was at least a six month lap between the two observations. The observations for each teacher were at the same class and same subject. All the observations were an hour and a half long. Interviews were conducted immediately after the lesson observed –

a total of 30 observations and 30 interviews. Informed consent was obtained at the data collection and we assured the teachers that their data would remain anonymous for any third party, including the school principal and the Ministry of Education. The interviews lasted about an hour; they were audiotaped and then transcribed.

Observation protocols and interview transcriptions were coded and analyzed using the qualitative content analysis technique (Bryant & Charmaz, 2012). Categories were formed by the third author through iterative reading of a sample of the observation protocols and interview transcriptions and then applied to the entire set of data. The coding categories were exclusive – each statement could be coded in one category. The categories were the same for the interviews and observational data in both periods of data collection. Twenty five percent of randomly chosen transcripts were re-estimated by the first author. The inter-rater reliability was high, Cohen's $\kappa = .89$.

The categories were formed from observation protocols and interviews transcriptions that represent different types of knowledge based on the TPACK (Koehler & Mishra, 2009) and digital wisdom (Prensky, 2009) frameworks (see Table 1). The TK category included themes of the 1X1 class management and general technical issues. The pedagogical knowledge (PK) category contained constructivist learning and student collaboration themes (without the involvement of technology). The TPK category included the themes of using technology to promote teacher-students and student-student interaction, technology-enabled differentiated learning, technology-enhanced presentations, e-collaboration, and e-communication. The TCK category contained the use of digital content and digital content development themes. Themes corresponding to the TPACK category were found neither in lesson observations nor in interview with teachers in both periods of data collection. Developing digital wisdom by teacher category included themes of technological class management, general technological issues, using technology to promote teacher-students and student-student interactions, technology-enhanced presentations, e-collaboration, and e-communication of students. Developing digital wisdom by student category contained themes of student developing e-collaboration skills and students sharing technological solutions with teachers. As can be seen from the themes presented above, the categories based on the TPACK and digital wisdom frameworks were significantly overlapped.

Results and discussion

This section first presents and discusses findings regarding the development of TPACK and digital wisdom in 1X1 classrooms. Following that, the section discusses findings in regard to changes in the role of the teacher as a result of technology implementation.

Technological, pedagogical, and content knowledge in 1X1 classrooms

Table 1 presents examples of citations from observation protocols and interviews transcriptions based on the TPACK (Koehler & Mishra, 2009) and digital wisdom (Prensky, 2009) frameworks.

Regarding the construction of *TK* (Mishra & Koehler, 2009), at the beginning of the academic year various technology-related problems in *class management* and *general technical issues* were observed, for example, laptop batteries are not charged, forgotten usernames or passwords for educational websites and LMS, applications or network failures, and slow content loading. Follow-up interviews revealed both the fear from technical problems and the luck of TK due to the lack of experience in 1X1 classroom. These results are consistent with a previous study (Storz & Hoffman, 2013) showing that in the early phase of

a 1X1 initiative most of the teachers feel technologically unprepared, frustrated, and out of their comfort zone.

> My knowledge of computers and application is limited … I have problems with technical issues … I'm afraid I would not be able to handle this area …
>
> You're trying to enter a website – and it uploads too slow … Students who need to charge their battery start changing places with those sitting near power outlets. This interrupts the lesson and takes precious time!

Toward the end of the academic year, significant improvements were observed in the capability of teachers to resolve or avoid technological class-management problems. Most of the teachers used applications and facilitated their use by students during the lessons in a very natural way. In the follow-up interviews they expressed confidence in 1X1 class-management.

A significant improvement of TK showed those teachers whose starting point in terms of TK was relatively low. In contrast, five teachers (33%) with a broad initial TK neither showed significant progress in lesson observations nor reported in interviews significant improvement in this area toward the end of the year. It appears that the low level of TK is not an obstacle for teachers. Within an appropriate professional development program and relatively short teaching experience in 1X1 classroom educators with a low technological start-point can successfully close the gap with their more advanced colleagues.

Technological class management and general technology-related themes were coded as both TK, based on the TPACK model, and digital wisdom by teacher category, based on the digital wisdom framework. The results show that toward the end of the first year of 1X1 initiative 14 out of 15 teachers demonstrated accepted level of TK and technology-related digital wisdom.

