Law, N., Niederhauser, D. S., Christensen, R., & Shear, L. (2016). A Multilevel System of Quality Technology-Enhanced Learning and Teaching Indicators. *Educational Technology & Society, 19* (3), 72–83.

A Multilevel System of Quality Technology-Enhanced Learning and Teaching Indicators

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ABSTRACT

In this paper we elaborate and extend the work of the EDUsummIT 2015 Thematic Working Group 7 (TWG7) by proposing a set of indicators on quality Technology-Enhanced Learning and Teaching (TEL&T). These indicators are intended as one component of a set of global indicators that could be used to monitor implementation of the Education 2030 agenda, which aims to "Ensure inclusive and equitable quality education and promote life-long learning opportunities for all." The proposed indicators address conditions at the student, teacher, school and system levels, and are organized in a systemic framework to help foreground interactions and interdependencies within and across the different levels. This framework highlights the need for longitudinal, multilevel designs in evaluation studies of TEL&T implementations, which will also contribute to a better understanding of the links between policy, policy implementation, outputs, and outcomes. Sample indicators are presented to illustrate the framework, and suggestions are made for use of the framework in evaluation studies. Further, the proposed framework could be used to underpin the development of an open, worldwide collaborative of educational evaluation researchers, practitioners and policymakers, thereby adopting a crowdsourcing approach to systematically address the complex challenges in evaluating quality TEL&T.

Keywords

Technology-Enhanced Learning, Indicators, Quality learning, Multilevel, Systemic change

Introduction

Improving quality of education is one of the six goals of the Education for All (EFA) Framework for Action that was slated to be achieved by 2015 (UNESCO, 2000). Representatives from 164 governments met in April 2000 in Dakar, Senegal and committed to:

Improving all aspects of the quality of education and ensuring excellence of all so that recognized and measurable learning outcomes are achieved by all, especially in literacy, numeracy and essential life skills. (p. 8)

According to the EFA Global Monitoring Report (UNESCO, 2015a), there have been impressive improvements across the world in access to education during this time, but quality of educational experiences and attainment of measurable learning outcomes both within and between countries have been extremely variable. There have been numerous cross-national assessments of education quality during this fifteen-year period, including four TIMSS and three PIRLS studies (http://timssandpirls.bc.edu/), six PISA studies (https://www.oecd.org/pisa/aboutpisa/), and the ICILS 2013 study (http://www.iea.nl/icils_2013.html), as well as multiple regional studies (e.g., the studies conducted by the Southern and Eastern Africa Consortium for Monitoring Educational Quality (SACMEQ, http://www.sacmeq.org/?q=about-sacmeq) and the Latin American Laboratory for Assessment of the Quality of Education (LLECE) (http://www.unesco.org/new/en/santiago/education/education-assessment-llece/). One major critique of these studies is their narrow focus on cognitive learning outcomes. Conceptions of quality education should be broadened to include outcomes such as attitudes and dispositions (Knezek & Christensen, 2008; Williams & Engel, 2013), and social and emotional outcomes (Learning Metrics Task Force, 2013).

Quality of teachers, faculty training opportunities, quality of learning materials, the nature of the learning environment, and school leadership all contribute to student learning outcomes in important ways (Burns & Darling-Hammond, 2014; OECD, 2013). Studies of quality learning and teaching should include the conditions for learning at multiple levels of the education system, including conditions that support teachers and school leaders, as well as students (Jaquith et al., 2015; Law, Kampylis & Punie, 2015). A shortcoming of existing large scale studies of student achievement is that these are cross-sectional studies, lacking longitudinal data to shed light on the effects of

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different conditions and interventions such as regional or national education reforms (Goldstein, 2004; Schmidt & Burroughs, 2013; Christensen, 2015) and discount the multiple levels that exist in education.

