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THE ROLE OF DIGITAL LEARNING IN ASIA'S EDUCATIONAL FUTURE

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Executive Summary

This Discussion Paper presents a vision of how curricula utilizing digital technologies can aid in improving students' motivation and learning throughout Asia. All countries now must compete in a global, knowledge-based, innovation-centered economy. For Asian nations to compete in this situation, students' educational outcomes should include motivation (both intrinsic interest and self-efficacy), academic achievement (content and skill acquisition), 21st century skills, entrepreneurial thinking, and character attributes such as persistence and flexibility. Mastery now requires the ability to apply these knowledge and skills not only in classroom settings and on standardized tests, but also in real-world contexts, demonstrating proficiency via effective, authentic performances.

The most useful digital tools and media for this purpose are:

- **Collaboration tools** that enable peer-to-peer learning as well as partnerships across distance;
- **Tools that support learners as makers and creators,** which empower students to study real-world problems linked to their personal passions, and to take authentic actions to resolve these problems;
- **Immersive media** that create virtual worlds to situate learning or augment the real-world with an overlay of computational information; and
- **Games and simulations** that are designed to enhance student motivation and learning**.**

The Discussion Paper provides a variety of examples for how different types of games and simulations can affordably and effectively accomplish these ambitious educational goals.

Various challenges and barriers must be overcome to realize this vision. Perhaps the largest obstacle is preparing a sufficient supply of high quality teachers who understand their subject, how students learn, and the role of digital tools and media in aiding learning. Fortunately, powerful models for online and blended teacher professional development are now available.

Asian nations vary in their current capacity to realize the vision expressed in this White Paper. At the high end of the spectrum, countries like Singapore and South Korea have made foundational investments necessary to move forward. However, most Asian nations have not made extensive investments in educational technology infrastructure, nor have they emphasized using technology as a means of moving away from teaching by telling and learning by listening. In particular, the two largest countries, China and India, face major challenges to their further economic development because they lack both the technological and the human capacity to implement deeper learning as an educational strategy. Further, the vast distances involved in countries of this size make national coordination and coherent implementation challenging.

Overall, realizing the full potential of economic and social wellbeing involves not only bringing all of each country's population up to a foundational level of skills and knowledge, but also enabling some fraction of students to compete in the global

economy by mastering sophisticated knowledge and skills: cognitive, intrapersonal, and interpersonal. Modern digital technologies provide powerful strategies for learning that can accomplish both these goals.

At this point in history, the primary barriers to altering curricular, pedagogical, and assessment practices towards the transformative vision of education this Discussion Paper advocates are not conceptual, technical or economic, but instead psychological, political, and cultural. We now have all the means necessary to implement next-generation models of education that truly prepare all students for a future very different from the immediate past. Whether we have the professional commitment and societal will to actualize such a vision remains to be seen.

This Discussion Paper, commissioned by the Head Foundation, discusses the role of digital learning in Asia's educational future. In particular, this document presents a vision of how curricula utilizing digital technologies can aid in improving students' motivation and learning throughout Asia. Particular attention is paid to the role of educational simulations and games in achieving this vision, as well as to challenges and barriers to achieving such a future.

Shifts in Educational Objectives

One of the United Nation's Sustainable Development Goals for Education (UNSDG) speaks to skills specific to sustainable development in the 21st century (United Nations, 2016): **4.7**

By 2030, ensure that all learners acquire the knowledge and skills needed to promote sustainable development, including, among others, through education for sustainable development and sustainable lifestyles, human rights, gender equality, promotion of a culture of peace and non-violence, global citizenship and appreciation of cultural diversity and of culture's contribution to sustainable development

All countries now must compete in a global, knowledge-based, innovation-centered economy (Araya & Peters, 2010). For Asian nations to compete in this situation, students' educational outcomes should include motivation (both intrinsic interest and self-efficacy), academic achievement (content and skill acquisition), 21st century skills, entrepreneurial thinking, and character attributes such as persistence and flexibility (National Research Council, 2008; Dede, 2010; Levin, 2012).