Regarding PK (Mishra & Koehler, 2009), since the participants were experienced teachers, as expected, the interviews did not reveal pedagogical difficulties. Surprisingly, observations both in the beginning and toward the end of the academic year showed relatively few examples of teachers facilitating the construction of knowledge or collaborative learning of their students (without the involvement of technology). The results showed significant discrepancies between the actual PK demonstrated during the lessons and the perceived PK expressed in interviews with 10 out of 15 teachers. This result suggests that technology-related professional development courses and training should emphasis pedagogy in order to insure successful implementation and meaningful use of technologies.

> During the professional development course we have studied about the importance of collaborative learning. But I did not implement it in the classroom yet … These things require more effort.

The themes of constructivist learning and student collaboration were coded as the PK category based on the TPACK model only, without the equivalent in the digital wisdom framework. No changes were observed in the PK category between the first and the second periods of data collection.

Concerning the conjunction of *technology and pedagogy* (TPK; Mishra & Koehler, 2009), observations showed that the 1X1 classroom provides many opportunities for interpersonal dialogs between teacher and individual students (rather than teacher–whole-class interactions), strengthens their relationships and promotes students' understanding of a

subject content. Consistent with previous studies (Storz & Hoffman, 2013; Zucker & King, 2009), it seems that the 1X1 model enables differential learning and provides assistance to students who need it.

> Those students who know what to do are working on their own and I am available to those who need assistance – I can watch how they progress within a task, let them comment and ask questions, and provide explanations in order to close gaps in their knowledge.

In addition, 1X1 technology promotes collaboration among students and topic-related peer dialogs that, as mentioned above, were almost absent in parts of observed lessons without technology assistance.

> Observation protocol: "The teacher directs students to a collaborative online activity that she prepared using a shared document in the Google Drive platform. They open the activity easily and start working; every three students work collaboratively on the same document, each from his or her laptop … Students seem to be immersed in the collaborative task …
>
> Students conduct many short task-related dialogues. Roughly one-fifth of the students consult their neighbors regarding the task; they point to specific parts of the shared document opened on the peer's laptop and receive more extensive explanations."

In terms of Vygotsky's (1978) socio-constructivist approach, these two examples show that the 1X1 model increases opportunities for on-topic dialogs and promotes students within their Zone of Proximal Development through the support of teachers or more advanced peers.

However, although laptops were explicitly used for learning purposes, most teachers think that students perceived the device primarily as a tool for social networking and playing digital games instead of a learning tool.

> The kids love laptops, but not for learning purposes. They use the technology mostly for fun, for example, Facebook.
>
> Students feel that laptops are designed to satisfy their leisure needs and less to support learning activities. They use their laptop mainly for updating Facebook profiles, playing games or listening music.

This opinion held by teachers is consistent with the results of Lee and Spires (2009) who revealed differences between in-school and out-of-school technological proficiency of students. However, teachers in the current study did not follow Lee and Spires' recommendation of developing skills relevant for learning purposes of their students. Moreover, most of the teachers sometimes opposed to the medium itself and did not understand that this technology, when used appropriately, promotes pedagogical goals, for example, produce opportunities for peer interactions and support, and increases the amount of students' writing. These results suggest the importance of teachers' values and beliefs in changing and maintaining their pedagogical practices.

> The kids are clearly prefer typing to writing, sometimes it's just laziness, but they MUST also write … .
>
> Interviewer: "Do you allow task-related online communication among students during the lesson?"
>
> Teacher: Online communication? No way! Obviously, this is not allowed. These applications are closed during the lessons.

Consistent with the results of teachers and students' interviews in Storz and Hoffman's (2013) study, our observations showed overuse of presentation tools by almost all the participants. Moreover, many of these presentations were designed quite ineffectively. For example, many presentations were over packed with text that was read during the lesson. Reading text from the screen quickly leads the audience to lose their attention (Mayer & Moreno, 2003) and our observations showed that when teachers read explanations from the slides students were mostly engaged in activities unrelated to the lesson.

Regarding the content knowledge, class observations revealed that, as expected, teachers were proficient in the content they teach. However, examination of the integration of *TCK* (Mishra & Koehler, 2009) showed that teachers continue widely using familiar printed textbooks or other printed learning materials. Despite the school subscription to relevant digital content from different providers recommended by the Ministry of Education, many teachers rarely used available digital textbooks and digital learning materials. This digital content was not presented to teachers during the professional development program and it seems that they have no motivation and time to invest in searching digital content by themselves and evaluating its appropriateness to their students. On the other hand, observations revealed examples of department coordinators and few innovative teachers who develop or significantly adapt existing digital learning materials and share them with colleagues. The review of research finding from a number of 1X1 initiatives (Pennuel, 2006) identified that getting help form colleagues or coaches can be very helpful for successful 1X1 implementation. We would recommend using more of these available resources during the implementation process.