The education agenda for the next fifteen years was set at the World Education Forum held in Incheon, South Korea in May of 2015. The Forum culminated in the Incheon Declaration report, *Education 2030: Towards inclusive and equitable quality lifelong learning for all* (World Education Forum, 2015), which defined high quality education as education that:

… fosters creativity and knowledge, and ensures the acquisition of the foundational skills of literacy and numeracy as well as analytical, problem-solving and other high-level cognitive, interpersonal and social skills. It also develops the skills, values and attitudes that enable citizens to lead healthy and fulfilled lives, make informed decisions, and respond to local and global challenges through Education for Sustainable Development (ESD) and Global Citizenship Education (GCED). (p. 7-8)

Although the overarching goal of the declaration report was broad and holistic in scope, authors recognized the central role that technology should play in addressing these goals, stipulating that: "Information and communication technologies (ICTs) must be harnessed to strengthen education systems, knowledge dissemination, information access, quality and effective learning, and more effective service provision (p. 2);" and calling for comprehensive systems to monitor and evaluate the implementation of the EFA goals at national and international levels.

An appropriate set of indicators lies at the core of any system of evaluation (Bryk & Hermanson, 1993)**.** For those countries that might choose to adopt such indicators, they could be used to measure progress and inform decision-making for continuous improvement at the national policy-making level, and provide global monitoring data for the UNESCO Institute for Statistics as called for in the Incheon declaration. Designing a systemic assessment approach, and identifying an appropriate set of indicators, was the focus of the EDUsummIT 2015 Thematic Working Group (TWG) for *Indicators of Quality Technology-enhanced Learning and Teaching*, with specific objectives to:

(1) Develop a literature-based conceptual model of the impacts of ICT implementation strategies on multiple levels of the education system: including individual, classroom, school, district and system levels.
(2) Identify a core set of quality indicators for technology-enhanced teaching and learning at the different levels based on the above conceptual framework.
(3) Develop a preliminary mapping of the indicators to existing cross-national studies, and common national/institutional monitoring and evaluation mechanisms.

Objectives were addressed within the TWG7 working group, and shared across the other working groups, during intensive meetings over a two-day period at EDUsummIT 2015. This article elaborates on a brief summary of the outcomes of those discussions (Law, Niederhauser, Shear & Christensen, 2015) with regard to developing a multilevel conceptual framework for the design of quality Technology Enhanced Learning and Teaching (TEL&T) indicators (Objective 1), and providing a preliminary sketch of the kinds of quality indicators that would contribute to such a framework (Objective 2). Objective 3 is beyond the scope of the present paper.

Indicators for quality TEL&T: Meaning and scope

Integrating the use of digital technology into the learning and teaching process to improve the quality of learning outcomes has become an important strategy for improving educational quality, and is often referred to as Technology-enhanced Learning and Teaching (TEL&T). Technology-Enhanced Learning (TEL) is an increasing focus for educational policy makers, school leaders and teachers around the world as technological literacy becomes progressively more important in the global society. Many countries have launched national policies that promote integrating TEL into the school curriculum (Plomp et al., 2009), with the US launching its first national technology plan in 1996; Singapore developing four IT Masterplans since 1997; the UK introducing its National Grid for Learning in 1997; and Malaysia launching its Smart Schools program in 1996. The policy level rationale for emphasizing TEL is not only to improve learning outcomes, but to also transform the learning process and foster new capabilities necessary for leading healthy and fulfilled lives, make informed decisions, and respond to local and global challenges in the 21st century (World Education Forum, 2015). UNESCO (2008) proposed a policy framework that aligned national educational goals and curriculum, and the role of information and Communications Technology (ICT) in teaching and learning, with the state of economic development. While the extent to which the UNESCO

document influences the formulation of national TEL master plans and strategies in different countries is not clear, it is evident that policy makers generally recognize the increasing importance of ICT in social and economic development, and the need to prepare citizens (particularly the school age population) for life in a knowledge-based society in which basic literacy and numeracy skills are no longer sufficient. Education in a digital age must prepare learners with information literacy skills as they use technology to communicate, collaborate, and problem-solve (Partnership for 21st Century Skills, 2003)—all necessary skills for successful participation in developed economies.