As described in the U.S. National Research Council (NRC) report *Education for Life and Work in the 21st Century* (NRC, 2012), cognitive, intrapersonal, and interpersonal dimensions of knowledge and skills are best developed in tandem. (Table 1 categorizes a broad range of knowledge and skills vital in the 21st century according to these dimensions.) Moreover, and in contrast to industrial-era schooling with its emphasis on multiple choice and short-answer testing, mastery now requires the ability to apply these knowledge and skills in real-world contexts, demonstrating proficiency via effective, authentic performances.

Cognitive Outcomes	***Intra-personal Outcomes***	***Inter-personal Outcomes***
Cognitive processes &	Intellectual openness	Teamwork &
Knowledge	Work ethic &	Leadership
Creativity	Positive core self-evaluation	Communication
Critical thinking	Metacognition	Responsibility
Information literacy	Flexibility	Conflict resolution
Reasoning	Initiative	
Innovation	Appreciation of diversity	

Table 1. Dimensions of Knowledge and Skills

If the future goal is to help students to reach such ambitious standards, how must schools in the Asian region change?

Shifts in Instructional Strategies

In its report, the NRC described "deeper learning" as an instructional approach important in preparing students with sophisticated cognitive, intrapersonal, and interpersonal skills. Modern digital tools and media now enable the use of deeper learning strategies in schools, including:

- **Connected learning** encourages students to confront challenges and pursue opportunities that exist outside of their classrooms and campuses (Ito et al, 2013);
- **Case-based learning** helps students master abstract principles and skills through the analysis of real-world situations;
- **Interdisciplinary studies** help students see how differing fields can complement each other, offering a richer perspective on the world than any single discipline can provide;
- **Collaborative learning** enables a team to combine its knowledge and skills in making sense of a complex phenomenon;
- **Apprenticeships** involve working with a mentor who has a specific real-world role and, over time, enables mastery of their knowledge and skills; and
- **Learning for transfer** emphasizes that the measure of mastery is application in life rather than simply in the classroom.

Teachers can simultaneously use all these strategies by developing instructional partnerships with people outside of school (e.g. parents, community members) who can play educational roles as mentors, coaches, and tutors about complex real-world problems. In schools, educators then can add learning partnerships that emphasize students and teachers working together to understand and act on these problems in ways that are authentic to the tasks adults perform for problem-solving, but appropriately simplified to reflect learners' developmental level, knowledge, and skills. Peer-to-peer learning is important in this process.

Combined, these instructional strategies and partnerships entail very different teaching methods than the familiar, lecture-based forms of instruction characteristic of traditional schooling, with its one-size-fits-all processing of students. Rather than requiring rote memorization and individual mastery of prescribed material, deeper learning involves connected learning about academic subjects linked to personal passions and real-world problems; case-based, interdisciplinary content; authentic diagnostic assessments embedded in instruction and apprenticeships; and peer-to-peer learning that emphasizes transfer from classroom to the real world and mirrors the collaborative nature of 21st century work and citizenship.

Realistically, most teachers will be hard-pressed to get from traditional instruction to deeper learning without the help of digital tools, media, and experiences. But adding digital supports and digital learning platforms for instruction will be effective only if this technology is not used to do conventional things better, but instead applied transformatively to do better things (Roschelle et al., 2000). For learning partnerships on real-world, authentic tasks, the most useful digital tools and media are:

- **Collaboration tools** that enable peer-to-peer learning as well as partnerships across distance;
- **Tools that support learners as makers and creators,** which empower students to study real-world problems linked to their personal passions, and to take authentic actions to resolve these problems;
- **Immersive media** that create virtual worlds to situate learning or augment the real-world with an overlay of computational information; and
- **Games and simulations** that are designed to enhance student motivation and learning**.**

To illustrate deeper learning for sophisticated knowledge, this Discussion paper focuses on the last of these, using specific examples as illustrations of the general points above.

Simulations

As an example of a simulation-based curriculum in mathematics, SimCalc, a well-known and much-studied mathematics curriculum, is configured to enable highly engaging whole class discussions (www.kaputcenter.umassd.edu/products/curriculum_new).