A significant integration between TPACK, that is, the use of digital content and technological tools for empowering teaching and enhancing the learning processes, has not been observed (yet) during the 2011–2012 school year. This is not surprising, since research examined teachers in their first year teaching in 1X1 classroom. The result is consistent with a previous study showing that the TPACK combination may happen only at a later stage of technology implementation (Koehler et al., 2007). Similarly, if we see our teachers as learners of new technologies and applications, our results can be explained in terms of Sharpe and Beetham (2010) developmental model. Consistent with the model, as learners of new tools, teachers make informed choices about how to use technologies relatively late – in the third developmental stage, after they (1) have access to a range of technologies, resources and services and (2) increase their confidence and can use their technical, information, communication, learning and organizational skills in a variety of learning contexts.

Changes the role of the teacher in 1X1 classroom

Consistent with the research literature (see Silvernail, 2011), the results of the interviews indicates that promoting or inhibiting the process of change in teaching in 1X1 classroom is related to the changing the role of teacher "from sage on the stage to guide on the side" (King, 1993). Toward the end of the academic year, some of the teachers report a reduction in whole-class teaching, thus allowing more time for team work or independent learning of students assisted by laptops.

Similarly, the second round of observations showed signs of successful classroom management and facilitation of students' independent learning with computers.

> Observation protocol: After a short explanation, students work independently on their laptops. They are concentrated on the task. Teacher moves from one student to another. They consult her and ask task-related questions. She helps them, asks scaffolding questions and sometimes

> correct errors. The teacher looks relaxed and comfortable when moderates 1X1 independent learning of her students.

Observations showed that students like to help teachers cope with technological issues. It happened in 9 out of 15 lessons of the second observation round when teachers allowed their students to solve technology-related problems and help the teacher using digital tools or navigating in digital environments. In this lessons cooperation of students and their responsibility for learning increased.

However, most teachers toward the end of the academic year still defined their teaching style as essentially "frontal" whole-class teaching. The need for class control was mentioned in the context of classroom management in 38 out of 60 interviews conducted. Thus the image of "a good teacher" presented by the participants was an image of the teacher who is able to control his or her class. "Control" was perceived as teacher-centered teaching without interruptions. Therefore many of the participants used the overhead projector, which support whole-class teaching, more than promoted individual or small-group learning of students through their laptops. These results are somehow different from Storz and Hoffman (2013) findings that, although whole-class presentations were prevalent in teachers' repertoire, they reported more individual and team learning of students than previously. This difference in the results can be explained by the focus of the previous study on teachers' voices, while our study tried to balance between the analysis of actual teaching behavior and its interpretation by teachers.

Furthermore, teachers who are very successful in frontal teaching tend to oppose to changing their role and giving up lecturing. It seems that these teachers see no reasons to change their teaching style. They feel that students having a laptop in class negatively affect the classroom management and their ability to control students' learning.

> [In traditional learning] there was more control over students' attention and focus.
>
> I love to play a central role. I feel more confident when I teach and they listen. It is difficult for me to release and allow students work independently.
>
> I feel uncomfortable when not using the class projector. When they work on laptops, I feel a lack of control, since I can't monitor student work and writing. When I can't see their screens, I don't know if they are working on a task or what applications they are really using … Do they really work independently or do some students work, share their outcomes with friends and others just cheat?

Observations revealed that working with laptops, students indeed produced greater restlessness in class than during frontal slots. It may be due to the fact that students work independently or in small groups and consult more with their peers. Most of the teachers indicate that restlessness of students is difficult to handle and it leads them to feel lack of control. These results are consistent with Storz and Hoffman's (2013) report that in 1X1 classroom there are more off-task activities difficult to monitor.

> There is less concentration, more noise. I have little control over what happens in my classroom.

On the other hand, in 6 out of 15 interviews of the second round teachers stated a positive aspect of this "back ground noise" – they notice the contribution of peer interactions on progress of less advanced students, who receive instant support just-on-time, and on self-esteem and learning motivation of their more knowledgeable peers. This result is consistent with Vygotsky's (1978) concept of Zone of Proximal Development – ZPD, according to

which progress in learning is stimulated by interaction with more advanced others – experts or peers.

> There is no doubt that 1X1 lessons are significantly less silent, but they are also much more energetic – most of the time students are actively involved.
>
> I think the noise level in the classroom is higher … but I do not see it negatively, it's a positive noise and a by-product of using laptops productively for learning.

