ICT, Education and the Knowledge Economy: Goals, Support and Practice

David Rutkowski*, david.rutkowski@iea-dpc.de
IEA Data Processing and Research Center, Hamburg, Germany

Leslie Rutkowski*, leslie.rutkowski@iea-dpc.de
IEA Data Processing and Research Center, Hamburg, Germany

Jason Sparks*, J.Sparks@sheffield.ac.uk,
The University of Sheffield, UK

* Order of authorship is alphabetical. Authors contributed equally to this manuscript.

Abstract

Investment in ICT in education has been largely successful in terms of bringing students and teachers into contact with ICT hardware and software in many nations. However, investment has also exposed the profound challenge of realizing the potential for the many transformations imagined by proponents, with particular attention focused on the limited integration of ICT into teaching and learning (Farrell & Wachholz, 2003; Pelgrum, 2001). In this study, using data and questionnaires from the 2006 SITES survey, we take up this discussion of teaching and learning appropriate for the knowledge-based economy in a consideration of the ways institutional support, teacher and principal goals, and math and science teacher practices, as detailed in the survey, impact what we have analyzed as a set of pedagogical features we are calling "KBE Teaching." Our research question can be stated as follows: Is there an agreement internationally between teachers and principals regarding the importance of using and fostering KBE-type practices in the classroom. Further, does ICT support for particular KBE-type activities predict the increased use of ICT in conjunction with those KBE-type activities in the classroom? Our findings show that, in general, regardless of country, principals acknowledge the importance of all KBE teaching practices. Further, we found that for each KBE-type activity, a small handful of countries displayed an association between ICT support and ICT use on KBE-type classroom activities. These findings are relevant for policy makers, teachers and principals in the countries analyzed, particularly with respect to communication of and support for goals to support ICT and KBE learning.

Introduction

Following the 1996 publication of the OECD's *The Knowledge-based Economy*, national educational policies around the world have increasingly reflected the OECD call to develop education appropriate for the "knowledge-intensive and high-technology" (OECD, 1996, p. 7) dimensions of a new economic imaginary (Peters & Besley, 2006; Rizvi & Lingard, 2006). These policies have mandated massive investments in information and communications technology (ICT) in education infrastructure, namely computers, software, Internet connectivity, technical support and teacher training. ICT investments saw, by the early years of this century, countries such as South Korea, Singapore and China quickly approach the level of ICT in education adoption of countries such as the United Kingdom and the United States, which had introduced ICT into their education systems in the early 1980s (Wellington, 2005).

ICT in education was promoted as a means to connect students with the information society; prepare students for the new work styles of the knowledge-based economy; transform teaching, learning and schools; bridge the 'digital divide' between the rich and poor within and across nations; and meet the Millennium Development Goals (ICT-Focused). Investment in ICT in education has been largely successful in terms of bringing students and teachers into contact with ICT hardware and software in many nations. However, investment has also exposed the profound challenge of realizing the potential for the many transformations imagined by proponents, with particular attention focused on the limited integration of ICT into teaching and learning (Farrell & Wachholz, 2003; Pelgrum, 2001). This challenge was reflected in several national and international studies aimed at exploring factors related to the integration of ICT into teacher pedagogies and the extent to which teaching and learning were indeed transforming, both in terms of ICT use and in terms of "ICT-using innovative pedagogical practices" (Farrell & Wachholz, 2003; Law, Chow & Yuen, 2004, p. 4), particularly those practices that are described in the literature as relevant to the knowledge-based economy. These practices shift the role of the teacher to that of a facilitator of more collaborative, self-directed, and inquiry- and project-based learning (Law, Chow & Yuen, 2004; New London Group, 1996; Pelgrum, 2001; Utilizing a Pedagogical Support System).

In this study, using data and questionnaires from the 2006 SITES survey, we take up this discussion of teaching and learning appropriate for the knowledge-based economy in a consideration of the ways institutional support, teacher and principal goals, and math and science teacher practices, as detailed in the survey, impact what we have analyzed as a set of pedagogical features we are calling "KBE Teaching."

Defining ICT

This research into the SITES 2006 study on Information and Communication Technology (ICT) implementation in schools is guided by the UNESCO Bangkok definition of ICT as technology "used to transmit, store, create, display, share or exchange information by electronic means," a definition that includes "technologies as radio, television, video, DVD, telephone (both fixed line and mobile phones), satellite systems, computer and network hardware and software; as well as the equipment and services associated with these technologies, such as videoconferencing, e-mail and blogs" (What is ICT?). In the context of the SITES survey, ICT can be more narrowly understood to mean those computer technologies integral to working with: conventional office software (word-processing, databases, spreadsheets, presentations); multimedia production, simulations/modeling; the Internet; PDAs/cellphones; interactive smart boards; and web-based learning environments (Technical Questionnaire, p. 6).

