Evolving learning paradigms: Re-setting baselines and collection methods of information and communication technology in education statistics

David Gibson[1], Tania Broadley[2] Jill Downie[3] & Peter Wallet[4]

[1]David Gibson//david.c.gibson@curtin.edu.au [2]Tania Broadley //tania.broadley@qut.edu.au /[3]Jill Downie //j.downie@curtin.edu.au // /[4]Peter Wallet//p.wallet@unesco.org

ABSTRACT

The UNESCO Institute for Statistics (UIS) has been measuring ICT in education since 2009, but with such rapid change in technology and its use in education, it is important now to revise the collection mechanisms to focus on how technology is being used to enhance learning and teaching. Sustainable development goal (SDG) 4, for example, moves beyond measures of access and increasingly focuses on the sustainability of education including issues of educational quality and student outcomes. A reassessment of how ICT in education is measured to support the attainment of the SDGs by 2030 is thus a timely endeavour. The paper discusses four aspects: 1) evolving mission, methods and core principles of ICT in learning and teaching; 2) nature of ICT in education in accelerating the emergence of new learner-centred pedagogies; 3) types of learning activities associated with the use of ICT including those for leaders, teachers and students; and 4) usage and deployment patterns. This paper proposes extensions and adaptions to the existing UIS data collection instrument to enrich its capacity for understanding how ICT is being used in learning and teaching.

Keywords

Evolving learning paradigms; ICT; learner-centred pedagogies; teaching and learning indicators.

Introduction

Since 2000, there has been enormous progress towards achieving global education targets as part of the Millennium Development Goals and *Education for All* targets including making progress towards universal primary education, greater numbers of girls in school, falling numbers of out-of-school children, and a dramatic increase in literacy rates. In the new Sustainable Development Goals (SDGs), goal 4 reaffirms the belief that education is one of the most powerful and proven transformative vehicles for sustainable development. This goal ensures that all girls and boys complete free primary and secondary schooling by 2030. It also aims to provide equal access to affordable vocational training, to eliminate gender and wealth disparities, and achieve universal access to a quality higher education. ICT in education and its significant role was also recently recognized at the International Conference on ICT and Post-2015 Education where Article 10 states: "Successful integration of ICT into teaching and learning requires rethinking the role of teachers and reforming their preparation and professional development. It calls for promoting a culture of quality in all its aspects: staff support, student support, curricula design, course design, course delivery, strategic planning and development." (UNESCO, 2015).

While information on the physical infrastructure of ICT in primary and secondary education has been collected and studied during the last decade (Scimeca et al., 2009; UIS, 2009), understanding the impact of ICT on pedagogical processes and educational outcomes is paramount for the next stage of policy and implementation. However, measuring the usage patterns of information and communication technology (ICT) in teaching and learning is a challenge for any country. Two challenges arise in particular: the local relevance of the information and the focus of that information on improving the experience of teaching and learning with educational technology. For example, the problematic validity of data sources has been noted by a World Bank report from the Systems Approach for Better Education Results (Trucano, 2012), when a collection activity "comes from data sources outside of the education sector itself and does not appear to be gathered according to common methodologies and definitions." Large-scale efforts such as the International Computer Information Literacy Study (ICILS) (Fraillon, Ainley, Schultz, Friedman, & Gebhardt, 2013) provide useful information for comparable systems views but often leave local educators without actionable information. The proposed indicators attempt to address these two issues of validity and relevance to local schools.

Studying the introduction of new technology in education some thirty years ago, Plomp & Akker (1988) noted the lack of research-based knowledge about usage patterns such as the method, frequency and intensity that teachers

were using computers to enhance learning as well as the resulting impact on educational practice including the school curricula. This finding still resonates today with current research that often fails to provide hard evidence of the impact of ICT on teaching and learning. While government policies often focus on implementation of infrastructure, access to technology, and teacher professional development, there is still not much known about the implementation and impacts of ICT in learning and teaching practices in many parts of the world. A 2011 report on Latin America and the Caribbean, for example, noted significant gaps and a clear lack of records concerning educational technology implementation (Hinostrosa & Labbe, 2011). Uma & Arulchelvan (2012) confirm in a study in India that there is a dearth of information about student use of technologies; while students are using ICT extensively outside of school, they engage in limited usage for formal in-school learning purposes and still rely primarily on traditional classroom teaching and textbooks for academic progress. In Africa and the Middle East, Isaacs (2012) noted that for many years, the focus of investments was on making successive waves of new technologies work in resource-poor education environment; an emphasis that tended toward a techno-centric approach to ICT in education.

To a large extent schools in some countries are still teaching a series of disconnected subjects using methods and structures that compromise motivation, engagement and deeper learning for superficial coverage of material expected on tests (Baker, 2007; Black, 2000; Koch & DeLuca, 2012). In contrast, the evolving paradigms of learning discussed in this paper, which have come from massive shifts caused by ICT practices in the global economy and culture, are beginning to change how people learn in informal and lifelong learning contexts and are emerging as best practices in formal educational systems. How quickly, how extensive and to what ends they are emerging depend on local education policy, funded commitments, access, schooling culture, teacher capacity and professional development, the adoption of lessons from learning sciences and sufficient reflective experience in the integration of ICT in teaching and learning.

