DL4D
DIGITAL LEARNING FOR DEVELOPMENT

The Potential of Digital Game-Based Learning for Improving Education in the Global South

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EXECUTIVE SUMMARY

The highly skewed distribution of wealth and power in many Global South countries causes huge challenges in educational quality and equity for the poor, in both rural and urban regions. This, in turn, leads to major issues in educational efficiency. This white paper articulates the role digital games might play as part of learning technologies that enhance educational quality, equity, and efficiency for nations in the Global South. Games usually have explicit goals and rules, and well-defined outcomes; games provide feedback to measure players' progress towards outcomes, and players can influence progress by their actions and overall strategies of play. Digital game-based learning (DGBL) is a proven educational innovation effective in the Global North, and is showing early promise in the Global South. However, the conditions for success are quite different in the latter. Many regions need games that emphasize foundational skills, with outcomes that do not depend on effective instruction, and that run on low-end cellphones and tablets under conditions of limited electric power and Internet access. Where feasible, repurposing mobile apps designed for entertainment, but potentially useful for education, may be a way to rapidly build capacity and enhance cost-effectiveness. However, the Global South cannot rely on hand-me-down games from the Global North to achieve its educational ends. Immediately building capacity on four dimensions is essential for DGBL to improve quality, equity, and efficiency in the Global South. First, increasing the number of DGBL designers familiar with the challenges of this region is crucial, so that games tailored to typical educational conditions are available. Second, improvements in the technology infrastructure of the Global South are vital for success in both education and economic development. Third, while teacher-proof games can help, building the capacity of a professional teacher force in Global South countries is vital for achieving equity with the Global North. Finally, additional research on the conditions for the success of DGBL in the Global South will aid in accomplishing these other three advances.

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INTRODUCTION

Civilization has changed in radical ways during the past few decades, and dramatic shifts are likely to continue for much of the 21st century (Fishman & Dede, 2016). Information and computing technologies, combined with increasingly powerful global transportation and communication infrastructures, have led to a leveling of the international economic playing field (Friedman, 2016). In a “flat” world, companies and other organizations can orchestrate manufacturing, support, and even complex knowledge-based work over great distances and across national boundaries.

The “Global South” is a term used to refer to underdeveloped countries with histories of colonialism, neo-imperialism, and differential economic and social change through which large inequalities are maintained in living standards, life expectancy, and access to resources (Dados & Connell, 2012). For all countries, including those in the Global South, the “flat” world places new demands on schooling to prepare today’s students with knowledge and skills previous generations did not need. This challenge has profound implications for teachers and the work of teaching, both in terms of what it means to teach and how one teaches.

Countries in the Global South seek to understand the emerging digital economy and how their workforce can take advantage of emerging opportunities. In every nation, schools need to help students develop the ability to collaborate and communicate effectively in many forms; the ability to identify and locate information, then transform that information into new knowledge and ideas; the ability to identify problems and develop novel solution paths; and the ability to manage one’s own work for continuous improvement (Darling-Hammond, 2009). Many of these skills intrinsically incorporate digital technologies, e.g., fluently using online media to communicate and collaborate across distance (National Research Council [NRC], 2012). Therefore, if teachers are to be successful in supporting students’ learning of these skills, digital technologies must be both an object of education and a tool for education (Dede, 2016). This includes integrating digital tools and media into the types of learning experiences that have proven effective in Global South countries (Evans & Popova, 2016).

Any educational strategy that nations in the Global South use to address these opportunities and challenges must center on quality, equity, and efficiency (United Nations, 2016). As discussed by Gašević (2018):

> … quality refers to the extent to which educational systems and institutions provide learning experience and gains consistent with the specific needs of particular learners in particular situations (Ossiannilsson, Williams, Camilleri, & Brown, 2015). Although traditionally linked to education access and general participation, equity is also related to education completion rates, to the transition from one educational level to another, and to overall educational achievement across different groups, based on factors such as gender, income, geographic location, minority status, and disabilities. Efficiency is an economic indicator of education and has internal and external dimensions: internal efficiency aims to enhance the effect on outputs (e.g., learning gains and employability) of resources invested in education, while external efficiency seeks to maximize the benefits of the outcomes of an educational system. (p. 4)

The highly skewed distribution of wealth and power in many Global South countries causes huge challenges in educational quality and equity for the poor, in both rural and urban regions (United Nations Educational, Scientific and Cultural Organization, 2015). This, in turn, leads to major issues in educational efficiency. This white paper articulates the role digital games could play as part of learning technologies that enhance educational quality, equity, and efficiency for nations in the Global South.