Defining the "knowledge-based economy": Problematics and pragmatics

Recent years have seen national policy agendas focus increasingly on introducing ICTs into educational systems. These national policy agendas, particularly since the influential report, *The Knowledge-Based Economy* (OECD, 1996), are largely articulated in terms of meeting the demands of the global knowledge-based economy (Grubb & Lazerson, 2006; Peters & Besley, 2006; Rizvi & Lingard, 2006). In addition to national investment, this educational agenda is significantly promoted, financed and directed by international organizations such as the World Bank and UNESCO, as well as a range of NGOs and corporate sponsors (ICT in Education; Partnerships: e-learning for life, 2008; Rizvi & Lingard, 2006).

The notion of the "knowledge-based economy," particularly in the context of education, is a vague, much-disputed and fundamentally-problematic one, fraught with tensions around capitalist ideology, an emphasis on social efficiency and human capital formation over social equity and democracy, and a reduction of the complexities of globalization to economic phenomena (Beck, 2000; Brown & Lauder, 2006; Peters & Besley, 2006; Rizvi & Lingard, 2006). It is beyond the scope of this paper to engage this problematization, and instead we seek to work with a pragmatic definition of the knowledge-based economy (hereafter, KBE) reflecting points of agreement among theorists seeking to describe a range of significant economic changes that are increasingly global in scope with profound local consequences. For purposes of this research on teaching and learning, our definition of the KBE includes the following features (Brown & Lauder, 2006; Drucker, 1994; Gee, 2004; OECD, 1996; Peters & Besley, 2006; Rizvi & Lingard, 2006): (1) Knowledge, itself, is a product ; (2) Science and technology-related industries are prioritized; (3) Knowledge workers process information and generate knowledge; (4) Education at all levels is increasingly important/lifelong learning; (5) ICT is used to access and process knowledge for knowledge production; (6) Strategic alliances formed among the "triple helix" of the state, universities, and industry ; and (7) Global/regional reconfiguration of markets, supply, manufacturing, and management. During the past ten years, these features of the transforming economy have been increasingly presented as rationale for national policy shifts around the world promoting ICT in education as a means to develop human capital (Brown & Lauder, 2006; Peters & Besley, 2006; Rizvi & Lingard, 2006; Wellington, 2005).

Education for the knowledge-based economy

We are using the term "Knowledge-based Economy Teaching" (or KBE Teaching) to describe the set of pedagogic features that reflect a convergence across many perspectives on the importance of the transforming global economy to education and on important aspects of teaching and learning that might be useful in it (Kalantzis & Cope, 2004; Jarvis, 2007; Peters & Besley, 2006). These features include the following (Framework for 21st Century Learning; Drucker, 1994; Gee, 2006; Jarvis, 2007; Kalantzis & Cope, 2004; Peters & Besley, 2006): (1) Collaborative/team-based work &

social learning; (2) Project-based work; (3) Networking/distributed learning; (4) Cultural and linguistic diversity; (5) Multi-skilled, adaptive, flexible workers; (6) Communication/presentation; (7) Multiple ICT skills and dispositions; (8) Criticality and problem solving; (8) Information/knowledge handling (accessing, analyzing, presenting, creating); (9) Self-initiative/self-direction; and (10) Formal and informal learning.

These features apply in multiple areas of social life as well (Edwards and Usher, 2008; Gee, 2004; Jarvis, 2007; Kalantzis & Cope, 2004). A pedagogical approach to developing students for success in such a new working environment would necessarily be "reconfigured" and "must involve a redefinition of the role of the teachers" (Edwards & Usher, 2008). Such a reconfiguration would (Framework for 21st Century Learning; Gee, 2006; Jarvis, 2007; Kalantzis & Cope, 2004; Peters & Besley, 2006): (1) release teachers from the traditional role as content providers; (2) make the learning process explicit; (3) facilitate inquiry-based, project-based learning; (4) link students in networks and distributed learning contexts with collaborators and experts within and beyond the school walls; (5) promote multiple literacies: media, technology, linguistic, and cultural; (6) promote student criticality in information use; and (7) promote student learning independence.

These features reflect research on teaching and learning with ICT that dates back to the early 1980s, a period that witnessed the first significant launch of ICT in schools in economically developed countries (Pelgrum & Schipper, 1993; Wellington, 2005). This era of desktop 'microcomputers' used in education for vocational purposes (Wellington, 2005, 1989) reflected an agenda promoted in policy discourses aimed at developing new skills for the “technology revolution” and the “information society” (Wellington, 2005, 1989).

By the late 1980s, educational debate reflecting the transformative effects of ICTs was evident in the effort to shift pedagogy from “learning about computers” to “learning with computers” (Pelgrum & Schipper, 1993; Wellington, 1989), an effort described in a report on the 1989 IEA Computers in Education study (Pelgrum and Schipper, 1993) in which teacher and principal attitudes toward ICT were found to be a challenge to a more widespread manifestation of the learning with computers innovations.

Wellington (1989) presciently describes the promise of ICT in education at this point: “the progress of IT, both in society and education, may lead us to examine not only how we teach, but what we teach” (p. 266). Furthermore, “the diffusion of IT across existing curriculum may actually undermine the structure of that curriculum and bring into question the wisdom of teaching separate subjects” (p. 266). However, research done during the past 10 years on implementation of these innovative pedagogies in national studies indicates that, despite the enormous amount of policy mandate, industry demand, parental demand and the rapid increase of ICT in schools during the 1990s and early 2000s, the promised transformations in teaching and learning have still largely gone unrealized (Anderson & Ronnkvist, 1999; Granger, et al., 2002; Jenson, et al., 2007; Cuban, et al., 2001; Plomp, et al., 2003; Tondeur, et al, 2007).