Since representations of student thinking and work can be rapidly distributed in a networked classroom, teachers have the opportunity to direct everyone's attention to specific participants and their contributions. For example, when using SimCalc's

Fishy World (see Figure 1), students each "become" a particular fish and learn how the linked graphical representation and symbolic functions relate to their and others' movements. In order to call attention to a particular mathematical concept (such as the relationships between the formulas for position, velocity, and acceleration Fishy World illustrates), the teacher can freeze each student's SimCalc environment, pausing the simulation for a group discussion. Or the teacher can show or hide each student's contribution, in order to have a different kind of discussion.

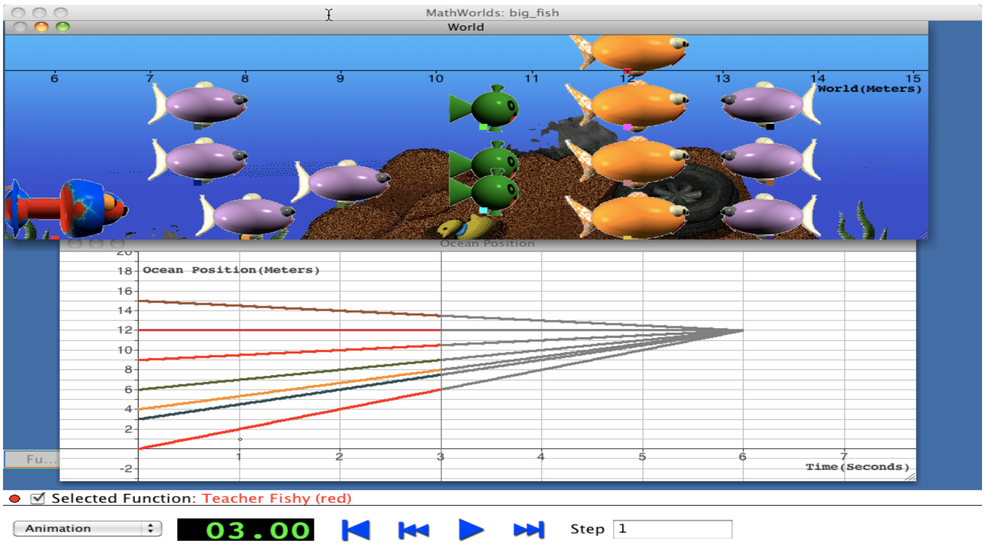

Figure SimCalc's Fishy World

For instance, a graph produced by one student group could be made invisible until the rest of the class has had a chance to talk about what they expect it to show, based upon their own work (Hegedus & Roschelle, 2013).

In short, much of the pedagogy in SimCalc classrooms involves the teacher facilitating discussions among students about what they learn from the dynamic representations on their computer screens. Substantial research has shown that these mathematical dialogues tend to involve almost everyone in the class, are highly engaging, and lead to deep understandings of the why behind mathematical formulas and theorems. And this form of collaborative discussion and debate—stimulated and grounded by the technology—prepares students well for the types of mathematics they will encounter in algebra.

Immersive Authentic Simulations

Experiences such as internships in 21st century workplace settings offer potential benefits for student motivation, academic learning, and mastery of skills for the global, knowledge-based, innovation-centered economy (Dede, 2012). However, providing extended, mentored real-world activities outside classrooms is difficult, particularly for younger students. Moreover, internship/apprenticeship models are hard, if not impossible, to bring to scale, partly because the number of workplace sites willing to accept mentoring responsibilities for students is limited, and partly because teachers accustomed to conventional classrooms often struggle to adapt to this form of education. Fortunately, virtual worlds and augmented realities now offer ways for students to experience simulated internships without leaving classrooms.

Two types of immersive media underlie a growing number of formal and informal learning experiences:

- **Multiuser virtual environments** (MUVEs, or "Virtual Worlds") offer students an engaging "Alice in Wonderland" experience in which their digital avatars in a graphical, virtual context actively participate in experiences with the avatars of other participants and with computerized agents (Ketelhut et al., 2010).

- **Augmented reality** (AR) enables students to interact—via mobile wireless devices—with virtual information, visualizations, and simulations superimposed on real-world physical landscapes. This type of immersion infuses digital resources throughout the real world, augmenting students' experiences and interactions (Klopfer, 2008).

By immersing students in authentic simulations, MUVEs and AR promote two deeper-learning strategies, apprenticeship-based learning and learning for transfer, that are very important for education.