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DEFINING DIGITAL GAME-BASED LEARNING

What are the defining characteristics of digital games? The National Research Council (NRC) (2011) posited in the report *Learning science: Computer games, simulations, and education* that games and simulations share important characteristics and can be defined along a continuum. Both are based on computational models simulating 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, unlike simulations, games usually have explicit goals and rules, and well-defined outcomes (often construed as winning or losing, although not all games are competitive). More than typical simulations, games provide feedback to measure players' progress towards outcomes, and players can influence progress by their actions and overall strategies of play. Simulations are typically used in an educational or workplace setting, but games are often played in informal contexts, on a voluntary basis, without instructional guidance (NRC, 2011). Some games are designed for educational purposes; others center on entertainment and leisure, but are sometimes used by teachers to help students learn knowledge and skills related to academic subjects.

Digital games, in contrast to board games or card games that use physical artifacts, are generally played completely on a computer. In addition, online games require Internet connection.

This report focuses on the potential for digital game-based learning (DGBL) to improve education in the Global South. In addition to excluding non-game simulations from its analysis, this white paper also does not cover an analysis of "gamification," i.e., the use of game design strategies and game mechanics in non-game situations (Martí-Parreño, Méndez-Ibáñez, & Alonso-Arroyo, 2016). For example, a teacher using gamification can make the class itself a game, using rewards, badges, and leaderboards (Hanus & Fox, 2015; Alaswad & Nadolny, 2015). Gamification is based on behaviorist psychology (Skinner, 1972). Extensive studies on using extrinsic rewards to motivate students have shown mixed to negative results (Lepper & Henderlong, 2000). Thus, this analysis excludes gamification in examining DGBL as a strategy for educational improvement in the Global South.

Furthermore, this report excludes studies on the value of student design and programming of DBGL, as opposed to playing these games. Research on the potential and challenges of this instructional approach is emerging (Akpinar & Aslan, 2015; Burke & Kafai, 2014; Hadad, 2013; Repenning et al., 2015), although these studies are not as numerous or conclusive as the research described later on about students playing DGBL. Creation of DGBL by students clearly involves additional classroom time and infrastructure beyond simply playing educational games. Because Global South countries are in the early stages of developing these resources, not including DGBL creation seems appropriate for this report.

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EARLY WORK ON DGBL IN THE GLOBAL SOUTH

DGBL is gaining momentum in the Global South, with growing work in design and implementation. Research based on these development activities is under way; a few studies have thus far been published on educational games in Global South countries. Halloluwa, Usoof, and Hewagamage (2014) argued that DGBL is an effective and affordable means of stimulating primary learners' motivation in Sri Lanka. Kim et al. (2012) documented the effectiveness of mobile DGBL in low socioeconomic communities in India. Roy and Sharples (2015) described using DGBL to enhance the learning of peer educators in India teaching about public health practices. Stubbé, Badri, Telford, van der Hulst, and van Joolingen (2016) discussed the design and effective use of *e-Learning Sudan*, a customized computer game for out-of-school children. Titus and Ng'ambe (2014) explored the use of DGBL to improve student engagement at a resource-poor institution in South Africa. Vate-U-Lan (2015) conducted a feasibility study on using DGBL in Thailand. Overall, these studies document that the promise of DGBL in the Global South is similar to the potential being realized in the Global North. However, as discussed later in Section 5, teachers and schools in the Global South face greater challenges in implementation to meet the necessary conditions for success.

An example of efficacious DGBL in the Global South is the Aan Khmer (read Khmer) early-grade reading mobile application that helps Cambodian children develop foundational reading skills, basic comprehension skills, and phonemic awareness. World Education developed the content and adapted it for mobile devices using ET4D's MoToLi platform. The app contains 31 units, each made up of three main components: 1) learn—new content (mostly letters and combinations of letters) is presented to the child; 2) practice—the child is shown three different activities to practice the new content; 3) short story—the new content is applied within connected text and presented as a read-along to the child with audio support (Kampuchean Action for Primary Education, 2017).

Aan Khmer can be used in various learning environments: individually, in a small-group setting, or in an entire class. Schoolteachers, librarians, and parents are trained on how to play Aan Khmer, use it as a tool for supplementary learning, and advance their own literacy instruction techniques. Special literacy coaches work closely with teachers, parents, and struggling students to lend follow-up support, monitor performance, and evaluate progress.

