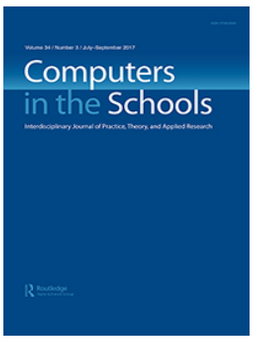

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Which Pedagogical Parameters Predict the General Quality of ICT Integration from the Perspective of Elementary School Leaders?

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ABSTRACT

Technological changes in the digital age require schools to integrate innovative technologies in learning and the curriculum. This study analyzes data collected from elementary schools toward the end of the second and the third years of the national program for the gradual integration of ICT in Israeli schools. The study examines how school principals and ICT coordinators assess the systemic changes that have occurred in their schools. The parameters explored were collaboration (intraschool vs. interschool collaboration), digital content (using vs. designing digital content), and e-communication (within the teaching staff vs. between staff and families). An online questionnaire was distributed to the entire district of the Ministry of Education. The analysis was carried out on a total of 358 schools. Regression analysis showed that intraschool collaboration, digital content use and design, pedagogical update of class websites, and e-communication within the teaching staff explained 47.7% of variance in the general quality of ICT integration. It seems that school ICT leaders assess the general quality of ICT integration according to internal factors—in terms of collaboration within their schools and online interactions with colleagues—rather than external factors—collaborative activities between schools or e-communication with students and parents.

KEYWORDS

Collaboration within and between schools; digital content use and design; e-communication between teachers; general quality of ICT integration; learning metaphors; school ICT leadership; student and parents

Technological changes in the contemporary digital age challenge schools to integrate innovative technologies in learning and teaching processes and require the teaching staff to acquire digital literacy competence (Kozma, 2010; Eshet-Alkalai, 2012). Since 2010, the Israeli education system has implemented a national program called "Adjustment of the Education System to the 21st Century." The program includes the integration of ICT in the curriculum on a daily basis, technology-enabled collaboration within and between schools, the use of digital-learning materials, connections between classroom and homework activities through class websites and learning management systems (LMSes), and the promotion of digital communication among teaching staff, students, and parents (Israeli Ministry of Education, 2014b).

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The elements of the program and the implementation process were conducted in a standardized top-down policy. However, the program also empowered internal school authorities through technological pedagogical professional development courses for school principals and ICT coordinators. School principals were responsible for promoting ICT integration at an organizational level. School ICT coordinators were chosen for leading ICT implementation in their organization. These coordinators, supported by school principals, encourage local ICT initiatives and activities and provide technological pedagogical support to their colleagues.

In this study we examine how the leaders of technological integration in educational institutions-school principals and ICT coordinators-perceive the systemic technological pedagogical changes occurring in their schools. The study was conducted in the entire district at the end of the second and the third years of a national ICT integration program in Israeli elementary schools. We examine whether and how the relationships between the various components of this initiative (e.g., collaboration type, digital content use and design, e-communication mode) promoted broad and substantial ICT integration over time.

Literature review

This section first discusses how the implementation of innovations evolves over time. Following that, we discuss different components of meaningful implementation of ICT at schools: collaborative learning within and between educational institutions; the use of existing digital-learning content and its design by teachers; as well as e-communication within a teaching staff and between teachers, students, and parents.

Integration of innovations in education over time

Time is an important component of technological implementation in general and implementation in educational institutions in particular. Rogers' (2003) Diffusion of Innovation model seeks to explain how new technological ideas spread through organizations' cultures over time. This model suggests main elements that influence the spread of innovations. The elements are complexity of the innovation, communication channels between members that distribute the innovation, time required to absorb the innovation, and a social system that assists in solving problems when using the innovative tools. According to Rogers, an organization does not change until the individuals within it actually implement the innovations, each person at his or her own pace. This pace is different for each person and involves personal growth in self-confidence and competence (Hall, 2013).

Rogers (2003) defined five categories to classify the varying pace in the adoption of innovations by individuals in the organizations. According to Rogers, the continuum of innovation adoption is normally distributed in the population and ranges in

a bell curve from Innovators (2.5%) and Early Adopters (13.5%), to Early Majority and Late Majority (34% each), and finally to Laggards (16%).

Peled, Kali, and Dori (2011) have adapted Roger's general Diffusion of Innovation model to the specific context of teaching and learning. They defined four categories of school principals and teachers according to the degree of their readiness to adopt technological innovations. The organization processes leading to the adoption of innovation described according to the general Diffusion of Innovation model by Rogers (2003) and in Peled and colleagues' school-specific approach are consistent with one another. In the first phase, Initiators and Path-Finders, who are comparable to Innovators and Early Adopters in Rogers' model, are the first teachers who are exposed to the new technological ideas, who understand the need for the innovation in the organization and its potential contribution to teaching, learning, and school effectiveness. This awareness creates positive attitudes towards the innovation and raises motivation to use it (Hall, 2013). The second phase in the adoption process occurs when the innovation process spreads to the Followers and Conformists, who can be seen as an equivalent of the Early Majority in Rogers' model. At the last phase of Peled and colleagues' model, the teachers defined as Evaders-analogous to the Late Majority in the Diffusion of Innovation model-finally join the innovation process. At this point the vast majority of the school staff realizes the benefits of the innovation to their organization in general and to their professional development in particular. As a result, integrated technological tools and appropriate pedagogical methods become an essential part of the school culture, and new teachers who join the school perceive them as being a natural way of teaching and learning (Hauge & Norenes, 2015; Shamir-Inbal & Kali, 2009). According to Peled et al. (2011), the remaining type of teachers, Antagonists, who correspond to Laggards in Rogers' model, will resist the integration of the new technology in the instructional process even after the entire organization has adopted it. But as technology becomes an integral part of the school culture, these teachers will remain on the margins of schooling (Shamir-Inbal & Kali, 2009). The integration of innovative technology in schools is a complex process, and its success depends on the involvement of the school leadership and the cooperation of the teaching staff (Dimmock, Kwek, & Toh, 2013; Thurlings, Evers, & Vermeulen, 2014). For successful integration of innovations in a school culture, reexamination of educational visions, organizational norms, and pedagogical perspectives as well as a reevaluation of educational design, is needed (Shamir-Inbal & Kali, 2009; Gunn, 2010; Dirckinck-Holmfeld, Hodgson, & McConnell, 2012).