What kinds of indicators would be needed to investigate the extent to which the vision of providing quality TEL&T has been achieved? At a basic level, we would need indicators for measuring students' *learning outcomes*. Since 21st century learning outcomes (e.g., problem solving and collaboration) go beyond specific knowledge or skills that can be taught and assessed directly, indicators are needed that will inform us of the students' conceptual understanding, actions and interactions as they engage in the learning process. In fact, literature on TEL&T over the past two decades shows a clear need for implementing more effective teaching and learning practices if we are to achieve more ambitious metacognitive, social emotional, attitudinal, and learning outcomes (Law, Pelgrum & Plomp, 2008; OECD, 2013). Hence indicators for quality TEL&T should include indicators for *learning processes and practice*s. We also know that learning processes and interactions do not take place in a vacuum, but are embedded in *conditions for learning*, which include the physical, social, cultural and digital aspects of the learning environment. Another crucial set of indicators should relate to the digital tools used and the roles the tools play in learning interactions, or *e-learning use*.

The four italicized categories of indicators described above refer to indicators for student learning. However, studying these aspects of student learning in isolation would not provide us with a holistic picture to enable a comprehensive understanding of the conditions that contribute to student learning. In the literature, both in TEL&T and in educational reform and innovation, there is wide recognition that changing pedagogical practices requires a deep level of teacher learning (Looi & Teh, 2015), which involves the acquisition of new knowledge, skills and competencies as well as changes in values and beliefs about learning, assessment and appropriate ways to use technology with their students. Hence, we must include indicators related to teachers' knowledge, skills and beliefs when determining indicators for quality TEL&T.

In turn, the teaching and learning practices that occur in schools are very much influenced by leadership and contextual factors at school and system levels. Thus, there is a need for a multilevel set of indicators that will help us understand and monitor the extent to which the goals of quality TEL&T have been achieved and better understand the factors contributing to student achievement.

Challenges to developing a set of quality TEL&T indicators Fit for national and global comparisons

Many countries have made heavy investments in infrastructure, teacher professional development and digital learning resources in the implementation of their TEL masterplans. Most of these countries have their own evaluation mechanisms, but unlike the case of scientific or medical research, where there is typically a set of commonly agreed upon indicator standards and conventions (as well as established requirements for data collection and analysis), educational researchers tend to develop their own instruments. One reason for this is that different indicators are needed to serve different research contexts and purposes. However, one often encounters very similar indicators and instruments in the TEL&T literature that share the same broad conceptual framework and methodological approach, but cannot be easily linked or compared because of differences in methodology and nature of the indicators. There are also differences in the expertise of those conducting the research, and varying levels of support for TEL&T research in different countries. Reflecting on the monitoring of the Millennium Development Goals (MDG; UNESCO, 2000), the UN System Task Team (2013) pointed to the need for well-coordinated and professionally staffed statistical services at national and international levels in order for global monitoring to be realized. Adequate monitoring is a resource intensive process, requiring both funds and expertise—which is particularly challenging for developing countries. Further, any system of monitoring at a system-wide level is necessarily limited in its scope and the scale of data collection.

A systemic multilevel framework to conceptualize quality indicators for TEL&T

To address the challenges discussed above, we elaborate in this paper a conceptual framework for the development of a set of indicators for evaluating TEL&T, and provide illustrations on the types of indicators that will be needed. Based on the definition of quality learning within the framework of Education 2030, the focus for TEL&T is not simply to help students learn more effectively what they have traditionally been learning. Rather, it is to develop lifelong learning capabilities by providing learning opportunities that would not be otherwise accessible to a given group of students (World Education Forum, 2015). A rich body of literature shows the need for innovations in pedagogy, curriculum and assessment to achieve such outcomes (e.g., Voogt & Knezek, 2008). Consequently, TEL&T initiatives need to be supported by strategies and mechanisms for teacher learning, leadership learning and organizational learning. Further, the biggest challenge to the implementation of ICT-enabled learning innovations is their scalability (Kampylis, Law & Punie, 2013). Studies on change, innovation and sustainability all point to the need for the change to be multilevel (Blamire & Gerhard, 2009; Law, Kampylis & Punie, 2015). Student learning takes place at the core of the education ecosystem, situated within classroom contexts, which in turn are dependent on hierarchically nested conditions such as teacher learning, leadership practices and infrastructure at the school level, and policies and practices at the system level (Davis, 2008). Changes that takes place at each level impact other levels as interactions occur within and across levels (Davis, Eickelmann & Zaka, 2013).