The interaction between the teacher and the learner is also being transformed and expanded by technology-enabled interactions and capabilities. The implications for teachers in terms of roles, pedagogy and approaches is well documented in the UNESCO ICT Competency Framework for Teachers (UNESCO, 2008). While some developed countries are advancing with ICT through the use of emerging tools and practices such as open educational resources (OER), social networking and a flattened world of information and communication technologies, other countries are progressing more slowly due to a variety of financial and policy constraints.

Beginning to address the gaps in knowledge about the use and impact of ICT in education and indicative of the evolving paradigms of learning with technology, the ICILS 2013 collected information from students, teachers, school technology coordinators and school principals. The constructs of that instrument point to a shift away from collecting information about infrastructure and access toward the use of technology to achieve educational benefits, especially preparing students to participate fully in the digital age. Computer and information literacy in this context is defined as "an individual's ability to use computers to investigate, create, and communicate in order to participate effectively at home, at school, in the workplace, and in society" (Fraillon, Schulz, & Ainley, 2013, p.17). Our proposed changes to international indicators follow as well as contribute new ideas to this trend.

The foundation for this paper stems from a vision to build capacity in global youth to support the goals of a knowledge economy and to achieve increased levels of digital literacy across society.

> VISION: A student who graduates from secondary education is ready for lifelong learning and using ICT for personal and professional productivity. Such a student is ready to use ICT to contribute to society, start a business, succeed in tertiary education, and to start or work for a local or global company.

The paper provides recommendations for new global indicators that go beyond basic infrastructure to focus on evolving learning paradigms for ICT in education. The primary focus is on *what teachers and students are doing with ICT to enhance learning* country-by-country, school-by-school, and classroom-by-classroom. The proposed dimensions for the indicators form a framework for baseline and annual progress monitoring using core ideas of what it means to be a successful global citizen with a high level of ICT literacy. Furthermore, in order to represent a holistic dataset of the global education system, this paper highlights the growing need for inclusion of data at the post-secondary level, thereby including the higher (tertiary) education sector in all aspects of the new indicators, including the need for disaggregated data by gender, location and socio-economic status to shed light on internal disparities within countries to support policymaking that aims to ensure there is balance in providing access to ICT and educational opportunities in order to maximize all human potential.

Previous data collections on how ICT is used in teaching and learning

A recent study, which summarizes 25 previous meta-analyses based on more than 40 years of research, concluded that computer use in the classroom does have an overall positive effect on achievement (Tamim et al., 2011). International and national student assessments have attempted to establish some relationships between usage of computers and student outcomes. For example, the International survey data from the Programme for International Student Assessment (PISA) of 15-year-old students in OECD countries sheds some light on the relationship between intensity or time using computers and performance in mathematics and science. For many countries in reading, mathematics and science, performance scores are generally curvilinear, whereby students not using computers during class as well as those using computers the most score higher than those using computers in moderation (OECD, 2015).

Caution should be taken when interpreting the OECD data however, since: i) lower-performing students are often assigned disproportionate time using computers for remedial purposes; ii) it is difficult to isolate the influence of home computer use on school performance; and iii) not all countries have successfully integrated ICT in pedagogically meaningful ways. One interpretation of the failure of ICT usage to be positively related with high student achievement is that building deep, conceptual understanding and higher-order thinking requires collaborative social interactions with peers and experts, often missing in ICT implementation (Griffin, McGaw, & Care, 2012; Webb & Gibson, 2015), where inappropriate use of technology can distract from this valuable human engagement. Another interpretation is that we have not yet become good enough at the kind of pedagogies that make the most of technology (Webb, 2011). The importance of training teachers to effectively use ICT in the classroom and supporting curricula with effective ICT tools and learning platforms that enhance learning instead of replicating traditional instruction within a digital environment cannot be over-emphasized. Finally, since PISA does not use experimental designs, and usage data are based on students' self-reports thereby possibly introducing reporting biases, so inferring cause-effect relationships and over-interpretation of the data should be avoided. In order to better understand the effects of usage on performance, further analysis of the types of activities undertaken by pupils may shed light on how to improve ICT in education.

The international student assessment study known as Trends in International Mathematics and Science Study (TIMSS) moves beyond usage intensity to collect among other areas data on type of computer usage and student achievement for pupils in several developed and developing countries. For example in mathematics data are collected on computer usage for i) exploring principles and concepts, ii) looking up information, iii) processing and analyzing data, and iv) practicing skills and procedures, while in science data are collected on computer usage for i) looking up information, ii) studying natural phenomenon using simulations, iii) practicing skills and procedures, iv) doing procedures and experiments, and v) processing and analyzing data (Martin et al., 2012; Mullis et al., 2012). While country-by-country analyses of these usage patterns have begun, the relationships between use and outcomes are still unclear and require more systematic study.