It is in this context that SITES 2006 study considered "the role of ICT in teaching and learning in mathematics and science classrooms" and "the extent to which pedagogical practices considered to be conducive to the development of *21st Century Skills* were evident in 22 countries. Our analysis of KBE Teaching is broadly similar to the survey's "21st Century Skills," defined as "the capacity to engage in life long learning (understood as self-directed and collaborative inquiry)" and "connectedness (communication and collaboration with experts and peers around the world)" (Executive Summary).

KBE teaching: Goals, practices and support

We have described as *KBE teaching goals* the following from those goals, outlined in the methods section, that matched between the principal and teacher questionnaires and that fit the definition of a KBE-type goal as defined previously. These goals are in contrast to other goals on the questionnaire. For example, the goal of improving students' performance in assessments/examinations, something that is clearly important for students, is not directly of relevance to innovations around ICT. Similarly, the goal of individualizing student learning experiences in order to address different learning needs, while suggestive of potential innovations, in no way explicitly points to innovations around ICT and pedagogies such as inquiry-based learning, something we see more directly in fostering students' ability and readiness to set their own learning goals and to plan, monitor and evaluate their own progress.

Similarly, we are calling KBE Teaching six practices that we have analyzed from the Teacher Questionnaire that (a) use ICT and (b) are directly suggestive of pedagogies we associate with inquiry-based learning, project-based learning, collaborative learning and other innovations that link students with resources, collaborators and experts outside the school walls through the Internet. These six KBE-type activities are described in the methods section. Here, we did not include "laboratory experiments with clear instructions and well-defined outcomes" because the reference to "clear instructions and well-defined outcomes" runs directly counter to the objectives of inquiry-based learning. It could be argued that we should have included "discovering mathematics principles and concepts"; however, we felt that the language was ambiguous, and we erred on the side of caution in not using it.

To study the relationship between support for and practice of KBE Teaching, we chose items from the Technical Questionnaire (p. 10) that corresponded directly to the teacher items noted above. Here, technical personnel were asked to what extent technical support was available for teachers who wanted to use those listed KBE-type activities. These items are also described in the methods section.

Research questions

Using theoretical perspectives outlined above and empirical methods described below, our research question can be stated as follows: Is there an agreement internationally between teachers and principals regarding the importance of using and fostering KBE-type practices in the classroom. Further, does ICT support for particular KBE-type activities predict the increased use of ICT in conjunction with those KBE-type activities in the classroom? This line of questioning is relevant for policy makers, teachers and principals in the countries analyzed, particularly with respect to communication of and support for goals to support ICT and KBE learning.

Methods

Data

SITES 2006 is the third survey in a series of projects under the general Second Information Technology in Education Study umbrella. According to Law, Pelgrum and Plomp (2008), SITES 2006 was designed as a survey of schools and teachers intended to examine the kinds of ICT-related pedagogical practices carried out in participating countries and how countries were using ICT. The study administered questionnaires to school principals, technology coordinators and teachers in mathematics and science in approximately 400 schools per country. As many as four year-eight teachers per school per subject were surveyed. In total, 22 education systems participated in the SITES 2006 survey. These are listed in Table 1. Given our interest in national systems of education, we chose to omit regional systems including the Alberta and Ontario Provinces of Canada; Catalonia, Spain and Moscow, Russian Federation. This left 18 national education systems for the current analysis.

Table 1. *SITES 2006 participating education systems*

Educational systems (including acronyms)	
Alberta Province, Canada (CAB)*	Japan (JPN)
Catalonia, Spain (ECT)*	Lithuania (LTU)
Chile (CHL)	Moscow, Russian Federation (RUM)*
Chinese Taipei (TWN)	Norway (NOR)
Denmark (DNK)	Ontario Province, Canada (COT)*
Estonia (EST)	Russian Federation (RUS)
Finland (FIN)	Singapore (SGP)
France (FRA)	Slovak Republic (SVK)

Hong Kong SAR (HKG)	Slovenia (SVN)
Israel (ISR)	South Africa (ZAF
Italy (ITA)	Thailand (THA)

*Regional educational system, not included in present analysis.

Sampling and survey administration for SITES 2006 was conducted at two levels – school and classroom. The school level involved a principal questionnaire and a technical questionnaire (to be answered by the ICT coordinator). The classroom level involved a teacher questionnaire to be completed by at least one mathematics teacher and one science teacher in each school. For complete details on the sampling design see the SITES international report *Pedagogy and ICT Use in Schools around the World* (Law, Pelgrum and Plomp, 2008).