Beyond the interpersonal differences highlighted by Rogers' (2003) and Peled and colleagues' (2011) models and beyond the effect of the organizational culture emphasized by Shamir-Inbal and Kali (2009), the same teachers can adopt different technological tools or functions at a different pace and rate (Blau & Hameiri, 2012; Blau, Weiser, & Eshet-Alkalai, 2016; Thurlings et al., 2014). The integration process is deep and may occur at a faster rate in relation to parameters that were prioritized higher by the school administration and are thus perceived as

a requirement by teaching staff (Blau & Presser, 2013). It seems that the educational vision and leadership are highly important in the integration of technological innovations.

Digital pedagogical design as a parameter of teachers' professionalism

Teachers' abilities, attitudes, and beliefs affect the efficiency of ICT integration in the education system (Blau & Peled, 2012). In order to maximize the potential impact of technology on teaching and learning, teachers need to perceive the integration of technology in education as an integral part of developing their professional knowledge (Wang, Hsu, Reeves, & Coster, 2014). The TPACK framework (Technological, Pedagogical and Content Knowledge) is one of the most widely accepted frameworks for describing teachers' knowledge in the context of technological integration (Mishra & Koehler, 2006). This framework emphasizes the importance of connections between technological, pedagogical, and content types of teachers' knowledge in order to optimize the integration of digital technologies for enhancing student-centered learning pedagogy (Blau, Peled, & Nusan, 2014; Koh, Chai, Hong, & Tsai, 2014). These connections are essential for effective coping with the cognitive aspects needed for integrating technologies into school systems and covering the entire range of knowledge that teachers should master (Avidov-Ungar & Eshet-Alkalai, 2014; Blau, 2011b).

One of the most important manifestations of teachers' professional knowledge is the ability to adjust existing teaching activities to the curriculum and to design new technologically-enhanced activities according to pedagogical goals and students' needs (Bruns, 2008). When designing lesson activities, teachers are faced with instructional problems that require the generation of solutions by synthesizing between various elements of their TPACK (Koh et al., 2014; Shamir-Inbal & Blau, 2014, 2016a; Wang et al., 2014). Thus, teachers with little experience of teaching with ICT must first gain the understanding of how digital resources can enrich teaching and learning. At the novice level, teachers usually use existing digital content as is and are less likely to adapt digital resources to students' needs or to design their own digital activities (Koh et al., 2014; Peled, Blau, & Grinberg, 2015). At the second stage, teachers are more open to designing learning activities in addition to consuming existing digital content. These digital activities involve the use of applications in a way that emphasizes problem solving, high-order thinking skills, collaboration, and students' interactions with content, peers, and teachers (Shamir-Inbal & Kali, 2007a).

Bruns (2008) claimed that Web 2.0 applications and social networks permeate the boundaries between producers and consumers of digital content and increase willingness to contribute information and content. Therefore, this author introduces the term *produsage*, referring to the high willingness of digital technology users to contribute their own content. In an educational setting, the produsage by teachers may refer to designing digital learning materials (Blau & Shamir-Inbal, 2017). The design of digital learning materials creates professional challenges and enables teachers to develop the ability to integrate technologies in teaching and learning

in a meaningful way, thus enhancing teachers' professional self-efficacy (Ertmer, & Ottenbreit-Leftwich, 2010).

E-Communication as a parameter of ICT integration

Effective digital communication is an essential skill for teachers and educational leaders (Caspi & Blau, 2011b). Previous studies have documented the intensive growth of digital communication and pedagogical data exchange among teaching staff, students, and parents in order to promote educational dialog through online platforms (Blau & Hameiri, 2010, 2012; Perelman, 2014) and mobile apps (Blau & Hameiri, 2013; Blau et al., 2016).

The use of e-communication is one of the requirements of the national ICT program (Israeli Ministry of Education, 2014b). This requirement is linked to the potential of online communication to blur the boundaries between classroom and home (Grant, 2011). E-communication in educational settings can be conducted through a variety of tools: school data management systems, LMSes, school portals, social networks such as Facebook, Google +, WhatsApp groups, and emails.

Schools and teachers can choose the appropriate technology and the complexity level of the e-communication dialog according to their goals (Benamotz & Blau, 2015). The main use of e-communication for teacher-family interactions, especially in the initial phase of its adoption, mostly depends on school policy (Ho, Hung, & Chen, 2013). When school policymakers encourage teachers to communicate online with students and their parents, teachers will gradually acquire the skills that are needed for effective e-communication (Blau et al., 2014; Ledbetter & Finn, 2013). In other schools, policymakers perceive online or ubiquitous mobile communication between schools and families as a less integral practice than communication within the school staff (Blau & Hameiri, 2016; Perelman, 2014). These schools tend to postpone teacher-family online interactions until later stages of the technology implementation process (Blau & Presser, 2013). Thus, while some schools integrate e-communication between teaching staff alone, others have chosen a more extensive option of online interactions between teachers, students, and parents. A previous study (Blau & Hameiri, 2012) has shown that when schools promote online communication with students and parents via an online system, the amount of pedagogical data exchanged between teachers themselves is significantly higher compared to schools maintaining e-communication within the teaching staff alone. Moreover, when teachers, students, and parents welcome the idea of using digital technologies for communication beyond school boundaries, it has an empowering effect on children's learning and teachers' attitudes towards technology use (Grant, 2011; Ledbetter & Finn, 2013).