At the national level, Brazil's Regional Center for Studies on Information and Communication Technologies for the Development of the Information Society (Cetic.br), under the auspices of UNESCO, has been conducting specialized surveys on ICT aimed at the regular production of statistics on access to and use of information and communication technologies in different segments of society, providing important input for the process of formulating sector-based public policies. Started in 2010, one of these surveys is "ICT in Education", which investigates the use of computers and the Internet in public and private schools (elementary and secondary) in urban areas of Brazil. The survey drew on work conducted by the *International Association for the Evaluation of Educational Achievement* (IEA) released in two publications: *Sites 2006 Technical Report: Second Information Technology in Education Study* and *Sites 2006: User Guide for the International Database* as well as the UNESCO *Guide to Measuring Information and Communication Technologies (ICT) in Education* from the UNESCO Institute for Statistics. Despite its limitations to an urban sample, the survey has become increasingly important for understanding the current scenario and trends related to the pedagogical use of new technologies and the Internet in Brazilian schools, especially in terms of the role of teachers as key agents for the dissemination of ICT in educational institutions.

This sampling of current collection instruments indicates the global shift that is occurring to better understand what learners and teachers are doing with technology, and forms a backdrop for recommendations to improve the UNESCO Institute of Statistics collection instrument.

Recommendations for the UNESCO Institute of Statistics Data Collection Instrument

An analysis of literature as well as policies and practice from around the world were undertaken, which included analyzing the existing UIS indicators (UIS, 2014). From that basis the team developed research-based recommendations for strengthening the data collection post 2015. A panel of experts was convened at UNESCO headquarters in Paris in December 2015, which provided extensive feedback to the resulting new indicators draft during a four-hour critical review and discussion session, which further shaped and validated the framework. UNESCO selected 10 panel members as part their role in authoring additional white papers aimed at informing deliberations concerning global data collection by the UNESCO Institute of Statistics. The recommendations in this paper have been organized in sequence with the current Questionnaire on Statistics of Information and Communication Technologies (ICT) in Education (UIS, 2014). In each section, a brief research-based rationale is presented for the recommendations.

A. General Information

The current survey probes five questions in relation to government policy, initiatives, incentives and equity. It is recommended that the updated survey:

- Collect new information on the response rate by total number of schools, by public and private sector, and compare the response rate in both categories in order to gauge the level of participation and to add validity to the results.
- Move the field labelled 'main data source' into a relationship to each item to track its data source as needed.

B. Policy and Curriculum

Ministers of Education are currently asked to provide data on policy and curriculum, including laws or regulatory mechanisms to promote the use of ICT in education and laws that address equity in favour of a number of disadvantaged groups, including females, minorities and rural people. The section also asks if there is a basic course on computer skills or computing, and which subjects (Mathematics, Natural Sciences, Social Sciences, etc.) have recommendations to use ICT to support teaching and learning. Finally, the section asks about the intended instructional time in basic computer skills and using ICT across the curriculum, and if there are accredited teacher education programs that include ICT-enabled distance education components. We recommend to add questions concerning:

- The development of leadership and training in ICT
- Emerging themes beyond basic computing involved in using computers to promote learning across the curriculum.

Recommended indicators for leadership & teacher training themes

Several authors and international organizations have emphasized having adequate infrastructure, technical support, and policies that encourage infrastructure usage by all students (International Society for Technology in Education, 2008; Kozma, 2003; Voogt & Knezek, 2011). For example, in their study of policies in Latin America and the Caribbean Hinostrosa & Labbe (2011) note that relatively few countries incorporated systems for evaluating policy implementation, half of the countries did not include enhanced student learning in policy, and twenty percent had not yet incorporated basic ICT competency into their curricula. Going beyond the basic conditions, educational systems must also take account of the changing context of knowledge, tools and practices of ICT that have impacted economics, science and culture across the world and have implications for education that extend from the science of learning through to the expectations of learners, and further to new horizons for curriculum and pedagogy (New Media Consortium, 2014). For example, the global shift toward the knowledge economy has created an acute need for *deeper learning* by larger and larger numbers of people, and so it is necessary to create and sustain ICT practices

in education that support personalization, social community learning, acquisition of knowledge and expertise, and timely, effective formative performance feedback as outlined by the EDUsummIT forums (Gibson & Webb, 2013).

The EDUsummIT community involves 200 researchers, practitioners and policymakers from around the world who collaborated on the current status and research-based practices of ICT in education in nine theme areas since the program was established (Voogt & Knezek, 2013). The theme areas, which build on and extend the science of learning and global best practices in ICT in education into a *systems view of education,* have been studied and validated by over 200 researchers from around the world since the early 2000's (Voogt & Knezek, 2008) and are reviewed every two years. Results from this research and reporting are available at www.curtin.edu.au/edusummit. Defined below are recommended items with edited texts from the international EDUsummIT reports:

- *School-Community Partnerships*

New forms of partnerships are critical to new forms of schooling. The international dialog has evolved from a definition of public-private and informal-formal partnerships to a complex and evolving ecosystem of relationships of schools and society. Ministers and school leaders need to understand how this ecosystem responds to policy and funding as well as the progress of the science of learning and research on education. Davis, Eickelmann, & Zaka (2013) for example, indicate the relevance of considering the co-evolution of pedagogy and technology.