Measures

To understand the relationships between principals' and teachers' value of KBE-type ICT goals, we used those goals that matched between principals and teachers. This included six goals, the topics of which included (a) providing opportunities for students to learn from experts and peers from other schools or countries; (b) providing real-world type activities; (c) fostering students' ability and readiness to set their own learning goals; (d) fostering students' collaborative and organizations skills for team work; (e) fostering students' communication skills in face-to-face or online situations; and (f) preparing students for responsible internet use.

Additionally, to investigate whether support for particular KBE activities predicted their use by the teacher in the target class, we used the following measures.

From the teacher questionnaire, we chose six KBE-type activities. In particular, the teacher was asked whether or not ICT was used for the following activities: (1) extended projects; (2) short-task projects; (3) production creation (making a model or a report); (4) self-accessed courses and/or learning activities; (5) scientific investigations (open-ended) and (6) field study activities. From the technical questionnaire, we chose items that corresponded directly to the above teacher items. That is, technical personnel were asked to what extent was technical support available for teachers who wanted to use those listed KBE-type activities. Responses ranged from no support to extensive support. Not applicable was also an option. We also reasoned that general ICT support may also play a role in whether or not ICT is used for KBE-type activities. As such, we included from the principal questionnaire five items summatively combined that indicated frequency of support from a variety of colleagues. This scale, referred to as *colleague support*, displays reasonable internal consistency in this sample $(\alpha = 0.75)$.

We also used as a general measure of school support for KBE activities eight summatively combined principal questionnaire items regarding actions in the past few years that would support KBE activities or ICT use. Actions included (1) re-allocating the workload to allow for collaborative planning for innovations in the classrooms; (2) re-allocating the workload to allow for the provision of technical support for innovations; (3) organizing workshops to demonstrate the use of ICT-supported teaching and learning; (4) meeting teachers to review their pedagogical approach; (5) establishing new teacher teams to coordinate the implementation of innovations in teachers teaching and learning; (6) changing class schedule to facilitate the implementation of innovations; (7) implementing incentive schemes to encourage teachers to integrate ICT in their lessons;

(8) encouraging teachers to collaborate with external experts to improve their teaching and learning practices. This scale, referred to as *school support*, also displays reasonable internal consistency in this sample $(\alpha = 0.71)$.

Analysis methods

To answer our first research question regarding the level of agreement between teacher and principal KBE values, we produced contingency tables for each math and science teacher and principal goal. Each table featured principal responses along the columns and either math or science teacher responses along the rows. Each cell in the table indicated the number of teachers who responded in a particular way with respect to a given goal compared with that teacher's associated principal's response. Given that both respondents indicated the degree to which they value a particular goal and (in most circumstances), four response options were possible (from low value of a goal to high value of a goal), cells on the diagonal are considered to be agreement between teachers and principals on a particular goal.

We also considered cells that were off diagonal by one position as a general level of agreement. That is, if a teacher said that they do not value a particular goal at all and the associated principal said that she disagreed that a particular goal was important, we said that this was general agreement. We allowed for this additional level of leniency because the response options between teachers and principals were not identical. For instance, principals were asked "To what extent do you agree or disagree that the school leadership (you and/or other school leaders) encourages Mathematics and Science teachers at Grade <target grade> to achieve the following goals?" Principals could respond on a scale from one to four with the categorical options *Strongly disagree*, *Disagree*, *Agree*, *Strongly agree*. Correspondingly, teachers were asked “In your teaching of the target class in this school year, how important is it for you to achieve the following goals?” Teachers could respond on a scale from one to four with the categorical options *Not at all, A little, Somewhat, Very much*. We reasoned that a teacher response of *Not at all* was probably not different in kind to a principal response of *Strongly disagree* and *Disagree*, and so on.

As a strict measure of agreement between teachers and principals we also considered Cohen’s kappa (Cohen, 1960); however, most measures of agreement were so low (<0.05), this strict criteria for agreement was abandoned. Instead, we considered several criteria to decide whether teachers and principals were in general agreement on the importance of KBE-type ICT goals. First, we looked at the proportion of principals in each country who indicated that they agree or strongly agree that a particular goal is important. If the proportion was greater than two-thirds, we said that principals generally valued a particular goal. We next looked the proportion of teachers who indicated that achieving particular goals was somewhat important or very important. The same criterion of two-thirds was used to determine if teachers generally value particular goals. Finally, we looked at the contingency tables for each goal. If 20% of teachers responded more than one position off diagonal in the contingency tables, we said that there was a meaningful level of disagreement between teachers and principals regarding the importance of KBE-type ICT goals. For instance, teachers who thought a particular goal was not at all important while their associated principals agreed or strongly agreed that the same goal was important were counted toward the proportion of teachers in disagreement with their principals regarding the importance of given ICT goals. Whether or not principals or teachers valued goals and whether there was general agreement was noted to inform further analysis and to get an overall impression of which goals were the most important for each country.