EcoMUVE as an example of multi-user virtual environments

The EcoMUVE middle grades curriculum teaches scientific concepts about ecosystems while engaging students in scientific inquiry (both collaborative and individual) and helping them learn complex causality (http://ecomuve.gse.harvard.edu). The curriculum consists of two MUVE-based modules, allowing students to explore realistic, 3-dimensional pond and forest ecosystems. Each module consists of ten 45-minute lessons and includes a complex scenario in which ecological change is caused by the interplay of multiple factors (Metcalf et al., 2013). Students assume the role of scientists, investigating research questions by exploring the virtual environment and collecting and analyzing data from a variety of sources over time (Figures 2, 3). In the pond module, for example, students can explore the pond and the surrounding area, even venturing under the water; see realistic organisms in their natural habitats; and collect water, weather, and population data. Students visit the pond over a number of virtual "days" and eventually make the surprising discovery that, on a day in late summer, many fish in the pond have died. Students are then challenged to figure out what happened—they travel backward and forward in time to gather information to solve the mystery and understand the complex causality of the pond ecosystem.

Figure 2. Students can collect pond and weather data

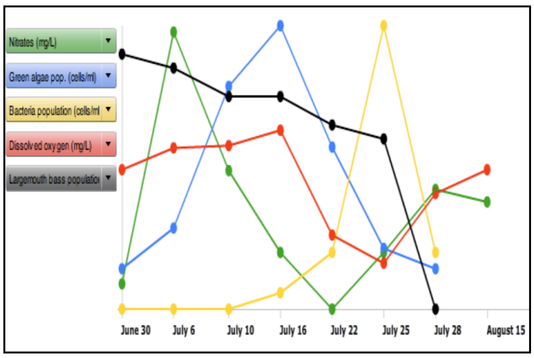

Figure 3. Summarizing and interpreting data

The EcoMUVE curriculum uses a "jigsaw" pedagogy, in which students have access to differing information and experiences; they must combine their knowledge in order to understand what is causing the changes they see. Working in teams of four, students are given roles that embody specific areas of expertise (naturalist, microscopic specialist, water chemist, private investigator) and that influence how they participate and solve problems. Using the differing methods of their roles, students collect data, share it with teammates via tables and graphs that they create within the simulation, and then work collaboratively to analyze the combined data and figure out how a variety of inter-connected parts come together to produce the larger ecosystem dynamics. The module culminates with each team creating an evidence-based concept map—representing their understanding of the causal relationships at work in the ecosystem—which they present to the class.

EcoMOBILE as an example of augmented realities

Designed to complement EcoMUVE, the EcoMOBILE project explores the potential of augmented reality (as well as the use of data collection "probeware," such as a digital tool that measures the amount of dissolved oxygen in water, to support learning in environmental science education (http://ecomobile.gse.harvard.edu). The EcoMOBILE curriculum is a blend of the EcoMUVE learning experiences with the use of digital tools that enhance students' real-world activities, as illustrated by a 3-day project that has been field-tested successfully (Kamarainen et al., 2013): During one class period, a group of middle school students participated in an EcoMUVE learning quest, completing a 5–10 minute on-line simulation in which they learned about dissolved oxygen, turbidity, and pH. The following day, the students went on a field trip to a nearby pond, in order to study the relationship between biological and non-biological factors in the ecosystem, practice data collection and interpretation, and learn about the functional roles (producer, consumer, decomposer) of organisms in the life of the pond.