- *Mobile Learning*

There has been a gradual shift of understanding in the theory and practice of mobile learning in the last ten years, from a techno-centric perspective focusing on the attributes and affordances of the technology, to a learner-centred perspective focusing on the mobility of the learner (not just space and time, but also access to people and resources) and contexts (Kukulska-Hulme, Sharples, Milrad, Arnedillo-Sánchez, & Vavoula, 2009). One example of such a perspective is provided by Sharples, Taylor, & Vavoula (2007), who define mobile learning as "the process of coming to know through conversations across multiple contexts among people and personal interactive technologies" (p. 225). Mobile learning is also closely linked to informal learning, which is characterised by "personal ownership of codified knowledge, user-generated ideas, user-constructed contexts...personal and contextualised, and controlled by the learner" (Laurillard, 2009). Learner control and agency is thus at the heart of mobile learning and both personalised and collaborative learning opportunities can be afforded by mobile technologies. The field has thus begun to see development of theories of mobile learning (e.g., Sharples, Taylor, & Vavoula, 2007; Laurillard, 2007).

- *Educational Equity*

Digital divides exist between countries, including between girls and boys, women and men, rural and urban areas (McConnaughey & Sloan, 1995), young and old people (Becker, 2000; Fox & Madden, 2006), poor and rich people (Eamon, 2004), persons with or without disabilities, indigenous and "foreign" people, and 'haves' and 'have nots' (Resta, 2011). As stressed by van Dijk & Hacker (2003), the digital divide is a complex and dynamic phenomenon, one that is multifaceted. DiMaggio & Hargittai, (2001) suggested five dimensions along which the gender, age and socioeconomic inequalities may exist: 1) inequality in technical apparatus; 2) inequality in autonomy of use; 3) inequality in skill; 4) inequality in the availability of social support; and 5) variation in the purposes for which people use the technology.

- *Assessment*

It has been recognised that assessment serves a range of formative and summative purposes. It is also clear that there are opportunities for IT-based assessments to serve 21st century learning goals including higher order thinking skills and deep knowledge (Gibson & Webb, 2013). The importance of assessment as a learning context has come to the fore and is particularly evident and arising in virtual performance assessment (Clarke-Midura, Code, Dede, Mayrath, & Zap, 2012; Pirnay-Dummer, Ifenthaler, & Spector, 2010; Webb & Gibson, 2015) where the experience of the assessment can be a learning engagement (Mislevy, Steinberg, & Almond, 2003). With the emergence of "big data" the need to develop assessment literacy (Stiggins 1995) in teachers and other users has

become even more important. Teachers need to understand the advantages and limitations of assessment types and processes and become confident in developing and analysing valid arguments from evidence (Black et al. 2010).

- *Creativity in the Curriculum*

This emerging research item refers to many forms of creativity, entrepreneurship, innovation, and non-verbal problem-solving, particularly when using ICT, that lead to new ideas and enhanced thinking skills (Mishra, 2012; Mishra, Cain, Sawaya, & Henriksen, 2013).

- *Indicators of ICT-enhanced Teaching and Learning*

How teaching and learning is enhanced by ICT includes measures of several relevant domains; e.g. learning affordances for critical thinking, communications, creativity and collaboration (Kay & Greenhill, 2011), student characteristics, task and student performance characteristics, and evidence models (Mislevy, Steinberg, & Almond, 1999) to ascertain the extent, costs and benefits of ICT in teaching and learning.

- *Digital Citizenship and Cyberwellness*

Parekh has written extensively on the topic of global citizenship (Parekh, 2008, 2003, and 2002). Rather than arguing for absolute global citizenship, he suggests that "...citizens should be globally orientated, and able to discharge their duties to global others by exercising their responsibilities as democratic citizens and where necessary challenging nationalistic policies which are against the interests of mankind" (Parekh, 2003). This framework would allow the world's citizens to move toward a global orientation; yet, within their region and nation-state contexts. Cyberwellness and keeping safe on the Internet is part of a larger conception of media and information literacy (UNESCO, 2013) which emphasizes the importance of accessing, evaluating and creating knowledge. Information literacy according to Catts & Lau (2008) includes capacities to 1) recognise information needs; 2) locate and evaluate the quality of information; 3) store and retrieve information; 4) make effective and ethical use of information; and 5) apply information to create and communicate knowledge.

- *Computer Science & Informatics in the Curriculum*

To what extent do schools give students learning opportunities in computer science and informatics? Computer science is the study of computation, coding, algorithms and related areas. Informatics is the use of information to solve problems (van Veen, Mulder, & Lemmen, 2004).

While these broad themes provide a foundation for new items that support the evolving paradigms essential for ICT in education, additionally learner-centred engagement and teacher use patterns are also integral to understanding the impact of ICT.

Learner-centred Engagement in the Curriculum

While students need access and support in order to learn with ICT, as important are the types of usage, for example to replace or extend traditional methods of teaching. In Latin America and the Caribbean Hinostrosa & Labbe (2011) point out that the school and teacher's perspective contributed significantly to the variation in learning opportunities from simple operations to creative uses of ICT. While it is therefore important to continue tracking the progress of countries on infrastructure, access and teacher training, *a shift toward learner-centred usage* is of critical importance for evaluating and comparing how students are being prepared for participating in the digital age. The shift toward learner-centred engagement has occurred at the policy level in developing countries for some years; however, it is evident that the implementation of such pedagogies has been fraught with inconsistency. For example, a case study in Namibia attempted to investigate the extent to which teachers (n=145) were implementing learner centred approaches as outlined in reform policy documents. While teacher interviews suggested an understanding of the approach and most teachers reported to be implementing the policy in the classroom, the researcher reported that rote teaching was in fact the main method of instruction (O'Sullivan, 1999). Hinostrosa & Labbe (2011) make almost no

comment on the types of pedagogical usage by teachers and the resulting learning opportunities for students in Latin America and the Caribbean, highlighting the need for new data collection measures and methods.