In summary, shortening explanations, giving up lecturing, changing classroom management, allowing students to work independently with laptops and helping other students, realizing that noise in a 1X1 classroom can be an indicator of productive learning and peer task-related interactions seem to be positive signs of teachers gradually developing professional digital wisdom.

Conclusions and implications

In this paper we pointed out the overlap between the development of "digital wisdom" (Prensky, 2009) by teachers in the context of implementing technology in 1X1 classrooms and their professional development as described by the TPACK model (Mishra & Koehler, 2009). The findings show signs of increasing teachers' awareness of the importance of integrating technology in teaching and learning on a daily basis, evidences of changing the role of teachers from lecturing to moderating student learning, and a significant increase of teachers' TK. There are also some evidences of connections between TPK, such as the use of laptops for promoting collaborative learning or individual learning of their students. In addition, the results showed various examples of connections between the TCK, such as the use of digital content available and even a few examples of preparing digital learning materials by teachers themselves and sharing these materials with colleagues.

However, despite the availability of laptops and digital content, many teachers still dedicate much of their teaching time to whole-class teaching based on familiar printed textbooks and traditional learning materials. Their use of technology is mainly based on what is called "technical interactivity" *by teachers* (Blau, 2011; Kennewell, Tanner, Jones, & Beauchamp, 2008), that is, interaction of teachers themselves with presentation technology – overhead projector, instead of promoting technical interactivity *by students* – using their laptops for accessing, processing and presenting information and educational digital content or instead of "pedagogical interactivity" – teacher-student and student-student discussions of learning topics. Lack of evidence for the integration of technological, pedagogical and content knowledge – TPACK, clear preference for "interactive whole-class technologies" (Beauchamp, Kennewell, Tanner, & Jones, 2010) by teachers for presentations over using 1X1 laptops for accessing, processing and presenting information by students, reading text from the screen during presentations, resisting the replacement of writing for typing, and prohibiting digital communication among students during lessons for learning purposes – all these are signs that, in Prensky's (2009) terms, teachers still stay in the early stages of developing a professional "digital wisdom."

It appears that the availability of technology in the classroom in general and in 1X1 classroom in particular is insufficient in order to develop "digital wisdom" by educators. The effective integration of technology, pedagogy and content by teachers, their ability to critically evaluate digital content available and willingness to create digital content and share it with colleagues, their confidence in using technology wisely for teaching purposes, in order to promote life-long learning and develop students' digital literacy are skills

that can grow and improve in a long-term professional development process, while supported by educational policies, and promoted by school principals and supervisors.

An evaluation of learning in the Israeli education system is over-focused on standardized tests excluding the measurements of digital literacy skills. Consequently, teachers are obsessed by "covering content" and are not sufficiently motivated to promote technology-assisted learning and develop the digital literacy of their students. To adapt education systems for the twenty-first-century needs, we need to encourage educational decision-makers and curriculum developers to more actively integrate digital content in the curricula, and adapt evaluation of learning process and outcomes to the reality of information available to everyone anytime.

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Notes on contributors

Dr. Ina Blau holds a Ph.D. in E-Learning and Cyber-Psychology. She is a Senior Lecturer in the Department of Education and Psychology at the Open University of Israel. Her research interests include social aspects of e-communication and e-leadership, integration of innovative technologies in K-12, academia and organizations, digital literacy skills, online privacy in social networking, and psychological ownership in e-collaboration. http://www.openu.ac.il/Personal_sites/ina-blau/

Dr. Yehuda Peled holds a Ph.D. in Technology and Science Education. He is a Senior Lecturer and the Head of the Information Studies Department at the Western Galilee College, Israel. His research interests include the use of collaborative environments in teaching and learning, various aspects of online and F2F academic dishonesty, cyber-bullying, and organizational aspects of technology adoption in education.

Anat Nusan holds a M.Ed. in Educational Leadership. She works as teachers' mentor in the Israeli Ministry of Education and teaches in a regional school in Northern Israel. Her main interests are teacher professional development and training, educational technology, and educational leadership.

References

Abbitt, J. T. (2011). Measuring technological pedagogical content knowledge in preservice teacher education: A review of current methods and instruments. *Journal of Research on Technology in Education*, *43*(4), 281–300.