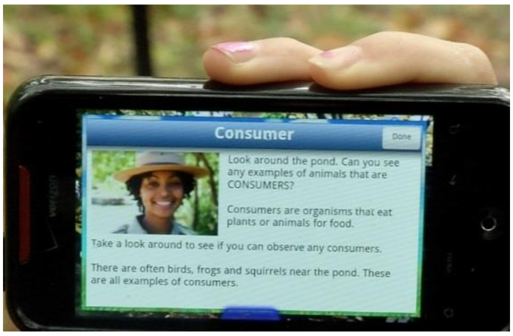

Figure 4. Handheld device delivering information

Figure 5. Collecting water data on turbidity

At a number of spots around the pond, students' handheld devices showed them visual representations—overlaid onto the real environment—of the natural processes at work in the real environment, as well as interactive media including relevant text, images, audio, video, 3D models, and multiple-choice and open-ended questions. Students also collected water measurements using Vernier probes (Figures 4, 5). On the next school day after the field trip, back in the classroom, students compiled all of the measurements of temperature, dissolved oxygen, pH, and turbidity that had been taken during the field trip. They looked at the range, mean, and variations in the measurements and discussed the implications for whether the pond was healthy for fish and other organisms. They talked about potential reasons why variation may have occurred, how these measurements may have been affected by environmental conditions, and how to explain outliers in the data. Our research shows that virtual worlds and augmented realities are powerful complements to enable learning partnerships for real-world, authentic tasks.

Games

Many of the ideas discussed in the prior section on teaching with immersive interfaces also apply to teachers using games to aid engagement and learning in and out of the classroom. The NRC report on *Learning science: Computer games, simulations, and education* (2011) argued that games and simulations share important characteristics and can be defined along a continuum. Both are based on computational models that simulate phenomena: natural, engineered, or invented. Most games are built as simulations of some real world situation, or an imaginary situation that has similarities to the real world. Both simulations and games enable user interaction and some amount of user control.

However, as the NRC report described, simulations and games are distinct along several dimensions. Simulations are computational models that allow users to explore the implications of manipulating or modifying parameters in natural phenomena and in real or hypothesized situations. Unlike a static visualization, such as a diagram in a textbook, simulations are dynamic and allow user interaction. As described later, some educational simulations allow users to observe and interact with representations of processes that would otherwise be imperceptible in the real world. Scientists, economists, and other professionals routinely use simulations to model and understand phenomena.

The NRC report delineated several ways in which computer games differ from simulations. Unlike simulations, which are typically used in an educational or workplace setting, games are often played in informal contexts, on a voluntary basis, without instructional guidance—although teachers sometimes bring these leisure-oriented games into classroom settings. Also, games usually have explicit goals and rules, as well as well-defined outcomes (often construed as winning or losing, although not all games are competitive). More than simulations, games provide feedback to measure players' progress towards outcomes, and players can influence progress by their actions and overall strategies of play

In contrast to simulations and educational games, commercial video games are a huge business. This section describes the opportunities for teaching and learning with educational games as well as with commercial videogames.

Supercharged as an example of an educational game

Supercharged is a three-dimensional educational game designed for classroom use (Anderson & Barnett, 2011). Its purpose is to help students learn basic physics principles related to electromagnetism. Players accomplish various game tasks and overcome challenges by navigating through space via using the properties of charged particles and field lines. For example, in the most difficult challenge, players must navigate their ship through a three-dimensional electromagnetic field seeded with various static charges.

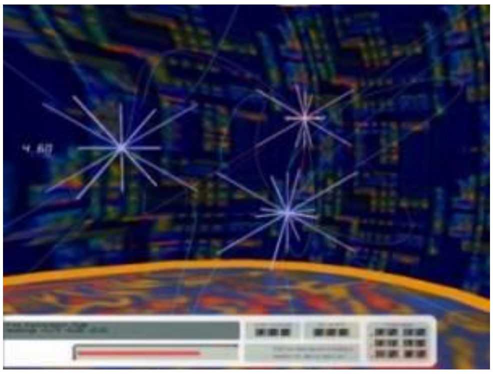

Figure 6. Image from Supercharged Game

This navigation task can be complex at higher levels of play (Figure 6). Supercharged is typical of short educational games designed to promote engaged, active learning. It develops both scientific inquiry skills and content knowledge (Jenkins, Squire, & Tan, 2003). When scaffolded by teacher-led interpretation and reflection, middle school students who played this game had higher pre/post-test gains than students who used a traditional guided inquiry curriculum (Squire, Barnett, Grant, & Higginbotham, 2004). In a later study, elementary school teachers who played Supercharged outperformed on pre/post-tests pre-service peers who participated in a conventional inquiry methods curriculum (Anderson & Barnett, 2011).