Teacher Use Patterns

Investigating what students are doing with ICT and which learning activities teachers plan for students when using ICT helps measure how ICT is being used in education. To better understand the impacts of ICT in education and increase the available information for comparison of various contexts, we recommend:

- Adding items concerning the usage patterns (e.g. time on tasks such as searching, working with models, creating, and computing).

Seminal work in seven countries by Stanford Research Institute (SRI) International (Shear, Gallagher, & Patel, 2011) demonstrated "while ICT use in teaching is becoming more common, ICT use by students in their learning is still an exception in many of these schools." Findings from a study in Korea indicate that student teachers who held constructivist beliefs had strong computer efficacy, showed positive attitudes toward ICT in education, and were more interested in using ICT in future teaching practices (So, Choi, Lim, 2005). A more recent ICILS study also confirms that teachers with greatest use are those who are more confident in their abilities, and those who develop higher levels of confidence in using ICT in teaching tend to work in school environments where staff learn together, collaborate in institutional planning, and where there are fewer resource limitations concerning the use of ICT in teaching and learning (Fraillon, Ainley, et al., 2013, p. 23).

C. Government expenditure

The current ICT in education survey instrument attempts to collect data on the total expenditure assigned to ICT infrastructure, including both hardware and software. We recommend that this section be removed from the current survey and be included in the main UIS survey on expenditures. Having a few financial items divorced from the main expenditure survey is not the best option since responding to a few items in the ICT in education survey is hard to respond to resulting in poor quality data. However, we recommend for that survey to include:

- Expenditure on teacher professional development

D. ICT Infrastructure

The current survey asks countries to indicate which education institutions have access to a broad range of infrastructure items, from basic electricity to broadband internet access. The ICILS study found that students from countries with greater access to computers in schools tend to have stronger computer and information literacy skills (Fraillon, Ainley, et al., 2013, p.23). The ICT infrastructure paper by Twining & Davis (2015) commissioned by UNESCO-UIS also addresses infrastructure issues in depth, so the following bulleted recommendations are offered as additional guidelines for survey-based comparisons.

- *Deployment patterns by space and type of access*

In order to understand the usage of ICT, it is recommended that data be collected in terms of 'minutes per week' estimated by the teacher (and even students in the classroom where possible) that focuses on deployment patterns inside and outside the classroom to help triangulate and validate deployment patterns. Documenting the access mode type (e.g. mobile, wireless or wired connections) would be beneficial. By collecting information on where and via what modes students are accessing ICT, comparability among schools will be improved and impacts can be better understood (Table 7).

- *Unique Student Data Records*

To support analyses and understanding of the impacts of ICT on students, schools and systems, we recommend the creation of a unique student identifier, ideally that is unique within the largest system of data collection envisioned (e.g. unique in the country). The unique student identifier (an integer or integer plus alphanumeric student ID code)

is recommended to allow in-depth analytics at the most granular level possible (i.e. individual student) and to prevent duplication of data. If these fields exist, then fine-grained analyses of gender equality issues are supported, otherwise gender and other issues are difficult to detect and validate.

- *Data Elements for Tracking Specific Impacts of ICT Policies*

ICT infrastructure includes data system structures for documenting how key policies drive the impact of using ICT in teaching and learning. Thus, a series of policy level estimations is recommended concerning the movement of schools on three measures that relate to the impact of ICT on teaching and learning: Retention, Student Satisfaction and Learning Analytics.. The survey should ask what percentages of schools are in the following categories: 1. No policy, 2. Policy developed, 3. Implementation planned or piloted, 4. System fully implemented. The fields would be defined as mutually exclusive. 'Policy developed' means that its implementation has not yet been planned or piloted. 'Implementation planned or piloted' moves a school out of the "Policy developed' category. 'System fully implemented' moves a school out of the category 'Implementation planned or piloted.' Each line adds to 100% of the country's schools.

E. ICT Tools

ICT tool allocation by pedagogical use

The types of ICT used in a school are closely aligned with the expected outcomes in that context (Dede, 2008; Vanderlinde, Braak, & Dexter, 2012). Key uses of ICT in schools can be divided into four types: ICT used for learning, ICT used for content or skills assessment, and ICT available for use during non-class time. One way to measure the amount of use in these categories is to count the number of available devices or the student-to-device ratio for these purposes. It is therefore recommended that:

- ICT device allocation numbers be subdivided to provide data on learning, content assessments, ICT skills assessments and devices allocated for free time use. The numbers would not be mutually exclusive, but give an approximate student-to-computer ratio for each of the four types of use.

An alternative measure might be to ask the school administrator to state the student-to-computer ratio available for each activity type.