In an effort to answer our second research question regarding relationship between ICT support for KBE-type activities and ICT use for KBE-type activities in the classroom, we developed several logistic regression models by country for both mathematics and science teachers. Each model used as the response whether or not a given teacher used ICT for six KBE-type activities listed in the *Measures* section. Logistic regression models were of the form:

$$\text{logit}(\pi) = \alpha + \beta_1(\text{ICT support}) + \beta_2(\text{colleague support}) + \beta_3(\text{school support}) .$$

In each of these models, ICT support, colleague support and school support predict the probability π that a given teacher uses ICT for a particular KBE-type activity. We reasoned that increased ICT support for KBE-type activities would significantly predict the use of ICT on these KBE-type activities.

Results

Math teachers: Goal agreement

Regarding goal agreement between principals and teachers, across all goals, and in nearly country, the majority of principals agreed that the school leadership encouraged both mathematics and science teachers to achieve the six KBE-type goals. Exceptions to this trend included only South Africa with respect to responsible Internet use and Finland

and Norway with respect to learning from experts. Regarding the following goals, (1) providing activities which incorporate real-world examples/settings/applications for student learning; (2) fostering students' collaborative and organizational skills for working in teams and (3) fostering students' ability and readiness to set their own learning goals and to plan, monitor and evaluate their own progress, mathematics teachers in nearly every country also felt that it was somewhat important or very important to achieve these goals. Exceptions to this trend included only France and Hong Kong on collaborative and organizational skills. Given the high level of agreement on these three goals, we only report in Table 2 notable value disagreement for the three remaining goals.

In Table 2, across all three remaining goals, a number of notable disagreements exist in several countries. In all cases of disagreement, these value disagreements are characterized by high levels of principal valuation contrasted with low levels of teacher valuation. Interestingly, teachers from many countries held learning from outside experts and responsible Internet behavior in low esteem.

Table 2. *Notable disagreement between principals and math teachers on the valuation of KBE-type goals.*

	To foster students' communication skills in face-to-face and/or online situations	To provide opportunities for students to learn from experts and peers from other schools/countries	To prepare students for responsible Internet behavior and/or to cope with cybercrime
Country	Value disagreement	Value disagreement	Value disagreement
Chile		X	
Chinese Taipei	X	X	X

Denmark	X	X	X
Estonia			
Finland			
France	X	X	X
Hong Kong		X	X
Israel		X	X
Italy			X
Japan		X	X
Lithuania			
Norway		X	
Russian Federation			X
Singapore		X	
Slovak Republic			
Slovenia		X	X
South Africa			X
Thailand		X	

Science teachers: Goal Agreement

As was true with mathematics teachers, science teachers across all surveyed countries highly valued the following goals (1) providing activities which incorporate real-world examples/settings/applications for student learning; (2) fostering students' collaborative and organizational skills for working in teams and (3) fostering students' ability and readiness to set their own learning goals and to plan, monitor and evaluate their own progress, mathematics teachers in nearly every country also felt that it was somewhat important or very important to achieve these goals. Exceptions to this trend included only Chinese Taipei and goal (3). Similar to mathematics results, we only report the results for the remaining three goals.

In Table 3, a number of notable value disagreements exist. In many countries, teachers diverge from their principals regarding the valuation of learning from experts and responsible Internet use. While a few countries differ between mathematics and science, results are generally consistent.

Table 3. *Notable disagreement between principals and science teachers on the valuation of KBE-type goals.*

	To foster students' communication skills in face-to-face and/or online situations	To provide opportunities for students to learn from experts and peers from other schools/countries	To prepare students for responsible Internet behavior and/or to cope with cybercrime
Country	Value disagreement	Value disagreement	Value disagreement
Chile		X	
Chinese Taipei	X	X	X
Denmark		X	X
Estonia			
Finland			
France	X	X	X
Hong Kong		X	X
Israel			X
Italy			X
Japan		X	X
Lithuania			
Norway			
Russian Federation			X
Singapore		X	X
Slovak Republic			X
Slovenia		X	X
South Africa			X
Thailand			

Math teachers: Support for and practice of KBE-type ICT activities in the class for extended projects

We first discuss the results for the model where support from colleagues, support from the school, and the availability of ICT support for extended projects predict the odds that math teachers use ICT for extended projects in the target class. Results are presented in general, detailed tables for this and the remaining models can be found in Appendix A. In most cases, we no consistent cross-country pattern with regard to ICT support for extended projects and teachers' use of ICT on extended projects. Exceptions to this finding included Chinese Taipei, South Africa, and Thailand. On average, teachers in Chinese Taipei had about half as high odds of using ICT on extended projects when some ICT support for extended projects was available compared to when support was not applicable. This was similarly true when extensive support was available. In other words, the availability of support reduced the odds that teachers used ICT for extended projects. In contrast, the availability of some or extensive ICT support of extended projects more than doubled the odds that a teacher would use ICT for extended projects in South Africa. Extensive ICT support increased the odds of using ICT for extended projects in Thailand.

Other notable findings for this model were a positive effect of school support in Chile and a positive effect of colleague support in Finland, France, Japan and South Africa. In these countries the odds of using ICT for extended projects were increased by about ten to 15 percent for a one-unit increase in school support.