World of Warcraft as an example of a video game used for educational purposes
Steinkuehler and Duncan (2008) describe research on how the massively multiplayer online entertainment game, World of Warcraft (WoW), can help participants learn scientific habits of mind. WoW is the largest commercial massively multiplayer online game (MMO); in 2012, approximately ten million participants paid monthly fees to play. WoW is a very complex environment in which players can explore, slay monsters, learn trades such as blacksmithing and herbalist, acquire treasures of various types, form guilds and teams to accomplish tasks, buy and sell artifacts, customize their avatars with clothing and weaponry, and enjoy many other activities appropriate to a "swords and sorcery" fantasy experience (Figure 7). Participants can also vary their gameplay by selecting their race, gender, character strengths, and fundamental moral stance; for example, a female human mage belonging to the Alliance will have different experiences than a male goblin warrior belonging to the Horde.

Figure 7. Scene from World of Warcraft

The opportunities that all these gameplay options present are a very rich set of models that underlie WoW and determine its dynamics. Typical of other complex entertainment games, user forums are available on almost any aspect of the virtual world, and much of the discussion in those forums is about inferring the dimensions and characteristics of these underlying models, so that participants can optimize their gameplay. Steinkuehler and Duncan (2008) studied the forms of scientific argumentation, model-based reasoning, and theory-evidence coordination that arise in WoW, as an example typical of many MMOs. They found it was not unusual for players to gather collective data about a particular monster or challenge in WoW, use spreadsheets to create simple mathematical models of the data, and then argue about whose model is superior in terms of prediction and explanatory scope. This collaborative construction of knowledge through debating alternative evidence-based hypotheses parallels what takes place in various scientific communities.

Steinkuehler and Duncan (2008) analyzed a random sample of nearly 2000 discussion posts in which participants interacted about various WoW-based topics. Their findings showed that 86% of the WoW discussion posts involved social knowledge construction: the collective development of understanding, often through joint problem solving and argumentation. Of these posts, 37% built on points other participants had raised, and 28% used data or evidence of some form to warrant their claims. 58% of the posts used systems based reasoning, citing components and processes that interact in ways involving causal interactions and, sometimes, feedback loops.

While the simplistic models that underlie MMOs do not parallel the scope of complexities that underlie real world phenomena, Steinkuehler and Duncan (2008) argue that cognitive and psychosocial skills are developed in these user forums that are of value if transferred into academic settings. They conclude that teachers could build on the skills and habits many MMO players have developed in their gameplay activities outside of school and could foster transfer of these strategies to promote academic achievement. Such an instructional approach would require, however, that teachers become familiar with these types of games so that they can scaffold students' application of their social knowledge construction skills in classroom settings (Sandford, Ulicsak, Facer, & Rudd, 2007).

This overview of specific illustrations has shown the value of simulations and games for teaching complex knowledge and skills. Overall, if used in concert, all the deeper-learning technologies listed earlier can help prepare students for life and work in the 21st century, mirroring in the classroom some powerful methods of knowing and doing that pervade the rest of society. Further, they can be used to create a practical, cost-effective division of labor, one that empowers teachers, instructional partners outside of school, and students to collectively perform sophisticated authentic tasks. In addition, these media can address the learning strengths and preferences of students growing up in this digital age, including bridging formal instruction and informal learning. And, finally, these technologies can provide powerful mechanisms for teacher learning, by which educators deepen their professional knowledge and skills in ways that mirror the types of learning environments through which they will guide their students.

Challenges and Barriers to Achieving this Vision of Education

Is it proven that technology can aid learning?

Some are skeptical about any proposal to enhance education with technology, arguing that the research results on "does technology aid learning?" are mixed. But this is the wrong question, just as "can books aid learning?" is the wrong question. No learning technology is like fire, where one has only to stand near it to get a benefit from it. Digital technologies are not the innovation—they are catalysts that, when well applied, can empower factors we know are powerful for learning: student engagement, deep content, guided learning by doing, valid assessments, and links between classrooms and life (Dede, 2008). Rather than ask if educational technology is effective, we should study questions such as:

- If deep content is provided, what proportion of students benefit from this? To what extent can improved instructional design expand this proportion?
- If guided learning by doing is enabled, when is this more effective than teaching by telling, and how efficient is this compared to learning by assimilation? For what types of content is rote memorization without understanding adequate and appropriate?
- If innovative assessments are more valid than paper-and-pencil item based tests, are they also reliable and fair? What should be the balance between embedded

diagnostic assessments formative for instruction and occasional summative assessments used for accountability?