Emerging paradigms of tool use in ICT in education

The Horizon Reports of the New Media Consortium NMC (2013, 2014) provide a source for comparing ICT uses being contemplated by ICT leaders in education. For over a decade these yearly reports detail the six technologies that will soon impact colleges and universities. The method of the report is based on a survey of current ICT leaders, who provide information about what is on their immediate timeline for adoption and implementation. Thus the reports give a field-based prediction about worldwide directions being taken in ICT in education. It is recommended that:

- Emerging paradigms in the use of ICT tool-based approaches to delivery and learning be tracked for comparison and change over time.
- Estimate the number of years until a policy will be in place and until implementation will begin.

Emerging technologies in recent NMC reports include bring your own device, cloud computing, flipped classroom, games-based learning, learning analytics and the internet of things.

F. Enrolment

Gender and cultural access to ICT

Enrolment statistics play an important role in promoting equal access to knowledge by all sectors of a society including equal opportunities for females and children from all different cultures, regions (urban versus rural), and

socio-economic levels. Gender-sensitive indicators and analysis are valued in national policies and to provide evidence-based information for concrete gender-specific measures such as projects and programmes (UNESCO, 2013). Items are recommended that:

- Use robust methods to identify gender, cultural and other biases.
- Include gender and socioeconomic or cultural analysis of participation in online learning

This latter recommendation recognizes that massively open online learning (MOOCs) can be valid forms of learning and need to be acknowledged (DeFreitas, Gibson, & Morgan, 2015). MOOCs are scalable, free sources of information that are open and available to anyone with access to the Internet. National policies are needed that review and make use of these unique Open Educational Resources to raise the level of education for all people. Schon & Conole (2014) provides a special issue on quality in MOOCs.

G. Teaching staff

ICT Competency Framework for Teachers

A recent UNESCO paper by DuToit "Teacher training and usage of ICT in education: New directions for the UNESCO Institute for Statistics global data collection in the post 2015 context" presents the UNESCO ICT Competency Framework as a guide to professional development of teachers, which suggests that six dimensions of training be provided at three levels. The six dimensions that we recommend new items begin to track include:

- Policy, curriculum and assessment, pedagogy, ICT as tools, organization and administration, and professional learning and the levels are defined as technology literacy (awareness and basic knowledge), knowledge deepening (applying knowledge) and knowledge creation, including self management and sharing knowledge as a model learner.

Conclusion

In order to understand the use of ICT in education in today's society, the indicators of *evolving learning paradigms* need to focus on what teachers and students are doing with ICT in relation to teaching and learning. Usage patterns will be affected by and can be correlated with ICT infrastructure, access to technology and information within the curriculum, and teacher training and support for the implementation of ICT.

The proposed survey items distribute the responsibility for reporting between the ministerial representative, the school administration, and teachers with evidence from students. Policy is led by and reported by the minister, access to tools is reported by the school administrator, and the balance of items are reported by the teacher, with a subset of classroom learning opportunity items confirmed by students.

A limitation of this current research is that the recommendations have not been field-tested. Next steps for future work include refinement of the items, field-testing of the new data collection methods, and if appropriate, adoption into the UIS data collection processes and instruments. The authors stand ready to join in the conversation and contribute to the development of ideas, and we hope that we have provided food for thought for others involved in shaping international data collection to better meet the evolving learning paradigms afforded by ICT in education.

The recommendations are proposed for the purpose of addressing the evolving mission, methods and core principles of ICT in education; the role if ICT in hastening the emergence of learner-centered pedagogies; and to document the types of learning activities and usage patterns that best support full participation in the knowledge society.

References

Baker, E. L. (2007). 2007 Presidential Address The End(s) of Testing. *Educational Researcher*, *36*(6), 309–317. http://doi.org/10.3102/0013189X07307970

Becker, H. (2000). Who's wired and who's not: Children's access to and use of computer technology. *Children and Computer Technology*, *10*(2), 44–75.

Black, P. (2000). Policy, practice and research: the case of testing and assessment. In R. Millar, J. Leach, & J. Osborne (Eds.), *Improving Science Education: the Contribution of Research* (pp. 327–346). Philadelphia: Open University Press.

Catts, R., & Lau, J. (2008). *Towards information literacy indicators*. Paris, France.

Clarke-Midura, J., Code, J., Dede, C., Mayrath, M., & Zap, N. (2012). Thinking outside the bubble: Virtual performance assessments for measuring complex learning. In *Technology-based assessments for 21st Century skills: Theoretical and practical implications from modern research.* (pp. 125–148). Charlotte, NC: Information Age Publishers.

Davis, N., Eickelmann, B., & Zaka, P. (2013). Restructuring of educational systems in the digital age from a co-evolutionary perspective. *Journal of Computer Assisted Learning*, *29*, 438–450. http://doi.org/10.1111/jcal.12032

Dede, C. (2008). Theoretical perspectives influencing the use of information technology in teaching and learning. In J. Voogt & G. Knezek (Eds.), *International Handbook of Information Technology in Primary and Secondary Education* (pp. 43–62). New York: Springer-Verlag.

DeFreitas, S., Gibson, D., & Morgan, J. (2015). Will MOOCS transform teaching and learning in higher education? *British Journal of Educational Technology*, *in press*.