Collaborative learning as a parameter of ICT integration

Collaborative learning takes place at different levels–from sharing information through cooperation in creating learning outcomes to collaboration in the whole learning process (Dillenbourg, 1999; Caspi & Blau, 2011a). Technologies facilitate

collaborative learning activities, mediate access to shared content, and can assist in constructing personal and group knowledge in digital environments (Hauge & Norenes, 2015). For example, cloud service platforms enable easy online access to shared documents and various apps, facilitate work in virtual teams, and support sharing of digital content (Blau & Caspi, 2009a, 2009b). These characteristics of cloud technologies can promote collaboration and innovative learning processes (Blau, 2011a; Ishii, 2014; Lakshminarayanan, Kumar, & Raju, 2013).

By using a cloud platform like Google Apps, students and teachers are able to share ideas quickly and efficiently (Ishii, 2014; Shamir-Inbal & Blau, 2016b). Teachers using such platforms in the classroom can encourage learning by producing collaborative learning outcomes and/or by students evaluating each other's learning activities (Kali, Levin-Peled, & Dori, 2009; Stahl & Hesse, 2009).

Despite the easy access and use of cloud service platforms, their potential for collaborative learning has not been fully explored by teachers (Blau & Presser, 2013). This may arise from the fact that teachers still see the main added value of ICT in accessing updated information and attractive demonstrations (Ilomäki, 2008; Stahl & Hesse, 2009). In terms of the TPACK framework (Mishra & Koehler, 2006), in order to use cloud platforms effectively for collaborative learning, teachers need professional training that emphasizes the development of a proper interconnection between their pedagogical and technological knowledge (Blau et al., 2014).

The National ICT Program perceives collaborative learning as an important component of ICT integration (Israeli Ministry of Education, 2014a). However, schools can integrate collaborative learning at different levels of complexity, such as collaboration between students in the class or between classes within a school, collaboration between students in different schools, and collaboration with students from other countries (Blau & Shamir-Inbal, 2017). It remains unclear whether different levels of collaboration will have a different impact on the quality of ICT integration in educational processes.

Research goal and questions

Previous studies have mostly referred to technological integration as technology use—for instructional preparation, instructional delivery, as a learning tool, or a combination of these categories (for review see: Inan & Lowther, 2010). In contrast, this study examines the quality and complexity of ICT integration rather than its use. In addition, in previous large-scale studies the operationalization of the dependent variable (technology integration) has usually been defined according to "teachers' self-rating of frequency of technology integration in their instruction" (Inan & Lowther, 2010, p. 141) or external assessment (for review see: Somekh, 2007). In this study, the data source was neither teachers' self-rating nor external evaluation but the report of internal ICT leadership—school principals and ICT coordinators. Moreover, in order to enhance generalizability of the results, the entire district of schools participated in the study. Lastly, the independent variables in

models explored in previous studies were teachers' background and demographics, such as years of experience (Mathews & Guarino, 2000), teachers' attitudes toward ICT in education and computer training (Van Braak, Tondeur, & Valcke, 2004), and teachers' readiness, beliefs, and the availability of computers (Inan & Lowther, 2010). In contrast, the independent variables in this study were components of ICT integration emphasized by educational policymakers rather than teachers' background and demographic data or technological availability.

We examined whether and how various components contribute to the general quality of ICT integration and its development over time through the following research questions:

1. How do the components of ICT integration develop over time?
2. How does the complexity level of the following parameters develop over time: collaboration (intraschool/interschool), digital learning content (using/designing), and e-communication (within the staff/staff with families)?
3. Which components of ICT integration are related to its general quality? General quality of ICT integration refers to the extent, if any, to which the school staff meaningfully integrates technology in order to enhance student-centered pedagogy.

Method

Participants

The online questionnaire was distributed among all 428 elementary schools (first through sixth grades) including all schools from the entire district of Israel that were part of the Ministry of Education's National ICT Program. The program highlights the national importance of ICT integration in teaching and learning and provides appropriate technological infrastructure and human resources to support teachers' professional development (Elgali & Kalman, 2011).

A school principal and a school ICT facilitator were asked to complete the questionnaire together during a face-to-face meeting. School principals and ICT facilitators are engaged in ongoing informal monitoring and observation of the teachers' integration of ICT in their school. Therefore, compared to teachers' self-reports, school leaders can provide a more objective evaluation of technology-based teaching and an organizational-level perspective regarding this process.

Data analysis was conducted on 368 completed questionnaires–86% of the elementary schools in the district. All 100 schools that joined the program in its first phase (i.e., completed the questionnaire after three years of ICT integration) participated in the study. An additional 268 schools joined the program in its second phase (i.e., completed the questionnaire after the second year of ICT integration). The questionnaire was administered simultaneously among schools in both phases. The return rates of the questionnaire did not differ significantly according to the phase (100% and 86% for the first and second phases, respectively).

The two phases of ICT integration included all primary schools in the district. The schools in the first phase were chosen by the Ministry of Education as a pilot of the program. The researchers were not related to the selection of the schools for the pilot. These schools were chosen regardless of their level of technological integration. Rather, the schools in the first phase were chosen to be representative in terms of the percentage of urban versus rural schools, Hebrew-speaking versus Arabic-speaking schools, and school communities with high versus low socioeconomic status.

Questionnaires from 154 Hebrew-speaking (41.8%) and 214 Arabic-speaking (58.2%) schools were analyzed. The percentage of Hebrew-speaking and Arabic-speaking schools in the study is consistent with their percentage in the district (List of Israeli schools, 2014).

Instruments

Table 1 presents the 10 items in the questionnaire and descriptive statistics for the study measurements. The general quality of ICT integration was measured on a Likert scale ranging from 1–10. Other measurements were rated on a scale from 1 (*very little*) to 5 (*very much*). The items reflect the goals of educational policymakers and refer to the components of the National ICT Program. Content validity of the measurements (Blau & Shamir-Inbal, 2017) was evaluated by two experts in ICT integration in K-12. The questionnaire covered the following topics: general quality

Table 1. Descriptive statistics ($n = 368$).