An evaluation of the program showed that Aan Khmer teaches early-grade reading in Khmer with a phonic pedagogy targeting specific, foundational skills for early learners (United States Agency for International Development [USAID], 2015). By using a phonics-based approach, Aan Khmer complements the Cambodian government's new early-grade reading curriculum. Also, Aan Khmer models pronunciation to increase phonemic awareness, a critical early reading skill that helps children understand letter sounds and begin to read simple words. An evaluation of its content showed that Aan Khmer has interactive game-based activities with a user-friendly interface and instructional support. Students and teachers found Aan Khmer fun and easy to use, engaging learners, educators, and entire communities in literacy promotion (USAID, 2015).

More than 100 schools across five provinces in Cambodia are using the Aan Khmer app. Schools that use Aan Khmer as an intervention report better reading achievements than comparable schools that do not (USAID, 2015). This illustrates that demand for high-quality, efficacious, and efficient DGBL is increasing in Global South settings, and that game designers are responding to this opportunity.

Another example of DGBL success in the Global South is the EduApp4Syria competition, which took advantage of widespread smartphone availability to deliver an engaging learning supplement for Syrian children (https://www.norad.no/eduapp4syria). Co-sponsored by the Norwegian Agency for Development Cooperation and a variety of international partners, the EduApp4Syria initiative recognized that almost 2.5 million Syrian children are out of school because of conflict. Many children have to cope with trauma and high stress levels, affecting their learning ability. However, the wide availability of smartphones among war-affected Syrian families can be a means to reach children through engaging and fun learning supplements, which can help facilitate their continued learning and future reintegration into school. "Feed the Monster" and "Antura and the Letters" were the two winners among a field of engaging, open-source, smartphone applications to help Syrian children learn how to read in Arabic and improve their psychosocial well-being. This development process can serve as a model for the successful production of high-quality, affordable DGBL in the Global South.

A further illustration of DGBL aiding learning in the Global South is the tablet-based implementation in Pakistan of game-based learning in mathematics. The research project studied the use of digital games to enhance students' achievement, motivation, and engagement by providing self-paced learning of mathematical concepts with minimum teacher intervention (Ahmad, Malik, Siddiqui, & Khan, 2018). A mixed-method quasi-experimental study was conducted with 200 street children, who belonged to an extremely low-income group and were formally enrolled in charity schools for out-of-school children in Pakistan (Ahmad, Malik, Siddiqui, & Khan, 2018). The experimental group was exposed to DGBL, while the control group was taught using traditional instructional methods (Ahmad, Malik, Siddiqui, & Khan, 2018). The study generated significant positive results on engagement and achievement data with a large effect size.

Building on this summary of Global South research studies and successful examples, and to understand the full potential utility of DGBL, Section 4 summarizes the more extensive research that has been conducted on DGBL in Global North educational settings. Then Section 5 contrasts typical educational settings in the Global North and Global South, describing the barriers to DGBL in the Global North and highlighting the major additional challenges faced in Global South educational settings.

4

ASSESSING THE POTENTIAL VALUE OF DGBL IN THE GLOBAL SOUTH

The types of games used for DGBL vary widely. Beyond the Global South examples described above, this section discusses four types of DGBL typical in the Global North, providing an example for each category:

- Quick, simple games designed for learning academic subjects and delivered via mobile phones
- Long, complex educational games played in and out of school
- Commercial video games used by teachers for engagement and learning
- Augmented reality games in real-world settings which involve playing a professional role (e.g., acquiring the knowledge and skills of a scientist).

This classification emphasizes games delivered on mobile devices such as cellphones and tablets, since that is the technology infrastructure in the Global South.

An example of quick, simple mobile games designed for academic learning in and out of classrooms is UbiqBio, a suite of four casual games for smartphones with associated biology curricula for classroom use (Perry & Klopfer, 2014). An overview of these games and details about research findings are available at http://web.mit.edu/mitstep/projects/ubiquitous-games.html.

An example of a long, complex educational game played in and out of school is The Radix Endeavor, a multi-player, online educational game (Clarke-Midura, Rosenheck, Haas, & Klopfer, 2013; Conrad, Clarke-Midura, & Klopfer, 2014). An overview of this game and details about research findings are available at https://www.radixendeavor.org/.