DiMaggio, P., & Hargittai, E. (2001). From the "Digital Divide" to "Digital Inequality": Studying Internet use as Penetration Increases. *Center for Arts and Cultural Policy Studies, Princeton University*, *15*, 1–23. Retrieved from http://www.maximise-ict.co.uk/WP15_DiMaggioHargittai.pdf

Eamon, M. K. (2004). Digital Divide in Computer Access and Use between Poor and Non-Poor Youth. *Journal of Sociology and Social Welfare*, *31*, 91–112. Retrieved from http://unomaha.on.worldcat.org/atoztitles/link?sid=ProQ:&issn=01915096&volume=31&issue=2&title=Journal+of+Sociology+and+Social+Welfare&spage=91&date=2004-06-01&atitle=Digital+Divide+in+Computer+Access+and+Use+between+Poor+and+Non-Poor+Youth&au=Eamon%2C+Ma

Erstad, O., Gilje, Ø., Sefton-Green, J., & Vasbø, K. (2009). Exploring "learning lives": Community, identity, literacy and meaning. *Literacy*, *43*, 100–106. http://doi.org/10.1111/j.1741-4369.2009.00518.x

Fox, S., & Madden, M. (2006). Generations Online. Retrieved from http://www.pewinternet.org/2006/01/22/generations-online/

Fraillon, J., Ainley, J., Schultz, W., Friedman, T., & Gebhardt, E. (2013). *Preparing for life in a digital age: The IEA international computer and information literacy study international report*. Melbourne.

Fraillon, J., Schulz, W., & Ainley, J. (2013). *International computer and information literacy study assessment framework*. Amsterdam, the Netherland. Retrieved from http://www.iea.nl/fileadmin/user_upload/Publications/Electronic_versions/ICILS_2013_Framework.pdf

Fullan, M. (2012). *Stratosphere: Integrating technology, pedagogy and change knowledge*. Toronto, Ontario: Pearson Education.

Gibson, D., & Webb, M. (2013). Assessment as, for and of 21st century learning. In *International Summit on ICT in Education* (p. 17). Torun: EDUsummIT 2013. Retrieved from http://www.edusummit.nl/fileadmin/contentelementen/kennisnet/EDUSummIT/Documenten/2013/6_WCCE_2013-_Educational_Assessment_supported_by_IT_1_.pdf

Griffin, P., McGaw, B., & Care, E. (2012). *Assessment and teaching of 21st century skills*. *Assessment and Teaching of 21st Century Skills*. http://doi.org/10.1007/978-94-007-2324-5

Hinostrosa, J. H., & Labbe, C. (2011). *Policies and practices for the use of information and communications technologies (ICTs) in education in Latin America and the Caribbean*.

International Society for Technology in Education. (2008). ISTE Standards for Teachers. Retrieved from http://www.iste.org/docs/pdfs/20-14_ISTE_Standards-T_PDF.pdf

Isaacs, S. (2012). *Turning on mobile learning in Africa and the Middle East*.

Kay, K., & Greenhill, V. (2011). Twenty-First Century Students Need 21st Century Skills. In *Bringing Schools into the 21st Century* (Vol. 13, pp. 41–65). http://doi.org/10.1007/978-94-007-0268-4_3

Koch, M. J., & DeLuca, C. (2012). Rethinking validation in complex high-stakes assessment contexts. *Assessment in Education: Principles, Policy & Practice, 19*(1), 99–116.

Kozma, R. B. (2003). Global Perspectives: Innovative Technology Integration Practices from Around the World. *Learning and Leading with Technology*, *31*(2), 6-9-54.

Kukulska-Hulme, A., Sharples, M., Milrad, M., Arnedillo-Sánchez, I., & Vavoula, G. (2009). Innovation in mobile learning : A European perspective. *International Journal of Mobile and Blended Learning*, *1*, 13–35. http://doi.org/10.4018/jmbl.2009010102

Laurillard, D. (2007). Pedagogical forms for mobile learning. In *Mobile learning: Towards a research agenda* (pp. 153–175).

Laurillard, D. (2009). The pedagogical challenges to collaborative technologies. *International Journal of Computer-Supported Collaborative Learning*, *4*, 5–20. http://doi.org/10.1007/s11412-008-9056-2

Martin, Michael O, Ina V.S. Mullis, Pierre Foy & Gabrielle M. Stanco (2012b). TIMSS 2011 International results in science. Boston, MA: TIMSS and PIRLS International Study Center/ Lynch School of Education, Boston College.

McConnaughey, J., & Sloan, T. (1995). Falling through the net: A survey of the“ have nots” in rural and urban America. *National Telecommunications & Information Administration*. Retrieved from http://www.ntia.doc.gov/ntiahome/fallingthru.html%5Cnhttp://scholar.google.com/scholar?hl=en&btnG=Search&q=intitle:Falling+through+the+net:+A+survey+of+the+%22have+nots%22+in+rural+and+urban+America#0

Mishra, P. (2012). Rethinking Technology & Creativity in the 21st Century: Crayons are the Future. *TechTrends*, *56*, 13–16. http://doi.org/10.1007/s11528-012-0594-0

Mishra, P., Cain, W., Sawaya, S., & Henriksen, D. (2013). Rethinking Technology & Creativity in the 21st Century: A Room of Their Own. *TechTrends*, *57*, 5–9. http://doi.org/10.1007/s11528-013-0668-7

Mislevy, R., Steinberg, L., & Almond, R. (1999). *Evidence-centered assessment design*. Educational Testing Service. Retrieved from http://www.education.umd.edu/EDMS/mislevy/papers/ECD_overview.html

Mislevy, R., Steinberg, L., & Almond, R. (2003). On the Structure of Educational Assessments. *Russell The Journal Of The Bertrand Russell Archives*, *1*(1), 3–62.