Measurement	Mean	Median	*SD*	Skewness	Range
General quality of ICT integration–To what extent, if any, does the school staff integrate ICT in order to enhance the quality of educational practices?	6.831	7	1.98	− 0.82	1–10
Intraschool collaboration–Teachers promote collaboration among students in the class and/or between students from different classes.	2.62	3	1.16	0.20	1–5
Interschool collaboration–Teachers promote collaboration with students from other schools.	2.22	2	1.28	0.65	1–5
Student use of shared docs–Teachers promote students' learning with shared documents.	3.12	3	1.27	− 0.17	1–5
Digital content use–The majority of teachers use learning materials available online or from digital content providers.	3.34	3	1.19	− 0.46	1–5
Digital content development–The majority of teachers design digital learning materials by themselves.	2.91	3	1.08	0.02	1–5
Staff e-communication–To what extent, if any, is e-mail and/or the school platform used for communication among the teaching staff?	4.35	5	0.85	− 1.35	1–5
Staff/family e-communication–To what extent, if any, is e-mail and/or the school platform used for teacher-parent communication?	3.26	3	1.20	− 0.14	1–5
Pedagogical website update–To what extent are ongoing pedagogical activities reflected on and visible through class/subject websites?	3.52	4	0.98	− 0.33	1–5
Administrative website update–To what extent is ongoing administrative information which is relevant to students and parents reflected on and visible through class/subject websites?	4.00	4	0.91	− 0.76	1–5

Table 2. Factor analysis for the complexity of ICT integration.

	Components		
Items	E-collaboration	Digital content	E-communication
Intraschool collaboration		.764	
Interschool collaboration		.852	
Digital content use			.524
Digital content design			.925
Staff e-communication	.897		
Staff/family e-communication	.658		

of ICT integration; intra and interschool collaboration of students; usage and development of digital content; e-communication among teachers and between teachers, students, and parents; pedagogical and administrative updating of class or subject websites.

As indicated in the data presented in Table 1, all the variables are normally distributed except for online communication among the teaching staff. The distribution of the variable "staff e-communication" is skewed to the right, reflecting a high level of online communication among teachers. Therefore, in the Results section a-parametric statistics is used for the analyses including this variable. For other variables we use parametric statistics, even though Likert scales fall within the ordinal level of measurement. That is, the response categories have a rank order, but the intervals between values cannot be presumed equal. As Blaikie (2003) pointed out, the assumption that the response categories are equal and consequent use of parametric statistics to analyze Likert scales is a common practice in research in general and in the field of education and psychology in particular. Jamieson (2003) added that if the Likert scale data is classed as interval, the researchers should pay attention to the sample size and to whether the distribution is normal. The sample of this study is large enough and all variables except one are normally distributed.

Table 2 presents the three dimensions yielded by a confirmatory factor analysis with Varimax rotation and Kaiser normalization for parameters representing the complexity of ICT integration. The analysis revealed three components: collaboration, content use and design by teachers, and e-communication.

In addition, the questionnaire included two open-ended questions. One of the open questions asked participants to describe specific examples of the integration of technology in classrooms, and another invited general comments, reflections, and insights regarding the ICT integration in their school. The inclusion of the qualitative data derived from these open-ended questions deepens understanding of the quantitative data.

Procedure

Toward the end of the academic year in June 2013, three years after beginning the gradual implementation of the National ICT Program in Israeli elementary schools,

policymakers from the Ministry of Education were interested in an external exploration of pedagogical changes as a result of the ICT implementation in the district's schools. For this purpose, a link to the online questionnaire was distributed to all elementary schools in the district. The participation of schools in the study was voluntary. The questionnaire was approved by the institutional ethics committee.

The data were collected via the Google Forms platform and analyzed using SPSS 22. In order to avoid conflict of interests, the analysis of the anonymous data was conducted entirely by the second author, since the first author, in addition to her academic appointment, is partially affiliated with the Ministry of Education.

The amount of qualitative data that emerged from the open-ended responses was not sufficient for quantifying codes. Hence, the qualitative were used to illustrate, complement, and enrich understanding of the quantitative findings.

Findings

Development of ICT components over time

To compare the impact of the implementation period on the degree of ICT integration, an analysis of variance was conducted for all measurements comparing schools that had finished their second year versus schools that had finished their third year in the National ICT Program. Table 3 presents descriptive statistics and the analysis of variance for these comparisons. Since the communication level among the teaching staff was not normally distributed, a standard value (z) of Mann-Whitney U test was used to compare the variable "staff e-communication" after the second and the third year of implementation. In addition, the number of schools in the first phase was significantly smaller than the number of schools in the second phase. Therefore the Levene's Test for Equality of Variances verified the t-test's assumption of homogeneity of variance. The results of the independent

Table 3. Comparisons of the measurements between schools after the second and the third year of implementation.

Measurement	Year	*N*	*Mean*	*SD*	*Test (t/Mann-Whitney)*
Intraschool collaboration	3rd	100	2.98	1.10	$t(366) = 2.05, p = .046$
	2nd	268	2.72	1.08	
Interschool collaboration	3rd	100	2.64	1.23	$t(366) = 2.19, p = .029$
	2nd	268	2.31	1.29	
Student use of shared docs	3rd	100	3.54	1.21	$t(366) = 2.92, p = .004$
	2nd	268	3.11	1.27	
Digital content use	3rd	100	4.05	0.81	$t(366) = 5.21, p < .001$
	2nd	268	3.52	1.02	
Digital content development	3rd	100	3.31	1.08	$t(366) = 2.02, p = .049$
	2nd	268	3.02	1.02	
Staff e-communication	3rd	100	4.62	0.65	$Z = -2.36, p = .018$
	2nd	268	4.42	0.79	
Staff-families e-communication	3rd	100	3.79	1.02	$t(366) = 4.29, p < .001$
	2nd	268	3.25	1.18	
Pedagogical website updates	3rd	100	3.66	1.02	$t(366) = 0.22, p = .824$
	2nd	268	3.63	0.88	
Administrative website updates	3rd	100	4.32	0.88	$t(366) = 2.03, p = .048$
	2nd	268	4.04	0.84	

samples *t* tests presented in Table 3 take into consideration the results of Levene's test. Namely, for the variables with different variances for the schools in the first and the second phase of the ICT integration, the table presents adjusted *t*-test values.