An example of a commercial video game used by physics teachers for student engagement and learning is Portal 2 (http://www.thinkwithportals.com/). Studies have shown the effectiveness of this game for learning academic content (Shute, Ventura, & Ke, 2015).

Augmented reality games superimpose virtual information and experiences on the real world;

Pokemon Go (http://www.pokemongo.com/) is a recent, popular example. EcoMOBILE is a suite of augmented reality games designed for learning ecosystems science (Kamarainen, Metcalf, Grotzer, Brimhall, & Dede, 2016). An overview of this suite of games and details about research findings are available at http://ecomobile.gse.harvard.edu.

Why would a teacher want to try these types of games? What makes designers and researchers believe this approach to learning is powerful and effective in delivering educational quality, equity, and efficiency?

One way to assess the potential value of DBGL in improving education is to apply a framework based on learning theory and pedagogical theory which is applicable to any form of instruction (Fishman & Dede, 2016). Such a framework for understanding the emerging contribution of DGBL is provided in the NRC report *How Students Learn*, which describes four key design lenses for framing teaching and learning environments (Donovan & Bransford, 2005, p. 13):

- The *learner-centered* lens encourages attention to preconceptions and begins instruction with what students think and know.
- The *knowledge-centered* lens focuses on what is to be taught, why it is taught, and what mastery looks like.
- The *community-centered* lens encourages a culture of questioning, respect, and risk taking. Community-centered design is depicted as an overarching lens to frame interaction within which the other three design lenses are actualized.
- The *assessment-centered* lens emphasizes the need to provide frequent opportunities to make students' thinking and learning visible as a guide for both the teacher and the student in learning and instruction.

DGBL is valuable if teachers who use this approach can extend or deepen the ways in which their instruction is learner-centered, knowledge-centered, assessment-centered, and community-centered, as a means to educational quality, equity, and efficiency.

In addition to these four dimensions centering on learning, issues on student motivation are a major factor in educational outcomes, particularly in middle school and high school (Schunk & Zimmerman, 2007). Recognizing this, the *Handbook of Research on Learning and Instruction* includes a chapter on learning with motivation (Anderman & Dawson, 2011), and embedded in all its chapters are numerous discussions on ways to engage students. Motivation is important in considering DGBL use because claims have long been made that digital media always engage students and increase their motivation (Warschauer, 1996). However, technology can bore and disengage students if used simply to automate teaching-by-telling and learning-by-listening (Clark, 1994). Many research findings indicate that technology in itself is not an automatic source of sustained engagement, but can be powerful in increasing students' interest and self-efficacy through deeper content, more active learning, timely diagnostic feedback, and interconnections between school and life (Dede, 2016). Jabbar, Azita, and Felicia (2015) document how game design strategies can enhance learning by increasing engagement. Increasing motivation is particularly important as a strategy for educational equity, as it aids socially marginalized students who often come to school disengaged and with low self-efficacy.

To understand the ways DGBL can extend or deepen these four design lenses for effective student motivation and learning, distinguishing between immersive and non-immersive games is important. Briefly, psychological immersion is the mental state of being completely absorbed or engaged in something. For example, a well-designed, complex digital game can draw viewers into the world portrayed on the screen, and participants can feel caught up in that virtual environment. The use of narrative and symbolism creates credible, engaging situations (Dawley & Dede, 2013); each participant can influence what happens through his/her actions and can interact with others. Via richer stimuli, head-mounted or room-sized displays can create sensory immersion to deepen the effect of psychological immersion and can induce virtual presence (place illusion), the feeling that one is at a location in the virtual world (Slater, 2009). Readers who would like more details about immersive learning are urged to read the Appendix before proceeding.