Level	Conditions for learning	Learning interactions	e-Learning use	Learning outcomes
Student	• **School ICT** • **Home access** • **Curriculum** • **Pedagogy** • **Assessment**	• **Collaborative inquiry** • **Peer assessment** • **Field investigation**	• **E-portfolio** • **Student generated content**	• **4Cs** (critical thinking, comm., creativity, collaboration) • **digital literacy**
Teacher	• **School vision** • **Staff appraisal** • **PD opportunity**	• **School-based co-planning** • **Joint-school project on e-learning innovation**	• **School intranet for sharing/ discussion** • **Joint school project website**	• **Teachers' TPCK** • **Learning & assessment design expertise**
School	• **National edu policies** • **National e-Learning plans** • **Sch inspection criteria**	• **School-based decision making** • **Joint school leadership circles**	• **School intranet** • **Project website** • **Database for evidence-based decision-making**	• **School ICT infrastructure** • **School vision & e-Learning plan** • **Staff appraisal** • **Timetabling**
System/ policy	• **National digital infrastructure** • **National digital learning resources**	• **Multi-stakeholder committees** • **Monitoring & fact finding visits/ observations**	• **National student/teacher portals** • **Big data infra-structure for evidence based decisions**	• **National edu priorities** • **e-Learning masterplan** • **school inspection criteria**

Figure 1. A diagrammatic representation of the interrelationship among the different levels of indicators (adapted from Law, Niederhauser, Shear & Christensen, 2015)

While there are multilevel models that analyze the influence of pedagogy and school level factors on student learning (e.g., Fraillon et al., 2014), there is no model of interaction among the factors within each level, nor is there an explicit model that differentiates the mechanisms through which factors at different levels influence students' learning outcomes. This results in the common practice of lumping all indicators from the different levels collected at the same cross-sectional time into a multilevel model. The lack of significant relationships among system-level factors, school factors, teacher factors, and student learning outcomes in large scale international comparative studies discussed earlier is an indication of the shortcomings of the current approach to multilevel modeling. Law (2015) proposed a parsimonious multilevel learning model to underpin the conceptualization of the many indicators

involved in TEL&T. This model (see Figure 1) considers the changes happening at student, teacher, school and system levels in the process of TEL&T implementation, building on the literature that highlights the interdependencies of the changes taking place across the different levels (Davis, Eickelmann & Zaka, 2013; Law, Kampylis & Punie, 2015).

The indicators listed in Figure 1 are not meant to be exhaustive, but serve to illustrate the interactions and interdependencies across the categories and levels of indicators. At the student level, examples of 21st century skills include critical thinking, communication, creativity, collaboration and digital literacy. The opportunity to learn these skills depends on whether students had opportunities to engage in the types of learning interactions, supported by appropriate e-Learning use such as those presented in the figure (this relationship is illustrated by the arrows #1 and #2 in the figure). These opportunities to learn are in turn influenced by the conditions for learning shown at the student level: the school ICT infrastructure, home access to ICT, the pedagogy adopted by the teacher, etc. (illustrated by the arrows #3 and #4). As the literature on TEL&T demonstrates, such conditions do not present themselves as a direct outcome of a policy stipulation, but involve complex emerging and interacting processes (Kozma, 2003; Kampylis et al., 2013). Taking the condition of pedagogy as an example, this requires that the teacher possesses Technological Pedagogical Content Knowledge (Mishra & Koehler, 2006), and learning and assessment design expertise (Laurillard, 2013). These professional capacities can be conceptualized as learning outcomes at the teacher level (arrow #5 in Figure 1), which are in turn dependent upon the opportunities to learn (learning interactions and e-Learning use) and the conditions for learning available to the teachers concerned.