Mullis, Ina V.S., Michael O. Martin, Pierre Foy and Alka Arora (2012a). TIMSS 2011 International results in mathematics. Boston, MA: TIMSS and PIRLS International Study Center/ Lynch School of Education, Boston College.

Organization for Economic Co-operation and Development (2015). Students, computers and learning. Paris: OECD Publishing.

O’Sullivan, E. (1999). *Transformative learning: Educational vision for the 21st century.* London: Zed Books.

Pirnay-Dummer, P., Ifenthaler, D., & Spector, M. (2010). Highly integrated model assessment technology and tools. *Educational Technology Research and Development*, *58*(1), 3–18.

Plomp, T., & Akker, J. van den. (1988). Computer integration in the curriculum: Promises and problems. In *Annual Meeting of the American Educational Research Association* (p. 18).

Resta, P. (2011). *ICTs and Indigenous Peoples*.

Schon, S., & Conole, G. (2014). Quality in MOOCs. *International Journal for Innovation and Quality in Learning*, *September*(3), i–vi.

Scimeca, S., Dumitru, P., Durando, M., Gilleran, A., Joyce, A., & Vuorikari, R. (2009). European Schoolnet: Enabling school networking. *European Journal of Education*, *44*(4), 475–492. http://doi.org/10.1111/j.1465-3435.2009.01407.x

Sharples, M., Taylor, J., & Vavoula, G. (2007). A theory of learning for the mobile age. In *The Sage Handbook of Elearning Research* (pp. 221–247). Retrieved from http://www.telearn.org/open-archive/browse?resource=215

Shear, L., Gallagher, L., & Patel, D. (2011). *Innovative teaching and learning research: 2011 findings and implications*. Seattle, WA. Retrieved from http://www.itlresearch.com/images/stories/reports/ITL Research 2011 Findings and Implications - Final.pdf

Tamim, Rana M., Robert M. Bernard, Eugene Borokhovski, Philip C. Abrami, and Richard F. Schmid (2011). What forty years of research says about the impact of technology on learning: A second-order meta-analysis and validation study. Review of Educational Research, 81(1), pp. 4-28.

Trucano, M. (2012). Information and Communication Technologies. In H. Patrinos (Ed.), *Strengthening education quality in East Asia* (pp. 101–108). Washington D.C.: World Bank.

Uma, M., & Arulchelvan, S. (2012). Usage of ICT among the Students and Teachers and its Impact on their Communication Behaviour. *European Journal of Social Sciences*, *36*(2), 160–170.

UNESCO. (2008). *Policy Framework*. *ICT COMPETENCY STANDARDS FOR TEACHERS*. Retrieved from http://cst.unesco-ci.org/sites/projects/cst/The Standards/ICT-CST-Policy Framework.pdf

UNESCO. (2013). *Global media and information literacy assessment framework : Country readiness and competencies*.

UNESCO Institute for Statistics. (2009). *Guide to Measuring Information and Communication Technologies (ICT) in Education*. http://doi.org/10.15220/978-92-9189-078-1-en

van Dijk, J., & Hacker, K. (2003). The Digital Divide as a Complex and Dynamic Phenomenon. *The Information Society*. http://doi.org/10.1080/01972240309487

van Veen, M., Mulder, F., & Lemmen, K. (2004). What is lacking in curriculum schemes for computing/informatics? *ACM SIGCSE Bulletin*. http://doi.org/10.1145/1026487.1008046

Vanderlinde, R., Braak, J. Van, & Dexter, S. (2012). Computers & Education ICT policy planning in a context of curriculum reform : Disentanglement of ICT policy domains and artifacts. *Computers & Education*, *58*(4), 1339–1350. http://doi.org/10.1016/j.compedu.2011.12.007

Voogt, J., & Knezek, G. (2008). *International Handbook of Information Technology in Primary and Secondary Education*. New York, NY: Springer.

Voogt, J., & Knezek, G. (2011). Under which conditions does ICT have a positive effect on teaching and learning? A Call to Action. *Journal of Computer Assisted Learning*, 1–13. http://doi.org/10.1111/j.1365-2729.2011.00453.x

Voogt, J., & Knezek, G. (2013). Building a global community of policymakers, researchers and educators to move education systems into the digital age. *Journal of Computer Assisted Learning*, *29*, 399–402. http://doi.org/10.1111/jcal.12028

Webb, M. (2011). Feedback enabled by new technologies as a key component of pedagogy. In *International Federation of Information Processing Working Group 3.3* (Vol. 2010, p. 8). Nashville, Tennessee, USA.

Webb, M., & Gibson, D. (2015). Technology enhanced assessment in complex collaborative settings. *Education and Information Technologies*, *June*. http://doi.org/10.1007/s10639-015-9413-5