4.1 Ways that DGBL Supports the Lens of Knowledge-Centered Instruction

Differentiating between immersive and non-immersive games is a key distinction in assessing knowledge-centered instruction. Learning experiences designed to teach complex knowledge and sophisticated skills are often based on "guided social constructivist" theories of learning. In this approach, learning involves mastering authentic tasks in personally relevant, realistic situations. Meaning is imposed by the individual rather than existing in the world independently, so people construct new knowledge and understandings based on what they already know and believe, which is shaped by their developmental level, prior experiences, and socio-cultural background and context (Palincsar, 1998). Instruction can foster learning by providing rich, loosely structured experiences and guidance (such as apprenticeships, coaching, and mentoring) that encourage meaning-making without imposing a fixed set of knowledge and skills. This type of learning is usually social; students build personal interpretations of reality based on experiences and interactions with others. Immersive digital games have features that enhance this type of learning; non-immersive games are limited in this respect. The Radix Endeavor, Portal 2, and EcoMOBILE are immersive; UbiqBio games are not. To maximize the power of immersive learning, it is important not to present isolated moments in which immersion is used to provide short-term engagement or fragmentary insight. Instead, extended virtual experiences that immerse students in rich contexts with strong narratives, authentic practices, and links to real-world outcomes are what truly unleash the transformational power of immersion. For example, while showing a 3-D model of a human heart illustrating blood flow is useful, immersing students in a digital game where they apply knowledge of the heart to save the lives of computer-based agents is much more motivating and is effective in fostering a wide range of sophisticated knowledge and skills.

In contrast, non-immersive games like UbiqBio are simpler, less constructivist media, giving more tightly structured experiences that support acquiring a narrow set of knowledge and skills by following a fixed path to success. Situated learning, a hallmark of immersive media, is far less pronounced in these types of games, which provide little sense of context other than the essentials of the situation that is modeled. Knowledge transfer is less scaffolded in simple games because the real world is far more complex than the mechanisms these experiences depict, forcing far transfer by students rather than near transfer. That said, simple games deliver a quick, relatively easy way of scaffolding the acquisition of uncomplicated knowledge and skills through active learning rather than passive assimilation.

4.2 Ways that DGBL Aids the Two Lenses of Learner-Centered and Community-Centered Instruction

Simple games share with immersive games the ability to promote students' intrinsic motivation through intrapersonal factors such as challenge, control, fantasy, and curiosity, as well as interpersonal factors such as competition, cooperation, and recognition (Malone & Lepper, 1987). As with immersive media, the challenge dimension of engagement is heightened when participants can achieve "flow" by interacting with a well-designed game or simulation (Csikszentmihalyi, 1988). A major difference, however, is that simple games like UbiqBio do not create the illusion of situated embodiment of one's identity into the learning experience, so the impact on self-concept may be less profound.

That said, the ways in which games provide clear goals and near-continuous feedback on progress towards those objectives is powerful for motivation and learning in ways that more open-ended, unstructured environments do not attain. For example, a personal trait that shapes student academic outcomes more strongly than gender, self-concept, and perceived utility of academic knowledge in later life is self-efficacy (Pajares & Miller, 1994). Bandura (1977) defined self-efficacy as the belief that one can successfully perform certain behaviors (e.g., succeeding on a high-stakes test). Pajares (1997) indicated that self-efficacy shapes a student's choices, expended effort, and emotional responses to a task. Students with higher academic self-efficacy are more likely to be engaged, see failure as an indication that more effort is needed, and are more interested in a career in the field to which an academic task relates. Perceived personal competence in accomplishing the goals of an academic activity (Dweck, 2002; Schunk & Pajares, 2005) depends in part on a student's beliefs about whether his/her abilities in that field are immutable (i.e., one is born either talented in mathematics or not – nothing can change that) or mutable (with practice, I can become capable in mathematics regardless of my initial abilities). Ketelhut (2007) developed and validated an instrument to assess a student's self-efficacy in scientific inquiry, showing that students with higher self-efficacy in science inquiry were more effective in learning from the River City virtual world. Games and simulations can provide repeated practice experiences with continuous feedback that supports building self-efficacy.

Another personal trait related to self-efficacy and identified as important in educational success is academic tenacity. The U.S. Department of Education report *Promoting grit, tenacity, and perseverance: Critical factors for success in the 21st century* (2013) describes the interrelationships among concepts such as persistence, tenacity, grit, perseverance, and conscientiousness when applied to educational contexts. The report documents how important these traits are for success in school and life; it suggests teaching strategies for fostering these traits and for seeing one's abilities in a subject as mutable rather than fixed. Following are some of the instructional strategies (Department of Education, 2013):

- Students need to have the opportunity to take on long-term or high-order goals that, to the student, are "worthy" of pursuit.
- Students need a rigorous and supportive environment to help them accomplish these goals and develop critical psychological

resources. These resources include teachers' fostering positive academic mindsets (e.g., my ability and competence grow with my effort), effortful control by students (e.g., staying focused despite distractions, and strategies and tactics [e.g., project planning skills]) (pp. 77–80).