The conditions for teacher learning in turn depend on school level factors such as the vision, professional development opportunities and staff appraisal system at the school level (arrow #6 in Figure 1). Similarly, the emergence of these school level factors depends on the system level factors such as national education policies, e-Learning masterplans and school inspection criteria (arrow #7 in Figure 1). These “factors” are not static, and changes require a process of interaction and decision-making among stakeholders. By categorizing these factors as learning outcomes at the school and system levels, we wish to highlight the fact that changes in these factors may be transient (as in superficial learning) and may not be sustainable unless there is deep engagement by the relevant stakeholders at the institutional/system level in the deliberation of these changes. In addition, stakeholder interactions can be designed and scaffolded to facilitate decisions that are aligned with the overall desired direction of pedagogical change.

There are two important benefits of adopting this framework in the development of TEL&T indicators. First, the factors to be considered at each level can be categorized into the same four groupings: learning outcomes, conditions for learning, learning interactions, and e-learning use. E-learning use refers to ICT use that specifically supports the relevant learning interactions. As indicated by the red arrows in Figure 1, students’ learning outcomes are influenced by the learning interactions and e-learning use of students, which are in turn are influenced by the conditions of learning available, such as school ICT infrastructure, pedagogy and assessment practices. Similar relationships exist across the four groups of factors at each of the other three levels.

A second benefit of grounding the indicators framework in a multilevel learning model is that it provides a theoretical guide to hypothesizing the causal connections among the factors across different levels. Students’ learning outcomes will feedback on the conditions for learning at the other three levels as these will strengthen or challenge the assumptions about learning, pedagogy, assessment and the role of ICT in supporting learning that underpin conditions such as the curriculum, school vision, national e-Learning plans, school inspection criteria, and national digital learning resources. The learning outcomes at the three higher levels affect the conditions for learning, learning interactions and e-learning use at other levels. For example, the teachers’ learning outcomes (TPCK, learning and assessment design expertise) influences the pedagogy and assessment practice as experienced by their students as conditions for learning; national strategies to support joint school/e-learning innovation projects (as system-level learning outcomes) provide opportunities for learning interactions at the teacher level; and staff appraisal criteria (as school-level learning outcomes) is one of the conditions influencing teacher learning.

In the following sections, we will provide an initial elaboration of the indicators under the four groupings at each level, as discussed in TWG7 at the EDUsummIT and supported by appropriate literature.

Student level indicators for TEL&T

In this section, we describe the kind of student level indicators suggested for inclusion during the EDUsummIT 2015 Workshop. Student learning is the focal goal of the educational system, which requires support and aligned learning interactions from many levels including teacher, school and system/policy. Around the world, preparation of students for constructive participation in our global society will require use of technology to effectively communicate ideas, and to collaborate locally and internationally to solve common problems.

Technology readiness involves more than just technological literacy skills. "Students will spend their adult lives in a multi-tasking, multifaceted, technology-driven, diverse, vibrant world – and they must arrive equipped to do so" (Partnership for 21st Century Skills (P21), 2003, p.4). Students must not only learn to use information technology (IT) but also to be ready to use technology for learning. Technology plays a major role in the definition of 21st Century skills, critical thinking, problem-solving, communication, and collaboration. This set of skills is commonly referred to as digital literacy (Resta et al., 2011, p. 3). According to ISTE Standards for Students, "students use critical thinking skills to plan and conduct research, manage projects, solve problems, and make informed decisions using appropriate digital tools and resources" (ISTE, 2007, p. 1).

Based on the above, indicators of TEL&T *learning outcomes* include:

- Students' ability to demonstrate digital literacy by selecting the appropriate technology tool for a required task
- The ability of students to take responsibility for their appropriate uses of technology including safety in interacting with others online, appropriate sharing of information on social media sites, limiting the amount of time spent on technology
- Students' demonstration of the skills necessary to organize, analyze, evaluate and communicate their ideas with others using digital resource
- The ability of students to demonstrate critical thinking in using digital resources to tackle unfamiliar, authentic and open-ended problems
- The extent to which students use digital tools to work productively with peers and subject matter experts

While systemic changes may be taking place in schools, changes in pedagogy and the learning environment may take more than a year or two before their impact on student learning becomes measurable. Indicators could be statements on a continuum to measure the levels of progress towards good practice. Based on the literature in this area (Fraillon et al., 2014; Sankey et al., 2014; ISTE, 2014) and discussions at EDUsummIT 2015, *conditions for learning* for students should include indicators to answer the following *types* of questions:

- To what extent do students have personal access to a variety of digital resources to complete school assignments?
- Are students provided with appropriate skills and access to communication tools for enhanced learning opportunities?
- To what extent are students given choices in the selection of topics to study and the application of personal learning strategies?