- If classroom learning is linked to life, does this benefit some students disproportionately? To what extent can our educational system compensate for students' individual challenges and needs to enable every person the chance to attain their full potential

When these types of questions are asked, research has established substantial benefits for many technology-enhanced educational innovations, but only when these are well designed and implemented with sufficient conditions for success.

What preparation do teachers need to use learning technologies effectively?

Another of the United Nation's Sustainable Development Goals for Education (UNSDG) speaks to the importance of developing qualified teachers (United Nations, 2016): **4.c**

By 2030, substantially increase the supply of qualified teachers, including through international cooperation for teacher training in developing countries, especially least developed countries and small-island developing States

Ultimately, the effectiveness of a technology-enhanced model of 21st century education depends on the quality of the educators involved. As discussed earlier, the innovation is not technology, but instead the empowerment of human performance through changing the ways education is structured and delivered. This type of professional development is very challenging because participants must not only learn new skills, but also "unlearn" almost unconscious beliefs, assumptions, and values about the nature of teaching, learning, and schooling. Professional development that requires unlearning necessitates high levels of emotional/social support in addition to mastering the intellectual/technical dimensions involved. The ideal form for this type of professional development is distributed learning communities, so that the learning process is consistent with the knowledge and culture to be acquired. In other words, teachers must experience technology-based learning as the medium of their professional development as well as its message. The NETP provides an extended discussion of this type of professional learning in its section on Teaching (U.S. Department of Education, 2010), as well as in its follow-on research on connected educators (http://connectededucators.org/).

Unfortunately, at present most teacher professional development programs are not of high quality, (Dede, Eisenkraft, Frumin, & Hartley, 2016). In addition, face-to-face, pull-out programs are unable to provide ongoing daily guidance for teachers as they attempt to implement novel curricula or pedagogies. This problem of just-in-time support is exacerbated when teachers attempt to implement new strategies in environments made hostile by reluctant peers or administrators who see those innovations as undercutting the current school culture. Further, conventional approaches to professional development typically fail to provide day-to-day professional mentoring for entry-level teachers; this lack of guidance is a major factor underlying the high attrition rate among new teachers within their first five years in the classroom. As a result of all these factors, teachers often become frustrated with professional development, at times because it is ineffectual, and at times because it requires sacrifices disproportionate to the enhancement it provides.

The need for professional development that is tailored to teachers' busy schedules, that draws on valuable resources not available locally, and that provides work-embedded support has stimulated the creation of online and blended teacher professional development programs. Generally, these programs are available to teachers at their convenience and provide just-in-time assistance. In addition, they often give schools access to experts and archival resources that fiscal and logistical constraints would otherwise limit. A range of objectives for educational improvement underlie these online teacher professional development ventures, such as introducing new curricula, altering teachers' beliefs and instructional and assessment practices, changing school organization and culture, and enhancing relationships between school and community. Many powerful models for online and blended teacher professional development are available (Dede, Eisenkraft, Frumin, & Hartley, 2016).

Overall, immersive media can be used in a number of ways to promote deeper learning, such as by facilitating case-based instruction, peer-to-peer collaborative activities, simulated apprenticeships, and the development of inquiry skills (Dede, 2014). Simulations allow students to learn skills under controlled conditions that may be difficult to replicate in the real world (Dawley & Dede, 2013), but which convey some degree of authenticity, allowing what is learned in one setting to transfer to the other. And Augmented Realities embed learning in the real world, giving students a deeper understanding of the immediate environment (Dunleavy & Dede, 2013). On their own, each of these approaches has important benefits for students; and blending them together presents even greater opportunities for deeper learning, student collaboration and partnerships on authentic real-world tasks. Teacher capacity building is the single most important step to take in realizing the potential value of these and other learning technologies. No educational device, tool, medium, or experience is better than the people using it.