Research has shown that digital games can be a powerful means of developing academic tenacity (Shute, 2011), and less complex games may also be effective in this. Central to achieving this outcome is the attainment of "flow" states through facing challenges that are difficult but surmountable at the student's current level of skill, coupled with the support that enables steady improvement in repeated attempts to accomplish a task (NRC, 2011). The development of these critical factors for success in life is particularly important as a strategy for educational equity, as it aids students who are marginalized in society and often come to school without academic tenacity or a growth mindset.

Many simple educational games are designed for individual use rather than team experience, although a teacher may conduct post-play briefings in which students compare their insights and accomplishments. In contrast, entertainment-oriented video games often involve team play. Both educational games involving collaborative experiences and video games offer opportunities for social knowledge construction. Because simple games typically have no built-in communication mechanisms for virtual interaction, this collective meaning-making often takes place outside the game environment through face-to-face interactions in classroom settings or via virtual channels in informal contexts (NRC, 2011).

4.3 Ways that DGBL Supports the Lens of Assessment-Centered Instruction

The NRC report contains a section on the role of simulations and games in science assessment (NRC, 2011). Any type of online game (e.g., The Radix Endeavor) offers the capability to collect logfile data on student behaviors and decisions. This is potentially a powerful method for formative and summative assessment. Shute (2011) described ways in which unobtrusive assessments can be woven into game-based learning. Subsequent research using these methods showed its power in several types of games (Shute, Ke, & Wang, 2017).

Overall, however, research on how to effectively assess learning through games is still in its early stages (Dede, 2015). The NRC report concluded that "games and simulations hold enormous promise as a means for measuring important aspects of science learning" (NRC, 2011, p. 103). However, the report states that games will reach their full potential in measuring students' performances only when unobtrusive, effective assessment tasks are routinely embedded into them. This has considerable promise for improving educational quality and efficiency, as well as personalizing learning to increase equity (NRC, 2011).

Thus far, this report has described what DGBL is and the potential of DGBL to extend and deepen the four dimensions of effective teaching (knowledge-based, learner-based, community-based, and assessment-based), as well as enhance student motivation. Contrasting the Global North and the Global South, what are the challenges that teachers face in implementing DGBL in classrooms to realize this potential?

5

CHALLENGES FOR TEACHERS IN USING DGBL

In Global North countries, many teachers have experienced issues when attempting to incorporate DGBL into their instruction. That said, simple educational games are less challenging to use in classroom settings than more elaborate immersive games (Dede, 2009b). The technology infrastructure needed for implementing simple games and simulations is less complex, as even low-level devices have enough power to run these applications. While 1:1 student-computer ratios are desirable for interacting with these learning media, teachers who have only a presentation station can conduct whole-class sessions in which students collectively make choices and see the consequences of these actions. Network connections are typically unnecessary, removing the issues of security, safety, and privacy associated with Internet access. Furthermore, relatively small amounts of class time are needed to use and debrief simple educational games, compared with more elaborate immersive games. On the other hand, classroom use of entertainment-oriented video games demands much more time and technical resources, comparable to an elaborate immersive environment. In Global North countries, teachers can draw on students' experiences with this type of game outside of school settings without necessarily using DGBL in the classroom during school (Duggan, 2015).

The primary challenge in Global North countries is not technology infrastructure but instructional strategy. For DGBL to be effective, teachers must shift their pedagogy from presentation to coaching, and students must change from rote assimilation to reflective interpretation (Sandford, Ulicsak, Facer, & Rudd, 2007). To illustrate effective use of educational games, Watson, Mong, and Higgins (2011) described a high school history class in which a game about World War II, Making History, had been implemented. The teacher was experienced in playing the game and had used it in his instruction for several years. Researchers noted that, even though the teacher was an effective lecturer adept at fostering group discussion, students were much more engaged in the active learning fostered by playing Making History (Watson et al., 2011). To turn that engagement into learning, the teacher implemented an instructional model in which students played the game in small groups so they could dialogue with each other about the rationale for various actions they took (Watson et al., 2011). Classroom interpretive dialogue was based around teachable moments when students found something that had happened in the game surprising to them, given their current mental model of history (Watson et al., 2011). The teacher also kept students focused on having goals to achieve for their country, taking positions about historical events, and reflecting on the consequences of their decisions. While the game was quite successful in engagement and learning, the teacher exerted substantially higher effort than using conventional lecture/discussion pedagogy.