As can be seen from the data presented in Table 3, in schools that had been running the national program for the last two years, the level of ICT integration was significantly higher in almost all of the ICT parameters than schools that had only been running the program for the last year.

The open-ended comments support these findings. For example,

> ICT became part of the school routine. Teachers began to feel it in everyday activities. Students began to understand the added value of the class website as a continuation of the learning process after school. Parents began to use the class websites to monitor their children's learning at home.

However, the parameter of pedagogical updating of websites was not higher as a function of time. It is plausible that the level of pedagogical use of school websites is highly emphasized by educational policymakers for reasons of visibility and accountability and already reaches its optimal level by the second year of integration; whereas all other ICT parameters continued growing during the third year of the program.

The complexity of ICT integration over time: E-collaboration, digital content, and e-communication

This section explores the complexity of ICT integration over time according to the following three parameters: intra versus interschool collaboration, use versus design of digital content by teachers, and e-communication within the teaching staff only versus e-communication between teachers, students, and their parents.

The *complexity of collaboration* refers to group projects conducted between students in the same class or students in different classes in the same school versus collaborative projects with other schools. An additional measurement–students' use of shared docs—was not used for analyzing the complexity of collaboration since this tool can be used for both intra and interschool collaboration. In order to compare the complexity of collaboration after the second versus the third year of ICT integration, a repeated measures ANOVA test with the complexity of collaboration as the within-subject variable and the year of implementation as the between-subject variable was conducted. Descriptive statistics are presented in Table 4.

The analysis of variance revealed statistically significant main effects with medium partial effect size for the impact of collaboration complexity and the time

Table 4. Descriptive statistics for the complexity of collaboration as a function of time.

Collaboration complexity	After 2nd year *(n = 100) Mean (SD)*	After 3rd year *(n = 268) Mean (SD)*	Total
Intraschool collaboration	2.72 (1.08)	2.98 (1.20)	2.79 (1.11)
Interschool collaboration	2.31 (1.28)	2.64 (1.22)	2.40 (1.27)
Total	2.48 (1.07)	2.85 (1.06)	2.66 (1.06)

of ICT integration $F(1, 366) = 23.70$, $p < .001$, ${}_{p}\eta^2 = .06$. The level of use of existing digital content in lessons is significantly higher than the level of development or significant adaption of digital content by teachers. As a rule of thumb, ${}_{p}\eta^2 = .01$ is considered a small partial effect, ${}_{p}\eta^2 = .06$ a medium partial effect, and ${}_{p}\eta^2 = .14$ a large partial effect size (Cohen, 1977). The level of collaboration within schools was significantly higher than the level of collaboration between different schools. In addition, generally speaking, the schools after the third year of ICT implementation collaborated to a greater extent than schools after the second year of ICT implementation, and partial effect size was medium, $F(1, 366) = 16.85$, $p = .003$, ${}_{p}\eta^2 = .03$. However, the interaction effect between the complexity of collaboration and the time of ICT integration was not statistically significant, and the partial effect size was almost zero, $F\ (1, 366)\ = 0.21,\quad p = .648,\quad {}_{p}\eta^2 < .01$.

The responses to open-ended questions were diverse. Some presented examples of collaboration with other schools: "We had a collaborative project with another school. One class in each school built an online quiz for the other class." Other comments contain pedagogical and management pros and cons of intra and interschool collaboration:

> We mostly perform collaborative activities in the classroom. It is easy to manage and its benefit for learning is clear. Students show their presentations to their peers and learn from each other … We have no ICT staff to coordinate collaborative learning with other schools.

The *complexity of digital content* refers to the teachers' ability to choose digital activities that are available in their subject according to students' characteristics versus design of their own digital content. To compare the complexity of digital content after the second and the third year of ICT integration, repeated measures ANOVA with the complexity of digital content as the within-subject variable and the time since ICT integration as the between-subject variable was conducted. Descriptive statistics are presented in Table 5.

The analysis of variance showed statistically significant main effects, with large partial effect size for digital content, $F(1, 366) = 85.57$, $p < .001$, ${}_{p}\eta^2 = .19$, and for the period of time since ICT integration, with medium partial effect size, $F(1, 366) = 15.59$, $p < .001$, ${}_{p}\eta^2 = .04$, as well as a significant interaction effect with medium partial effect size between the two variables, $F(1, 366) = 12.35$, $p = .002$, ${}_{p}\eta^2 = .03$. Schools after the third year in the national program both use and produce digital content significantly more in comparison to schools after the second year of implementation. The interaction effect shows that the use of existing

Table 5. Descriptive statistics for digital content use and design as a function of time.

Digital content	After 2nd year *(n = 100) Mean (SD)*	After 3rd year *(n = 268) Mean (SD)*	Total
Digital content use	3.52 (1.02)	4.05 (0.89)	3.66 (0.99)
Digital content design	3.01 (1.02)	3.21 (1.08)	3.06 (1.03)
Total	3.27 (0.96)	3.63 (0.93)	3.45 (0.91)

Table 6. Descriptive statistics for e-communication types as a function of time.

E-communication	2nd year *(n = 100) Mean (SD)*	3rd year *(n = 268) Mean (SD)*	Total
E-communication among teachers	4.42 (0.78)	4.62 (0.65)	4.47 (0.75)
E-communication with families	3.25 (1.18)	3.79 (1.02)	3.39 (1.17)
Total	3.84 (0.69)	4.21 (0.80)	4.02 (0.67)

digital content increases as a function of time significantly more than its design by teachers.