Addis, D., & Falk, C. (2010). Literature review: A literature review on one to one laptop program effects on student. *ETEC 500 – Research Methodology in Education*. Retrieved June 23, 2013, from http://blogs.ubc.ca/addisetec565/files/2010/08/DAddisFA1.pdf

Beauchamp, G., Kennewell, S., Tanner, H., & Jones, S. (2010). Interactive whiteboards and all that jazz: The contribution of musical metaphors to the analysis of classroom activity with interactive technologies. *Technology, Pedagogy and Education*, *19*(2), 143–157.

Bebell, D., & Kay, R. (2010). One to one computing: A summary of the quantitative results from the Berkshire wireless learning initiative. *Journal of Technology, Learning, and Assessment*, *9*. Retrieved June 23, 2013, from http://ejournals.bc.edu/ojs/index.php/jtla/article/view/1607/

Bebell, D., & O'Dwyer, L. M. (2010). Educational outcomes and research from 1:1 computing settings. *Journal of Technology, Learning, and Assessment*, *9*. Retrieved June 23, 2013, from http://escholarship.bc.edu/jtla/vol9/1/

Bennett, S. (2012). Digital natives. In Z. Yan (Ed.), *Encyclopedia of cyber behavior* (Vol. 1, pp. 212–219). Hershey, PA: IGI Global.

Bennett, S., Maton, K., & Kervin, L. (2008). The "digital natives" debate: A critical review of the evidence. *British Journal of Educational Technology*, *39*(5), 775–786.

Bernard, H. R., & Bernard, H. R. (2013). *Social research methods: Qualitative and quantitative approaches*. Florida, FL: Sage.

Blau, I. (2011). Teachers for "smart classrooms": The extent of implementing of an interactive whiteboard-based professional development program on elementary teachers' instructional practices. *Interdisciplinary Journal of E-Learning and Learning Objects*, *7*, 275–289.
Blau, I., & Peled, Y. (2012). Teachers' openness to change and attitudes towards ICT: Comparison of laptop per teacher and laptop per student programs. *Interdisciplinary Journal of e-Learning and Learning Objects*, *8*, 73–82.
Bryant, A., & Charmaz, K. (2012). Grounded theory and psychological research. In H. Cooper, P. M. Camic, D. L. Long, A. T. Panter, D. Rindskopf, & K. J. Sher (Eds.), *APA handbook of research methods in psychology, vol 2: Research designs: Quantitative, qualitative, neuropsychological, and biological* (pp. 39–56). Washington, DC: American Psychological Association.
Buckingham, D. (2013). *Beyond technology: Children's learning in the age of digital culture*. Bodmin, Cornwall: John Wiley & Sons.
Eshet, Y. (2012). Digital literacy: A revised model. *Issues in Informing Science and Information Technology*, *9*, 267–276.
Graham, C. R., Burgoyne, N., & Borup, J. (2010). The decision-making processes of preservice teachers as they integrate technology. In C. Crawford, D. A. Willis, R. Carlsen, I. Gibson, K. McFerrin, J. Price, & R. Weber (Eds.), *Proceedings of the society for information technology & teacher education international conference 2010* (pp. 3826–3832). Chesapeake, VA: AACE.
Grimes, M., & Warschauer, M. (2008). Learning with laptops: A multi-method case study. *Journal of Educational Computing Research*, *38*, 305–332.
Harris, J., Grandgenett, N., & Hofer, M. (2010). Testing a TPACK-based technology integration assessment rubric. In C. Crawford, D. A. Willis, R. Carlsen, I. Gibson, K. McFerrin, J. Price, & R. Weber (Eds.), *Proceedings of the society for information technology & teacher education international conference 2010* (pp. 3833–3840). Chesapeake, VA: AACE.
Hofer, M., & Swan, K. O. (2008). Technological pedagogical content knowledge in action: A case study of a middle school digital documentary project. *Journal of Research on Technology in Education*, *41*(2), 179–200.
Howe, N., & Strauss, W. (2000). *Millennials rising: The next great generation*. New York, NY: Vintage.
Johnson, J. (2008). Can a laptop change how the world teaches? *Knowledge Quest Maps: The Why of Where*, *36*, 71–73.
Kennewell, S., Tanner, H., Jones, S., & Beauchamp, G. (2008). Analysing the use of interactive technology to implement interactive teaching. *Journal of Computer Assisted Learning*, *24*(1), 61–73.
King, A. (1993). From sage on the stage to guide on the side. *College Teaching*, *41*, 14–16.
Koehler, M., & Mishra, P. (2009). What is technological pedagogical content knowledge (TPACK)? *Contemporary Issues in Technology and Teacher Education*, *9*(1), 60–70.
Koehler, M., Mishra, P., & Yahya, K. (2007). Tracing the development of teacher knowledge in a design seminar: Integrating content, pedagogy and technology. *Computers and Education*, *49* (3), 740–762.
Lee, J., & Spires, H. (2009). What students think about technology and academic engagement in school: Implications for middle grades teaching and learning. *AACEJ*, *17*, 61–81.
Mayer, R. E., & Moreno, R. (2003). Nine ways to reduce cognitive load in multimedia learning. *Educational Psychologist*, *38*, 43–52.
Mishra, P., & Koehler, M. (2006). Technological pedagogical content knowledge: A framework for teacher knowledge. *Teachers College Record*, *108*(6), 1017–1054.
Mishra, P., & Koehler, M. (2009). Using the TPACK framework: You can have your hot tools. *Learning & Leading with Technolog*, *36*(7), 14–18.
Oppenheimer, T. (2003). *The flickering mind: The false promise of technology in the classroom and how learning can be saved*. New York, NY: Random House.
Papert, S. (1996). *The connected family: Building the digital general gap*. Atlanta, GA: Long Street Press.
Pennuel, W. R. (2006). Implementation and effects of one-to-one computing initiatives: A research synthesis. *Journal of Research on Technology in Education*, *38*(3), 329–348.
Prensky, M. (2001). Digital natives, digital immigrants. *On the Horizon*, *9*(5). Retrieved June 23, 2013, from http://www.marcprensky.com/writing/prensky%20-%20digital%20natives,%20digital%20immigrants%20-%20part1.pdf
Prensky, M. (2009). *H. sapiens* digital: From digital immigrants and digital natives todigital wisdom. *Journal of Online Education*, *5*(3). Retrieved June 23, 2013, from http://innovateonline.info/pdf/