This and other studies document the importance of effective implementation by teachers in realizing the full potential of DGBL (Kangas, Koskinen, & Krokfors, 2017; Martinez-Garza & Clark, 2013; Martinez-Garza, Clark, & Nelson, 2013; Ertmer & Ottenbreit-Leftwich, 2010). Since teachers teach as they were taught, this means that professional development should also include game-based learning as an instructional approach. Unfortunately, few examples of this capacity-building strategy exist as yet (Meredith, 2016).

Additional Challenges to DGBL Faced by Teachers in the Global South

In the Global South, many teachers face additional challenges in implementing DGBL beyond those described above. For example, the digital devices available are typically marginal. Games like UbiqBio and EcoMOBILE can be played on cellphones or low-end tablets, as can the successful DGBL implementations in the Global South described in Section 3. However, games such as The Radix Endeavor or Portal 2 require at least a high-end tablet computer. Nevertheless, given the steady advance of technology, in a few years, mid-range tablets—and eventually even low-end tablets—will be adequate to play relatively complex games.

A further issue with technology infrastructure is having access to adequate electric power and Internet connectivity. A digital device is a doorstop once its battery is exhausted, so the ability to recharge as needed is crucial for consistent educational use. Also, workarounds can handle some aspects of marginal or no Internet connectivity (e.g., transferring data via "sneakernet" using flash drives). However, for higher-end games and real-time assessment, moderate bandwidth and reliable Internet access are important. These problems in parts of the Global South will hopefully lessen over time because of investments in technology infrastructure to aid not only education but also economic development.

Some regions in the Global South suffer from pervasive issues of teacher availability, motivation, and capacity. Often, these challenges are difficult to overcome because their cause is rooted in dysfunctional policies and lack of accountability. As a result, designing DGBL for the Global South requires developing learning experiences for which, in the worst case scenario, no teacher input is necessary. In the Global North, "teacher-proof" learning experiences are avoided, but in parts of the Global South, this is an asset in current DGBL, at least for the immediate future. In the long run, successful education beyond rudimentary skills in the Global South will require resolving these systemic issues about teaching. As discussed in Section 4, DGBL can aid teacher preparation and professional development.

Finally, some educational systems in the Global South face lack of clarity about educational objectives. Beyond fundamental literacy and numeracy, as discussed earlier, many students in every country need more advanced skills to compete in the global economy. The evolutionary path for DGBL in the Global South must extend beyond basic concepts and skills to the more sophisticated knowledge educational games can convey, as described in Section 4.

Thus far, this report has described what DGBL is and the potential of DGBL to extend and deepen the four dimensions of effective teaching, as well as to enhance student motivation. It has also discussed the challenges for teachers in implementing DGBL. Given all this, to what extent has DGBL thus far fulfilled its promise?

6

RESEARCH OVERVIEWS OF DGBL IN ENHANCING QUALITY, EQUITY, AND EFFICIENCY

Are books an effective medium for learning? The answer is, it depends on what is in the book and how adeptly or ineptly the teacher fosters student learning using its contents. In general, asking whether an entire class of educational tools or media work is the wrong question because the answer is, it depends. No educational medium is a technology like fire, where one only has to stand near it to benefit from it (Dede, 2008). Knowledge does not intrinsically radiate from computers running digital games, infusing students with learning as fires infuse their onlookers with heat. However, DGBL can aid various aspects of teaching and learning, as discussed in Section 4 above.

A better analogy for technology-based learning experiences than fire is antibiotics. Antibiotics are effective for most people, but only when they are applied to the medical situation for which they were developed and only when they are used in the manner intended. Grinding up antibiotic pills and smearing them on your body, or taking them all at once instead of spreading out gradually over days, will not produce the desired effects. In other words, antibiotics have simple conditions for success that must be met for effectiveness. Typically, educational interventions are similar, except their conditions for success are far more complex, given variations in students' prior knowledge and misconceptions, native language and socioeconomic status, and educational goals.