Responses to the open-ended questions primarily emphasized the importance of ongoing use of available digital content in lessons. For example, "The uses of digital learning resources have opened a variety of new possibilities for us, and it is difficult to imagine teaching without using them. They facilitate teachers in demonstrating main ideas and students in practicing skills." Only a few of the responses to the open-ended questions highlighted the added value of designing digital content by teachers. For example, "Our teachers design online activities which are richer than the existing digital content … Teachers can adjust the activity level precisely to the needs of their students. They are less dependent on searching for existing digital content."

The *complexity of e-communication* refers to online interactions among the teaching staff alone versus digital communication of teachers with students and their parents. To compare the complexity of e-communication after the second and the third year of ICT integration, we conducted repeated measures ANOVA with e-communication as the within-subjects variable and the time since ICT integration as the between-subjects variable. Descriptive statistics are presented in Table 6.

The analysis of variance revealed statistically significant main effects for e-communication type, $F(1, 366) = 243.74$, $p < .001$, ${}_{p}\eta^2 = .40$, for the time since ICT integration $F(1, 366) = 15.57$, $p < .001$, ${}_{p}\eta^2 = .04$, as well as a significant interaction effect between the two variables, $F(1, 366) = 9.86$, $p = .009$, ${}_{p}\eta^2 = .03$. Teachers communicate significantly more with colleagues compared to online communication with students and their parents, and the effect size was very large, ${}_{p}\eta^2 = .40$, while other partial effects were medium. Schools after the third year of ICT integration generally communicate online significantly more in comparison to schools after the second year in the National ICT Program. The interaction effect shows that e-communication with students and their families grows significantly more over time in comparison to the growth of e-communication among teaching staff, which was initially already high.

The open-ended comments regarding digital communication within the staff were consistent with the qualitative results: "Teachers understand the importance of ongoing e-communication via email between the school principal and the staff and between colleagues and are enthusiastic in embracing it." In contrast, concerning digital interactions between teachers and families, open comments were not as optimistic as the quantitative results. The responses suggested that school ICT leaders are not satisfied with the current level of e-communication with school communities and tend to blame parents for this situation. For example, "Digital communication

with parents is still problematic because not all of the parents have appropriate habits and understand the importance of this communication channel."

The general quality of ICT integration

In order to explore the impact of different ICT parameters on the general quality of ICT integration, a multivariate regression analysis was conducted. The seven teachers' pedagogical activities presented in Table 7 explained 47.7% of the variance in the general quality of ICT integration, $F(7, 360) = 61.56$, $p < 001$.

As Table 7 shows, the only variables that were not significant predictors of the general quality of ICT integration were collaboration with other schools and e-communication of teachers with students and parents. It seems that when school leaders think about the general quality of ICT integration in their school, they are focused on collaboration within their schools rather than on interschool collaboration and emphasize online pedagogical interactions within their teaching staff to a greater extent than e-communication between teachers, students, and parents.

Despite the extensive integration of technology reported in the quantitative data, responses to the open-ended questions indicated that school ICT leaders are rather skeptical regarding the quality of its use in classrooms in order to promote pedagogy. For example, "Most of our teachers make extensive use of different applications in the classroom through their laptops, but do not necessarily explore the added value of ICT in a meaningful way."

In order to further explore the impact of the independent variables on the general quality of ICT integration, we conducted the same multivariate regressions separately for the schools in the second and the third year in the program. The independent variables explained 34.7% of variance in the general quality of ICT integration in schools after the second year in the national program and 54.5% of variance in schools after the third year of ICT integration. The only difference in the results of the regression analyses was found for e-communication within the teaching staff: E-communication among teachers was a significant predictor of the general quality of ICT implementation during the second year, $\beta = 21.2$, $p < .001$, but not during the third year of implementation, $\beta = 11.8$, $p = .176$. It seems that after three years of ICT integration, e-communication within the teaching staff becomes *transparent* for the school leaders and is no longer perceived as related to the ongoing ICT integration but as an integral part of the school culture.

Table 7. Regression coefficients predicting the general quality of ICT integration.

ICT parameters	β	t	p
Intraschool collaboration	.18	2.24	=.005
Interschool collaboration	.04	1.00	=.320
Digital content use	.25	5.99	<.001
Digital content development	.20	5.04	<.001
Pedagogical website update	.24	5.82	<.001
Staff e-communication	.19	3.25	=.001
Staff/family e-communication	.05	1.24	=.215

Discussion

This section first discusses the findings regarding changes in components of ICT integration as a function of time as well as the complexity of collaboration, digital content, and e-communication. Following that, we discuss components that predict the general quality of ICT integration.

Development of ICT components over time

ICT integration is a complex process that gradually develops over time (Kozma, 2010; Avidov-Ungar & Shamir-Inbal, 2013; Blau & Shamir-Inbal, 2017). It includes technological and pedagogical factors and components of classroom management (Fishman & Krajcik, 2003). In order to examine the impact of time on the degree of ICT integration, we compared schools toward the end of second versus third year in the National ICT Program. The ICT components explored in this study included collaborative activities within the school and with students from other schools, the use of available digital content and design of digital learning materials, e-communication among the teaching staff and between teachers, students, and parents, as well as pedagogical and administrative updating of class websites.

The results indicate that between the second and third years of the implementation significant change occurs in almost all of these parameters. After the third year of ICT integration, schools reported more extensive use of existing digital content and design of digital learning activities by teachers, a wider use of collaborative learning within and between schools, a higher level of use of shared documents, and an expansion of e-communication among the teaching staff and between teachers and families. These results are consistent with previous investigations of changes in national ICT programs over time that described significant changes in instruction (Elgali & Kalman, 2011; Koh et al., 2014; Rodrigues, 2013). It seems that after three years of technology integration, we can apply Hall's (2013) "crossing the bridge" metaphor and describe the changes as a point of no return.