Once the basic conditions for learning are in place, how students use technology for enhanced learning is important. The indicators for *learning interactions* include:

- How does technology support the students' ability to revise their work based on peer, teacher and expert feedback?
- In what way does technology support the learner to be in charge of collaborative exploration of authentic problems?
- Does technology allow students to better self-reflect and self-monitor their learning?

Student indicators discussed in this section imply corollary teacher, school and system level indicators that need to be in place to monitor and evaluate holistically the technology enhanced learning ecosystem.

Teacher level indicators for TEL&T

Teacher-level factors, like access to technology, frequency of use and amount of teacher professional development, have frequently been assessed when examining TEL&T in schools. However, TWG7 teacher-level indicator subgroup participants felt it was more important to examine HOW teachers use ICT with their students to support the kind of learning outcomes that will prepare students to lead healthy and fulfilled lives, make informed decisions, and respond to local and global challenges as advocated in the Incheon Declaration (World Education Forum, 2015) and to ensure they develop the 21st century skills that will allow them to do so. How teachers choose to integrate ICT use into their practice is intrinsically linked to their personal belief systems about teaching and learning, which exert powerful influences on teachers' curricular decision-making and their pedagogical practice (Niederhauser & Stoddart, 2001).

It is relatively easy to track factors like the number of Internet-connected computers to which teachers have access, the number of hours teachers used technology with students, and time teachers spent in professional development activities. Examining intrapersonal factors like teachers' technological knowledge and skills, confidence in their ability to use technology and the value they perceive in using technology to aid in the teaching/learning process, the depth of knowledge they have in the content they are teaching, and their beliefs about how students learn, is a much more challenging endeavor. We will need to move beyond the kinds of self-report surveys and questionnaires that have been the norm up to this point and include research methods that draw on ethnographic research traditions like observation and interviews that take place over extended periods of time.

Based on the literature in this area and TWG7 teacher-level indicator subgroup discussions at EDUsummIT 2015, indicators of teachers' *learning outcomes* could include personal attributes and observable behavior, as exemplified in questions 1-3 and questions 4-5 below respectively:

(1) To what extent do teachers have positive self-efficacy and outcome expectations that will motivate them to effectively integrate technology into their practice?
(2) To what extent have teachers developed knowledge and expertise that allows them to engage in pedagogy that support the kinds of learning outcomes associated with helping students develop 21st century skills?
(3) To what extent do teachers have deep knowledge of the content they are teaching that would allow them to teach using the pedagogical practices advocated by current reform efforts?
(4) To what extent do teachers integrate technology into the curriculum in ways that promote meaningful learning?
(5) To what extent do teachers provide activities that require the learner to use appropriate technologies while engaged in collaborative exploration of authentic problems?

Extensive research has shown that professional development opportunities that are hands-on, sustained, and focused on student learning, have a significantly more positive effect on teaching practices than more traditional workshops (e.g., Darling-Hammond & Richardson, 2009), as do professional communities that provide collaborative ongoing supports (Vescio, Ross, & Adams, 2008). Indicators for *learning interactions* of teachers should include:

- Do teachers have opportunities to undertake collaborative lesson planning and assessment design for TEL&T?
- Do teachers have opportunities to peer-observe TEL&T lessons and to receive support for reflective practice such as action research?
- Do teachers have opportunities to engage with peers and school leaders in joint identification and exploration of drivers & obstacles to TEL&T?

Teachers need to be provided with the necessary *conditions for learning* in order that the above learning interactions can take place, and indicators for these include:

- Do teachers have access to technology (including learning analytics) and technological pedagogical support to design, implement, assess and provide feedback to students' collaborative inquiry?
- Do teachers have, in their schools, organizational routines and structures to support collaborative co-design, peer learning, and an open, trusting and collaborative culture for sharing and risk taking?
- Do teachers have, in their schools, a formal role and organizational mechanisms for them to participate in decision-making on curriculum, assessment and TEL&T developments?