Science teachers: Support for and practice of KBE-type ICT activities in the class for extended projects

Similar to the mathematics results, we found no consistent pattern of association between support for and use of ICT on extended projects in general. However, exceptions occurred. We found that ICT support for extended projects was positively associated with the odds of using ICT for extended projects in Chile, the Russian Federation, Slovakia and South Africa. Notably, science teachers in South Africa who were offered extensive ICT support for extended projects had 12 times higher odds of using ICT than teachers who had no support. We also found small positive effects for colleague support in Slovakia and Singapore and a small negative effect for colleague support in Estonia. Similarly, small positive effects for school support were present in the Russian Federation and Slovakia. In both cases, odds of using ICT were increased by about 10 percent for each unit increase in school support.

Math teachers: Support for and practice of KBE-type ICT activities in the class for short task projects

In Israel and the Russian Federation colleague support was positively associated with ICT use on short-task projects. In both countries, the odds were increased by about 10%. In Italy, increased school support is associated with 18% increase in the odds of using ICT for short-task projects. In the Russian Federation, no ICT support for short task projects significantly decreased the odds of using ICT for short-task projects. In particular, the odds of using ICT support are only about 1/5 as high as teachers for whom support for short term projects was not applicable. In South Africa, we again find a strong association between support for and use of ICT. In particular, the odds of ICT use for projects significantly are about seven and five and a half times given some support or extensive support for short-task projects, respectively.

Science teachers: Support for and practice of KBE-type ICT activities in the class for short task projects

In Estonia, the Russian Federation and Singapore, we found negative effects for ICT support for short task projects on the odds of using ICT in these types of projects. In contrast, France, Slovakia and South Africa showed significantly positive associations between support for ICT and use of ICT on short task projects. Again, the odds in South Africa were about 12 times as high for teachers receiving extensive support than for teachers receiving no support. With respect to school support, the Russian Federation was the only country who exhibited significant effects, with an increase in the odds of about 22 percent. Similarly, colleague support in Singapore and Slovenia increased the odds of using ICT for short task projects by about 10 percent.

Math teachers: Support for and practice of KBE-type ICT activities in the class for production projects

In France and Russia, colleague support was a significant predictor of using ICT for production projects. In particular, increases in colleague support increased the odds of using ICT for production projects by about 20% in France and 8% in the Russian Federation. Again in South Africa, strong positive associations exist between ICT support for production projects and ICT use in production projects. In particular, some support for production projects increases the odds of using ICT by more than 500% and extensive support increases the odds of using ICT by 1000%.

Science teachers: Support for and practice of KBE-type ICT activities in the class for production projects

While only two countries were found to have an association between support for and use of ICT for production projects, the magnitude of the effects in Lithuania and South Africa are quite large. In South Africa, moderate support for ICT is associated with approximately six times higher odds of using ICT, while extensive support is associated with more than eight times higher odds of using ICT for production projects. In Lithuania, the odds of science teachers using ICT for production projects given that extensive ICT support was provided are over 24 times higher than teachers for whom support was not an option. In much smaller magnitude, colleague support was significant in the Russian Federation and Thailand. Finally, school support in Estonia and the Russian Federation was associated with the odds of using ICT in production projects. In both cases the odds are increased by about 20 percent.

Math teachers: Support for and practice of KBE-type ICT activities in the class for self accessed activities

Colleague support was an important predictor for ICT use in self-accessed activities in Chile and Thailand. In both countries, increases in colleague support increased the odds of using ICT for self-accessed activities by about 10%. In Chile, Norway and the Russian Federation, we find significantly positive effects for some or extensive ICT support for self-accessed activities. In all three countries, we find that the effect of extensive support is consistently stronger than just some support. In Slovakia and Chinese Taipei, a lack of ICT support for self-accessed activities is associated with significantly reduced odds of using ICT for self-accessed activities.

Science teachers: Support for and practice of KBE-type ICT activities in the class for self accessed activities

In Taiwan and Singapore, teachers had about one-fifth to one-third as high odds, respectively, of using ICT for self-accessed activities when ICT support for those activities was provided. In contrast, some support approximately doubled the odds of using ICT in Israel and Finland, while the odds in South Africa were markedly higher given moderate to extensive ICT support (11 – 18 times higher). Finally, extensive support also doubled the odds of using ICT for self accessed activities in Israel.

In Estonia, school support was negatively associated with using ICT on self-accessed activities; however, Slovakia and the Russian Federation both exhibited significantly positive effects for school support, where the odds were increased by about 15 percent. Finally, colleague support in Finland and Thailand was significantly, yet only slightly, associated with increased odds of ICT use. In both countries, the odds were increased by about 10 percent.

Math teachers: Support for and practice of KBE-type ICT activities in the class for scientific investigation

Colleague support was a significant predictor of ICT use in scientific investigations in Thailand where the odds were increased by about 13%. School support in Finland was a significant predictor of ICT use in scientific investigations where incremental increases in school support resulted in about a 26% increase in the odds of using ICT for scientific investigations. ICT support for scientific investigations was positively associated with ICT use for scientific investigations in Thailand. Notably, in

Thailand extensive support for ICT in scientific investigations increased the odds of using ICT in scientific investigations by about 950%. In contrast, some ICT support for scientific investigations reduced the odds of using ICT in scientific investigations in Estonia.