The only parameter in which no statistically significant difference was found between the second and the third years of ICT integration was the "pedagogical update of class websites." This parameter probably reached its optimal level of integration already in the second year, since it was highly emphasized by educational policymakers in order to enhance visibility of pedagogical processes and promote ubiquitous learning. Policymakers from the Ministry of Education explained that pedagogical update of class websites is essential for ICT visibility. This explanation is consistent with findings reported by Blau and Hameiri (2012). Their findings indicated that the dimensions of the program which were most important to educational policymakers (school principals in that case) already reach their optimal level at the first stages of program implementation. This similarity, despite the differences in research method (log-analysis of actual activities in a school data system in previous study versus self-report in the present study), indicates the

effectiveness of educational policies and emphasizes the importance of making informed decisions by educational policymakers at different levels.

Interestingly, administrative updating of class websites—another component of visibility emphasized by the Ministry of Education—continued growing in the third year of ICT integration. One possible explanation is that, in addition to the requirements of educational policies, the updating of class websites is related to teachers' perceptions of its added value. Pedagogical use of websites seems to be perceived as more important and professionally rewarding, with teachers showing more willingness for pedagogical rather than for administrative updates. Future studies may conduct interviews with teachers in order to examine this explanation.

The complexity of ICT integration over time: E-collaboration, digital content, and e-communication

The complexity of ICT integration over time is measured in this study by comparing schools after the second and the third years of the National ICT Program according to three parameters: intra versus interschool collaboration, use versus design of digital content, and e-communication within the teaching staff alone versus e-communication between teachers, students, and parents.

Regarding the complexity of collaboration, the level of collaboration within schools was significantly higher in comparison to collaboration between different schools. Moreover, in general, collaboration was more prevalent in schools after the third year than in schools after the second year of technology integration. However, there was no significant interaction effect between the complexity of collaboration and ICT integration as a function of time, suggesting that the schools after the third year of technology implementation did not collaborate more with other schools than schools after the second year of implementation. Some open comments stated that collaboration between schools is logistically more complicated than collaboration within schools, and it seems that administrative and pedagogical barriers inhibit widespread collaborative activities between schools in both earlier and later phases of ICT integration. This possible explanation is consistent with Mor, Mellar, Warburton, and Winters' (2014) claim that collaboration between different learning communities, and especially cross-cultural activities, is challenging and requires a mediator who is familiar with the learning culture of different groups. In addition, if the added value of collaboration between schools is not clear enough for the teaching staff and they have no external need for coordination, they are unlikely to find reason to put effort into its delivery.

Concerning the complexity of digital content, our results showed that teachers use existing digital content significantly more than they develop digital learning materials by themselves, and the effect size was large, ${}_{p}\eta^2 = .19$. The open comments indicated that school ICT leaders understand how existing digital activities enhance teaching in their schools. These materials create visualization of processes, make presentations more interesting, and open additional possibilities for practice. Regarding the design of digital content, schools after the third year in the national

program produced significantly more digital content in comparison to schools after the second year of ICT integration. According to the interaction effect found between the time and the complexity of integrating digital content, the use of existing digital content increases over time significantly more than content design by teachers. It seems that incorporating existing digital activities into a curriculum provides a sense of stability and allows ICT integration on a daily basis without investing extensive amounts of time and effort (Shamir-Inbal & Blau, 2016a).

In contrast to the quantitative results that highlighted the increase in the use of existing digital content, the open comments also reflect its limitations. It seems that our participants understand the added value of teacher-designed learning materials as customization of learning materials and processes by adjusting them to the level and needs of students. In order to open the window for pedagogical innovations and reach a sense of empowerment in teachers' professional development, according to the principle of *understanding by designing* (Penuel, & Gallagher, 2009), in addition to the use of existing materials, it is important to encourage teachers to develop digital content by themselves. The ability to develop digital content affects teachers' TPACK perceptions (Koh et al., 2014), enhances meaningful integration of innovative technologies in the curriculum (Mor, Ferguson, & Wasson, 2015), and thus plays an important role in teachers' professional development (Shamir-Inbal & Kali, 2009). It is possible that after two or three years of ICT integration, many teachers still do not feel sufficiently technologically competent to design digital content. Future studies may use interviews in order to explore this possible explanation. In addition, it is important to investigate whether longer experiences of ICT integration in the classroom and/or emphasizing the benefits of designing digital content in professional training will change teachers' attitudes in relation to this issue.

Concerning the complexity of e-communication, the results showed that e-communication within the teaching staff alone was significantly more prevalent than e-communication of teachers with students and parents, and the effect size was very large, ${}_{p}\eta^2 = .40$. Open comments indicated that, unlike e-communication with families, digital communication between the teaching staff was perceived as effective and easy to adopt. This result is consistent with the perspective of school principals on e-communication presented in a previous qualitative study (Blau & Presser, 2013). Moreover, various comments in this study indicated that class websites were perceived as a comfortable way to transmit messages to the school community and sufficient for e-communication with students and parents. This kind of information transmission is one-way communication (Blau et al., 2016)—a teacher publishes a message but does not know whether parents read it and what they think about its content. In contrast, communication with the school community via email, a school management system, or a social network group is an active two-way dialogue and requires the involvement of all stakeholders (Blau & Hameiri, 2016).

The interaction effect between the time since ICT integration and the complexity of e-communication showed that e-communication with students and their families becomes more extensive over time in comparison to e-communication among teaching staff. In the third year of integration, e-communication between teachers,

students, and parents continued to expand, while e-communication among teachers seemed to exhaust its potential to grow. This report from school ICT leaders is consistent with the results of the actual behavior of teachers, students, and their parents that was explored through the log analysis of a school management system in previous studies (Blau & Hameiri, 2010, 2012).