The successful implementation of TEL&T in the classroom implies support from school and system levels.

School level indicators for TEL&T

As described above, successful implementation of TEL&T in the classroom entails a complex transition for many teachers, requiring not only the use of new tools but the adoption of new models of teaching. School-level indicators, then, focus on the types of support that school-level leadership, cultures, and resources can provide to support teachers through the transition and to sustain that support over time. This section focuses on four commonly-recognized elements (e.g., Kennisnet, 2014): opportunities for professional learning, access to technology, curriculum resources, and leadership and vision.

The most common indicators tracked for professional development often relate to access and dosage, such as the number of hours teachers spend in professional development courses related to TEL&T. On the other hand, teachers' practices will not be changed by increasing access and dosage per se, but rather by professional learning opportunities that support professional collaboration and reflective practice. A similar principle applies for the relationship between the level of digital infrastructure/technical support available and the quality of TEL&T implemented in a school. Common basic measures (e.g., UNESCO, 2015b) include pupil-to-computer ratios and access to electricity, connectivity, and other elements of infrastructure that allow their use. Further indicators such as technical support to teachers and learners, the bandwidth and reliability of Internet access during the school day, and digital learning resources are also important in mature implementations to support strong integration of ICT into teaching and learning without disruption. Research findings indicate that the pedagogical potentials of digital infrastructure and resources are often not realized (Cuban, 2009). Availability alone will not have impact on teachers' practices unless teachers perceive these to be in response to their professional aspirations and needs. This requires the conditions of learning for teachers to be school level decisions made as a consequence of teachers' professional explorations in TEL&T (i.e., teacher learning) *and* the participatory decision-making process involving different stakeholders (i.e., school level learning). Conceptualizing the indicators of conditions for teacher learning as *indicators of school level learning outcomes* helps to highlight the need to take account of the dynamic, interactive history of these indicators in predicting how these may contribute to a school's capacities to implement TEL&T for quality learning in students.

The *conditions for learning* and *learning interactions* at the school level depend greatly on the availability of school routines such as co-planning and peer observations, timetabling, and staffing arrangements to support a productive architecture for learning (Stein & Coburn, 2008). Hence indicators of *conditions for learning* and *learning interactions* at the school level are closely related conceptually to the literature on instructional leadership (Robinson, Lloyd, & Rowe, 2008; Leithwood et al., 2004), including a clear vision for teaching and learning. Indicators related to instructional leadership and vision may include the frequency of various leadership activities, both central and distributed, and more qualitative indicators of the leadership supports perceived by teachers (e.g., Bryk et al., 2010). Additional measures examine not just the existence of vision statements, but the focus and the degree of guidance given to support 21st century educational outcomes (Twining, 2014).

An additional set of indicators for *conditions of learning* at the school level relate to system level factors. Vision and goals for TEL&T, priorities for staff and infrastructure development, as well as strategies and leadership practices at the school level are heavily influenced by educational policies and strategies at the system level, including:

- Whether TEL&T is a national educational priority, and if so, the nature of its vision;
- Whether the national curriculum, assessment, school inspection/accountability and teacher accreditation systems are aligned with an emphasis on nurturing 21st century skills such as learner self-direction and collaborative inquiry;
- Whether there are policy level structures and mechanisms to support TEL&T innovations, such as joint-school innovation projects, quality circles, sharing of good practices, etc.

System level indicators for TEL&T

The system level factors that constitute conditions of learning at the school level described in the previous section are in themselves *system level learning outcomes*. This is because national educational priorities, TEL&T goals and strategies and associated implementation mechanisms are in themselves products of negotiations and decision-

making processes at the system level; and such processes constitute learning interactions at the system level. Indicators of *learning interactions* at the system level include:

- The extent to which different stakeholders are involved in the policy discussions;
- The extent to which decision-making is informed by authentic explorations of TEL&T implementation in different school and community contexts;
- Whether there are mechanisms to promote sharing of experiences across schools, districts and regions in the TEL&T implementation process;
- Whether there are monitoring, evaluation and feedback mechanisms to fine-tune the system level factors (i.e., improve the system level learning outcomes) as the implementation progresses.