Implications for Asian Nations

Achieving the United Nations sustainable development goals requires national educational systems to prepare a substantial proportion of their students to compete in a global, knowledge-based, innovation-centered economy. These students' educational outcomes should include motivation (both intrinsic interest and self-efficacy), academic achievement (content and skill acquisition), 21st century skills, entrepreneurial thinking, and character attributes such as persistence and flexibility. Accomplishing this requires creating classrooms that utilize deeper learning, an instructional approach important in preparing students with sophisticated cognitive, intrapersonal, and interpersonal skills.

At the high end of the spectrum, the Asian nation that has come furthest towards these goals is Singapore, through a series of information and communication technology (ICT) masterplans. The Intelligent Nation (iN) 2015 Plan sets forward this vision for the future of education in Singapore (iN Steering Committee, 2015, pg. 8):

Using infocomm, the Education and Learning sector seeks to deliver a more engaging learning experience to meet the diverse needs of learners. Here, the EdVantage programme seeks to make the dream of "classrooms without walls" a reality. This includes providing each student with a personalised infocomm device, to serve as a doorway to textbooks, lessons and projects and catalysing the development of learning applications and content. This will be supported by a seamless and pervasive broadband infrastructure.

This technology infrastructure can enable many aspects of deeper learning, If accompanied by extensive adoption of the sophisticated instructional approaches described earlier, this pervasive usage of infocomm both encompasses learning within school and reaches beyond the classroom in life-wide ways. At this level, which is not frequently observed in current any nation today, teachers are adept at orchestrating learning across a range of providers within and beyond the school, and at customizing instructional conditions for learners. Collaborative learning approaches are maximally effective at this level, as is engagement and transfer of skills from school to life.

South Korea is another Asian nation that has made extensive investments in technology infrastructure, as both a means of economic advancement and educational improvement. Their focus on learning technologies began in 2005 and has continued through a series of five year plans, similar to Singapore's approach (Grzybowski, 2013). By emphasizing engaging and interactive instruction, the South Korean technology infrastructure in education is creating a foundation for implementing deeper learning.

There is a need for most Asian nations to expand extensive investments in educational technology infrastructure and build human capacity to implement the relevant strategies. In recent years, there has been substantial growth in educational technology in China (Edtech Review, 2015). The government's goal is to have the entire K-12 student population online by 2025. The growing prevalence of tablets and smartphones provides a foundation that, with substantial investment in both technology infrastructure and human capacity, could enable deeper learning approaches. Many entrepreneurs are emerging to take advantage of this potential opportunity, with over 1000 new online education companies entering the market in 2013.

The Indian educational system is more decentralized than that of China, Singapore, or Korea, so it faces challenges of creating and coordinating innovation. India lacks qualified teachers as well as a technology infrastructure (Kupathil, 2015). If this situation is to improve in the near future, this likely will come through the actions of entrepreneurs and non-profits. This poses a stark contrast to the national planning and initiatives characteristic of countries who have laid the foundations for implementing deeper learning.

Conclusion

Asian nations have the opportunity for a bright future by investing in education for sustainable development. It is important to recognize that realizing the full potential of economic and social wellbeing involves not only bringing all of each country's population up to a foundational level of skills and knowledge, but also enabling some fraction of students to compete in the global economy by mastering sophisticated knowledge and skills: cognitive, intrapersonal, and interpersonal. Modern digital technologies provide powerful strategies for learning that can accomplish both these goals.

The central insight is to see technology as a catalyst rather than an innovation in itself. Using digital tools and media to automate teaching-by-telling and learning-by-listening is an inadequate approach. Students must also engage in deep content, guided and collaborative learning by doing, authentic assessments, and links between classrooms and life. Many examples of effective and affordable ways to accomplish this, using the mobile devices now prevalent in Asia, are emerging.

All of these innovations require skilled educators working in partnership with learning technologies. Investing in human capacity is as vital as developing a technology infrastructure. Here also digital tools and media provide powerful ways of helping teachers and educational leaders to be effective in the 21st century. At this point in history, the primary barriers to altering curricular, pedagogical, and assessment practices towards the transformative vision of education this Discussion Paper advocates are not conceptual, technical or economic, but instead psychological, political, and cultural. We now have all the means necessary to implement next-generation models of education that truly prepare all students for a future very different from the immediate past. Whether we have the professional commitment and societal will to actualize such a vision remains to be seen.

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Note

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