The general quality of ICT integration

The integration of new technologies is a complex process involving cultural and behavioral adaptations. In early stages of the implementation process, teachers mostly explore the functions of a new technology and do not necessary explore its full potential for enhancing teaching and learning (Fishman & Krajcik, 2003; Rodrigues, 2013). Our analysis showed the variety of factors included explained 47.7% of variance in the general quality of ICT integration. Among previous studies, Inan and Lowther's model (2010) explained 56.4% of the variance in teachers' technological integration, while the model in van Braak and colleagues' (2004) study, which only focused on teachers' background and demographic variables, found that they explained 21% of the variance. However, as mentioned, both previous studies operationalized technological integration as its use, while our model refers to the quality of ICT integration. The findings reported in this study are based on data from the entire district of schools and are generalizable nationally and internationally for early stages of top-down ICT programs with some bottom-up components. Thus, it is important to continue exploring the pedagogical quality of technologically-enhanced activities in other educational contexts. Intraschool collaboration, digital content use and design, pedagogical updating of class websites, and e-communication within the teaching staff predicted the general quality of ICT integration. In contrast, collaboration with other schools and e-communication of teachers with students and their parents were not significant predictors of the general ICT quality. It seems that when school leaders think about the general quality of ICT during its early stages, they focus primarily on collaboration within their own school and on online interactions with colleagues rather than on collaborative activities with other schools or e-communication of teachers with students and their parents. Another possible explanation for the results regarding e-communication between teachers and families can be related, as suggested above, to the administrative use of class websites by teachers for one-way communication with students and parents. Future studies may investigate these possible explanations.

Figure 1 presents the elements that significantly predicted the general quality of ICT integration. This model is consistent with the approach to learning in general and technology-enhanced learning in particular through three metaphors of knowledge (Brown, 2008; Paavola Lipponen, & Hakkarainen, 2004; Sfard, 1998): the acquisition metaphor with a monologue view of knowledge as a property of the individual mind; the participation metaphor with a dialogical view of knowledge as constructed in communities through interaction with other people and cultures; and the knowledge creation metaphor with a trialogical approach to learning, in

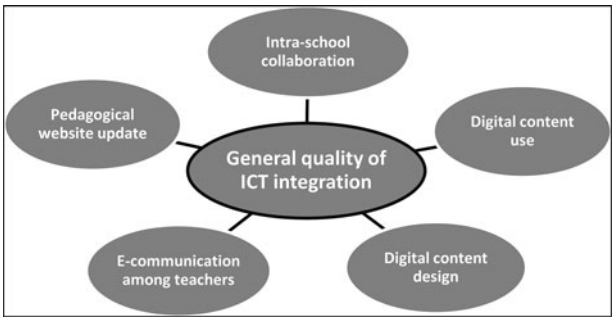

Figure 1. Significant predictors of the general quality of ICT integration in schools.

which common activity objects are collaboratively developed through mediated processes. Among the parameters presented in Figure 1, digital content use reflects the acquisition metaphor, pedagogical updates of class or subject websites and e-communication among teachers represent the participation metaphor, while intraschool collaboration and design of digital content by teachers correspond with the knowledge creation metaphor. It seems promising that, consistent with the claim presented in the literature (Sfard, 1998; Brown, 2008), the research model reflects the comprehensive perspective of school ICT leaders on technology-enhanced learning that includes all three knowledge metaphors and refers to both students and teachers.

Conclusions and implications

Teaching students in the twenty-first century requires the development of digital literacy skills, which will ensure their effective functioning in digital environments (Bruns, 2008; Eshet-Alkalai, 2012; Prensky, 2009). This includes, among other things, effective collaboration using technologies and communication with others in digital environments–demands that challenge teachers, educational policymakers, and the education system in general (Israeli Ministry of Education, 2014a).

This study highlights the importance of seeing ICT integration as a multidimensional process that occurs over a long period of time. The results indicate that between the second and third years of ICT integration significant changes occur in most of these parameters. Moreover, the results showed that intraschool collaboration, digital content use and design, pedagogical updating of class websites, and e-communication within the teaching staff explain almost a half of the variance in the general quality of ICT integration as perceived by school leaders. The model suggested in this paper is consistent with a comprehensive approach to the learning process in educational institutions reflected by three metaphors of learning: knowledge acquisition, participation and creation.

However, it seems that educators assess the general quality of ICT integration as internal-collaboration within their schools and online interactions within the teaching staff, rather than external-collaborative activities with students from other schools or e-communication with families. This perception of school-level leaders

of ICT integration may affect the integration process. We recommend school principals and educational policymakers not pass over such essential components of using technologies in education systems, namely the experience of e-collaboration with unknown students from other schools and online interactions between different stakeholders in a school community. Interschool collaboration is an important experience for building future competence of e-collaboration with remote coworkers in digital workplace or peers in lifelong e-learning processes. E-communication with students and parents can enhance parental involvement, empower learning-related dialog and thus closer teacher-families relationships, and improve student wellbeing (Benamotz & Blau, 2015; Carenzio, Triacca, & Rivoltella, 2014; Heng & Blau, 2016; Shamir-Inbal & Kali, 2007b).

The ICT parameters we suggested as essential for long-term integration also include produsage–the use of available digital content as consumers and design of digital learning materials as producers (Bruns, 2008). However, the deepest change in teachers' use of technology in the classroom requires the experience of self-development of digital learning materials according to the principle of understanding by designing (Penuel & Gallagher, 2009). We suggest that educational policy makers and designers of professional development programs promote adoption of the produsage approach by both teachers and students.

Limitations and future directions

This study adds to the research literature a model of general quality of ICT that is predicted by components which were empirically revealed by data from the entire district. However, it should be noted that this model is based on the perspective of school principals and ICT coordinators. On the one hand, compared to teachers' self-reports, school leaders can provide more objective evaluation of technology-based teaching and a broad organizational-level perspective on this process. On the other hand, the report based on school leaders' evaluation of technology-enhanced teaching may differ from the evaluation of lessons conducted by an entirely neutral observant. In addition, learning processes and measurements of students' learning outcomes were out of scope of this research. Future studies may replicate the suggested model and deepen the understanding of technologically-enhanced teaching and learning by conducting lesson observations of teachers' behavior in classrooms and/or by analyzing learning activities and student outcomes on class websites.

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