vol5_issue3/H._Sapiens_Digital-__From_Digital_Immigrants_and_Digital_Natives_to_Digital_Wisdom.pdf

Rowlands, I., Nicholas, D., Williams, P., Huntington, P., Fieldhouse, M., Gunter, B., & Tenopir, C. (2008). The Google generation: The information behaviour of the researcher of the future. *ASLIB Proceedings*, *60*(4), 290–310.

Schmidt, D. A., Baran, E., Thompson, A. D., Mishra, P., Koehler, M. J., & Shin, T. S. (2009). Technological pedagogical content knowledge (TPACK): The development and validation of an assessment instrument for preservice teachers. *Journal of Research on Computing in Education*, *42*(2), 123–149.

Sharpe, R., & Beetham, H. (2010). Understanding students' uses of technology for learning: Towards creative appropriation. In R. Sharpe, H. Beetham, & S. De Freitas (Eds.), *Rethinking learning for the digital age: How learners shape their experiences* (pp. 85–99). London: Routledge.

Shulman, L. S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher*, *15*(2), 4–14.

Silvernail, D. L. (2011). *A middle school one-to-one laptop program*. Portland, ME: Maine Education Policy Research Institute, University of Southern Maine.

Solhaug, T. (2009). Two configurations for accessing classroom computers: Differential impact on students critical reflections and their empowerment. *Journal of Computer Assisted Learning*, *25*, 411–422.

Storz, M. G., & Hoffman, A. R. (2013). Examining response to a one-to-one computer initiative: Student and teacher voices. *RMLE Online: Research in Middle Level Education*, *36*(6), 1–18.

Tapscott, D. (1998). *Growing up digital: The rise of the Net Generation*. New York, NY: McGraw-Hill.

van't Hooft, M., Swan, K., Cook, D., & Lin, Y. (2007). What is ubiquitous computing? In van't M. Hooft & K. Swan (Eds.), *Ubiquitous computing in education: Invisible technology, visible impact* (pp. 3–18). Mahwah, NJ: Erlbaum.

Vygotsky, L. S. (1978). *Mind in society.* Cambridge, MA: Harvard University Press.

Washuk, B. (2011). Years after laptops come to Maine schools, educators say technology levels playing field for students. *Maine Sun Journal*. Retrieved June 23, 2013, from http://www.sunjournal.com/state/story/988012

Watson, D. M. (2001). Pedagogy before technology: Re-thinking the relationship between ICT and teaching. *Education and Information Technologies*, *6*(4), 251–266.

Zucker, A. A., & King, K. E. (2009). Teaching with laptops. *The Science Teacher*, *76*, 22–26.