The *conditions for learning* at the system level are macro conditions outside of the arena specific to the education system. Examples of these indicators include:

- GDP of the country;
- National digital infrastructure such as broadband penetration and home ownership of computational devices;
- Extent to which the political system allows/encourages democratic discussion and community participation in policy decisions.

Discussion and conclusion

In this paper we elaborate and extend the work of the EDUsummIT 2015 Thematic Working Group 7 (TWG7) by proposing a set of indicators on quality Technology-Enhanced Learning and Teaching (TEL&T) as one component of a set of global indicators that could be used to monitor implementation of the Education 2030 agenda. The core contribution of our work is to propose a multilevel system of quality indicators that can be used for the monitoring and evaluation of TEL&T implementations. Quality learning that fosters 21st century outcomes requires student-centered, collaborative, inquiry-oriented learning interactions that are vastly different from the mainstream pedagogical practices currently found in classrooms. Achieving quality TEL&T student outcomes will require interdependent changes at all levels of the educational system. The proposed model conceptualizes factors influencing TEL&T implementation that result from school and system level decisions as learning outcomes at these respective levels. This model of indicators highlights that evaluations should not only focus on the magnitude of these *learning outcomes* factors, as their impact on TEL&T implementation depends very much on how far the stakeholders within and across the different levels had opportunities to engage in learning interactions (i.e., interaction that promote the sharing and alignment of vision, understanding and concerns) during the decision-making process. We have also argued for the need to go develop more informative indicators by drawing on ethnographic research traditions that take place over extended periods of time.

An important implication of this paper is the need for a systemic approach to the design of indicators in evaluation studies of TEL&T. This indicators framework highlights the need for all stakeholders (policy makers, funders, educators and researchers) to take account of the different timespans typically involved for the learning interactions to lead to observed learning outcomes. It provides a framework to identify which sets of indicators need to be included for the purpose of a specific study, and to avoid overlooking the key interdependent indicators. It also calls for multilevel, longitudinal evaluation designs in evaluation (Goldstein, 2004).

For policy makers and funders, this framework can be used to guide the selection of indicators that matter most in the context of the policy goals and initiatives. In particular, it is not adequate to simply measure policy input and student learning outcomes, and should also include indicators of learning processes and learning outcomes at all levels. By making the interdependencies of the different indicators explicit, mechanisms can also be established for these indicators to influence policy and decision-making.

For educators, institutional leaders and practitioners, the conceptual framework can be used to guide the selection and use of indicators to provide feedback and ensure alignment across contexts, processes and outcomes within a level. The appropriate choice of indicators can also provide feedback on whether the changes taking place at the focal level (e.g., teacher or school level) is aligned with what is needed and what is happening at other levels.

For researchers, this multilevel system of indicators can also serve as a framework to facilitate an open "crowdsourcing" approach to collaboration within the educational evaluation research community, similar to the open-source software development communities. Currently this is just a bold idea, which clearly requires support from the global research community as well as resources and expertise support from international research agencies to establish the necessary statistical infrastructure, quality criteria and guidelines, and protocols for the sharing of indicators and data. Such a development will potentially stimulate collaboration among researchers within and across national boundaries at an unprecedented scale, and help to address the global evaluation challenge for Education 2030. It will also allow us to build more holistic theories of connected learning: learning of students, teachers, schools, leaders and policy-makers as a connected system.

Acknowledgements

We are grateful for the contributions of the working group members of the EDUsummIT 2015 Thematic Working Group 7, who include, in addition to the authors, the following: Linda Shear, Esther Care, David Smith, Jonghwi Park, Bent Andresen, Hans van Bergen, Deirdre Butler, Allan Christie, Jill Downie, Tania Broadley and Louise Starkey. Nancy Law acknowledges that her contribution to this work is supported by the Hong Kong Research Grants Committee Humanities and Social Sciences Prestigious Fellowship Scheme # 37600414.

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