Science teachers: Support for and practice of KBE-type ICT activities in the class for scientific investigation

In Lithuania, teachers who received no support had about one-sixth the odds of using ICT for scientific investigations when compared to teachers for whom support was not an option. Norwegian and Russian Federation teachers who had moderate or extensive ICT support for scientific investigations, respectively, had more than four times higher odds of using ICT. Slovakia and Thailand both had significantly positive effects for school support. In both countries, the odds were increased by 16 percent for each unit increase in school support.

Math teachers: Support for and practice of KBE-type ICT activities in the class for field study activities

We found significantly positive effects for colleague support on the odds of using ICT in mathematics field study activities in Israel and Slovenia. We also found significantly positive effects for ICT support on the odds of using ICT in field study activities in Italy, the Russian Federation and South Africa. Notably some support increases the odds of using ICT in field studies by more than 900% in South Africa. An eighteen-fold increase in the odds of using ICT in field study activities is associated with extensive ICT support for field study activities in the Russian Federation. Additionally extensive ICT support for field study activities in Italy is associated with nearly a 250% increase in the odds of using ICT in field study activities.

Science teachers: Support for and practice of KBE-type ICT activities in the class for field study activities

Moderate ICT support for field study activities was a significant predictor of ICT use for science field study activities in Italy and the Russian Federation, where the odds of using ICT were 2.75 and 3.71 times higher, respectively. In Israel and Thailand, colleague support was significantly associated with ICT use for field study activities. In both countries, about a 10 percent increase in the odds of using ICT was found.

Discussion and Conclusion

Our results show that based on principal self-reported measures, principals in surveyed countries emphatically agree that KBE-type goals are an important focus in their schools. In general, associated teachers also generally value the same sets of goals. However, we found that where exceptional levels of disagreement existed, it was always in terms of teachers placing a lower value on particular goals than their principals. This may be the result of poor communication flows between teachers in principals in the noted countries; however, it could also be an issue of principals systematically answering in a socially acceptable way. That is, principals highly endorsed all items that they believe to be important for the community or policy makers. On the other hand, teachers are generally not saddled with the responsibility of community intermediary and therefore can more honestly answer questions regarding values. It may be that future research on the ways ICT-related educational goals are communicated in schools might prove useful in exploring this issue.

We found that the goals where the most notable disagreement occurred were in terms of bringing in outside experts from other schools or countries and preparing students for responsible internet behavior. Given the nature of these goals, it is reasonable to expect wide-spread discrepancies. First, bringing in outside experts, particularly from other countries is likely an untenable option in most schools around the world and is particularly problematic in less economically developed nations. Second, it may be that teachers view responsible Internet use as a value best taught in the home and not strictly the responsibility of teachers. Given the massive investment and rapid adoption of ICT around the world in addition to the importance of KBE education for economic development and global competitiveness, attention should be paid to the ways in which teachers understand the goals of KBE and ICT and how they operationalize these goals in the classroom. As a frequent and direct contact with children around the world, teachers are the conduit for sharing 21^{st} century skills and it is worth investigating the occurrences and correlates of ICT use for KBE learning.

In terms of the availability of ICT-support for KBE activities and the odds of using ICT for KBE-type activities, the results are largely country dependent. In general, we found that for each KBE-type activity, a small handful of countries displayed an association between ICT support and ICT use on KBE-type classroom activities. While we generally found no consistent pattern across countries for ICT-support and ICT-use, South Africa consistently deviated from these findings. That is, ICT-support for KBE activities was highly associated with the odds of utilizing ICT for nearly every KBE-type activity. This could be of interest to South African policy makers in the development and support for national projects that align themselves with the ICT focused MDGs.

As noted above, our findings show that, in general, regardless of country, principals acknowledge the importance of all KBE teaching practices. That international organizations' rhetoric (such as the OECD's report and the MDGs) has penetrated this deeply into educational systems internationally is telling; however, the degree to which educators (who have direct contact with students) understand and operationalize these goals is notably different. The SITES study provides us with a valuable resource to examine how teachers and principals view KBE practices. Further research is needed to understand the possible relationships between teachers' view of KBE and students' knowledge of KBE practices.

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Appendix A

Model Details

Table 4. *Support predicting practice for extended projects.*

Mathematics Achievement

Country	Significant effects	Estimate	P-value	Odds
Chile	School support	0.14	0.02	1.15
Chinese Taipei	Some support	-0.75	0.02	0.47
	Extensive support	-0.93	0.01	0.39
France	Colleague support	0.16	0.04	1.17
Japan	Colleague support	0.14	0.04	1.15
South Africa	Colleague support	0.12	0.00	1.13
	Some support	2.01	0.00	7.46
	Extensive support	2.45	<0.01	11.59
Thailand	Extensive support	1.62	0.04	5.05

Science Achievement

Country	Significant effects	Estimate	P-value	Odds
Chile	Extensive support	0.7	0.04	2.01
Estonia	Colleague support	-0.12	0.02	0.89
Russian Federation	Extensive support	0.99	0.01	2.69
	School support	0.19	0.00	1.21
Slovak Republic	Some support	1.14	0.04	3.13
	Extensive support	1.25	0.03	3.49
	School support	0.1	0.02	1.11
South Africa	Some support	1.86	0.01	6.42
	Extensive support	2.53	0.00	12.55

Table 5. *Support predicting practices for short term projects.*

Mathematics Achievement

Country	Significant effects	Estimate	P-value	Odds
Italy	School support	0.17	0.00	1.19
Russian Federation	Colleague support	0.11	0.01	1.12
	No support	-1.53	0.02	0.22
South Africa	Some support	1.93	0.00	6.89
	Extensive support	1.70	0.02	5.47

Science Achievement

Country	Significant effects	Estimate	P-value	Odds
Estonia	Some support	-1.49	0.03	0.23
	Extensive support	-1.75	0.01	0.17
Russian Federation	No support	-0.91	0.04	0.40
	School support	0.20	0.00	1.22
Singapore	Extensive support	-0.73	0.02	0.48
Slovak Republic	Some support	0.71	0.00	2.03
	Extensive support	0.85	0.00	2.34
Slovenia	Colleague support	0.13	0.01	1.14
South Africa	Some support	1.75	0.03	5.75
	Extensive support	2.45	0.01	11.59

Table 6. *Support predicting practices for production projects.*

Mathematics Achievement

Country	Significant effects	Estimate	P-value	Odds
France	Colleague support	0.19	0.01	1.21
Russian Federation	Colleague support	0.08	0.04	1.08
South Africa	Some support	1.68	0.01	5.37
	Extensive support	2.31	<0.01	10.07

Science Achievement

Country	Significant effects	Estimate	P-value	Odds
Estonia	School support	0.24	0.01	1.27
Lithuania	Some support	2.94	0.01	18.92
	Extensive support	3.19	0.01	24.29
Russian Federation	Colleague support	0.1	0.02	1.11
	School support	0.16	0.01	1.17
South Africa	Some support	1.78	0.03	5.93
	Extensive support	2.11	0.01	8.25
Thailand	Colleague support	0.09	0.02	1.09

Table 7. *Support predicting practices for self-accessed activities.*

Mathematics Achievement

IDCNTRY	Significant effects	Estimate	P-value	Odds
Chile	Colleague support	0.10	0.01	1.11
	Extensive support	1.51	0.01	4.53
Chinese Taipei	No support	-0.96	0.04	0.38
Norway	Some support	1.14	0.04	3.13
	Extensive support	1.44	0.04	4.22
Russian Federation	Some support	2.06	0.01	7.85
	Extensive support	2.54	0.01	12.68
Slovak Republic	No support	-1.38	0.04	0.25
Thailand	Colleague support	0.10	0.01	1.11

Science Achievement

IDCNTRY	Significant effects	Estimate	P-value	Odds
Chile	School support	0.16	0.03	1.17
Chinese Taipei	Some support	-1.00	0.02	0.37
Estonia	School support	-0.19	0.02	0.83
Finland	No support	0.79	0.04	2.20
	Some support	0.97	0.02	2.64
	Colleague support	0.11	0.01	1.12
Israel	Some support	0.71	0.02	2.03
	Extensive support	0.59	0.04	1.80
Russian Federation	School support	0.16	<0.01	1.17
Singapore	No support	-1.51	<0.01	0.22
	Some support	-1.23	<0.01	0.29
	Extensive support	-0.92	0.01	0.40
Slovak Republic	School support	0.11	0.01	1.12
South Africa	Some support	2.41	0.02	11.13
	Extensive support	2.90	0.01	18.17
Thailand	Colleague support	0.08	0.04	1.08

Table 8. *Support predicting practices for scientific investigations. .*

Mathematics Achievement

Country	Significant effects	Estimate	P-value	Odds
Estonia	Some support	-1.26	0.01	0.28
Finland	School support	0.23	0.01	1.26
Thailand	Colleague support	0.12	0.00	1.13
	Some support	1.92	0.04	6.82
	Extensive support	2.25	0.02	9.49

Science Achievement

Country	Significant effects	Estimate	P-value	Odds
Lithuania	No support	-1.79	0.03	0.17
Norway	Some support	1.48	0.04	4.39
Russian Federation	Extensive support	1.58	0.02	4.85
Slovak Republic	School support	0.15	0.01	1.16
Thailand	School support	0.15	0.02	1.16

Table 9. *Support predicting practices for field study activities.*

Mathematics Achievement

Country	Significant effects	Estimate	P-value	Odds
Israel	Colleague support	0.10	0.04	1.11
Italy	Extensive support	0.86	0.04	2.36
Russian Federation	Extensive support	2.93	0.04	18.73
Slovenia	Colleague support	0.16	0.01	1.17
South Africa	Some support	2.21	0.01	9.12

Science Achievement

Country	Significant effects	Estimate	P-value	Odds
Israel	Colleague support	0.08	0.01	1.08
Italy	Some support	1.01	0.03	2.75
Russian Federation	Some support	1.31	0.00	3.71
Thailand	Colleague support	0.10	0.02	1.11