As discussed below, the research literature shows that DGBL can be powerful for learning, but only when its conditions for success, discussed in Section 4, are met. This conclusion about the effectiveness of well-designed and appropriately implemented DGBL is one that researchers have reached in the last few years. In 2011–2012, three substantial reviews of research on educational games (NRC, 2011; Tobias & Fletcher, 2011; Young et al., 2012) delineated findings on the capabilities of DGBL for teaching and learning. Tobias and Fletcher (2011) were the most positive in their conclusions, finding that games providing imaginative play, rapid responses, challenges, and competition—at levels appropriate to a player's cognitive constraints (e.g., mental workload, prior knowledge)—could develop knowledge and skills related to academic topics and to life situations. They also found substantial research to support the assertion that well-designed games are engaging and motivate most players to spend substantial time interacting with them. Tobias and Fletcher, in aggregating various studies on the effectiveness of games for education, also found that capabilities acquired during game play could be generalized to non-game environments, including education and training contexts, and everyday life. To attain transfer from the game to other curricular assignments and to tasks in the real world, substantial overlap is required between the cognitive processes engaged by the game and those required for the tasks; superficial similarities do not lead to a transfer.

In contrast, Young and his colleagues (2012) focused on commercial video games, as opposed to serious games for learning. They concluded that studies to date did not generally support the educational value of using video games in classrooms. Their research posits that this may be due in part to how video games are often used in schools—as quick activities that may have too low a "dosage" of multiplayer interaction, continuity of learning, and extended engagement to be effective. Even under these adverse conditions, they did find some positive results in using video games for language learning and, to a lesser degree, physical education.

The outcomes from these two early reviews of research on the use of games (whether explicitly educational or not) were generally consistent with the findings of the NRC report on games and simulations for teaching science (NRC, 2011). At that time, the NRC found DGBL worthy of future investment and investigation as a means to improve science learning. These media were seen as having the potential to advance motivation to learn science, conceptual understanding, science process skills, understanding the nature of science, scientific discourse and argumentation, and identification with science and science learning. However, the NRC report stated that the evidence for games in supporting learning was judged inconclusive largely due to a very limited base of high-quality research findings.

Given the promise of DGBL, these reports indicated, in the last five years designers have expanded their offerings of educational games, and many high-quality research studies on DBGL have been conducted. These, in turn, have led to recent articles synthesizing these studies to draw conclusions about whether the promise of DGBL was now being realized. Space does not permit discussing in detail all their findings, but an overview is presented below.

Many large meta-analyses and syntheses have documented that, when DGBL in K-12 classrooms is well-designed and its conditions for success are met, this is an effective strategy for motivation and learning. These studies include Clark, Tanner-Smith, and Killingsworth, 2016; Connolly, E. Boyle, J. Boyle, Macarthur, and Hainey, 2012; Hainey, Connolly, Boyle, Wilson, and Razak, 2016; Jabbar et al., 2015; Kangas et al., 2017; Ke, 2016; Ke, Xie, and Xie, 2016; Li and Tsi, 2013; Martinez-Garza et al., 2013; Qian and Clark, 2016; Romero, Usart, and Ott, 2015; Saleh, Prakash, and Manton, 2014; Tsekleves, Cosmas, and Aggoun, 2016; and Wouters and van Oostendrop, 2013. This makes DBGL perhaps the most studied educational intervention in the past five years, so these findings of effectiveness given conditions for success are very robust. These studies also concluded that, without the conditions for success, DGBL is generally ineffective. All the studies indicated that further research is needed to fully understand the strengths and limits of DGBL for K-12 education.

Some of these studies focus on particular aspects of DGBL. Jabbar et al. (2015) described strategies for designing game play to enhance engagement and learning. Kangas et al. (2017) documented the types of pedagogical activities teachers should use to incorporate DGBL into instruction. Saleh et al. (2014) presented a framework to help students accept DGBL as a valued form of learning. Both Qian et al. (2016) and Romero et al. (2015) focused on the value of DGBL for students honing 21st century skills.

Furthermore, Ali, Nuñez-Castellar, and Van Looy (2015, 2016) made methodological suggestions on how to improve assessments of DBGL's educational value.

Fewer meta-analyses and syntheses have been conducted on DGBL in higher education. Alanne (2016) and Bodnar and Clark (2017) synthesized studies showing that DGBL is valuable in engineering education. Mayer, Dale, Fraccastoro, and Moss (2011) examined how DGBL can enhance the transfer of learning in business education. Sitzmann (2011) conducted a meta-analysis showing that computer-based simulation games were an effective and engaging form of personnel training. Overall, it seems likely that the findings of DGBL in K-12 education can be generalized to higher education and to adult training and learning.

Almost all of these studies were written from the perspective of educational quality, equity, and efficiency in the Global North. In the Global South, Section 3 documents a few early successes of DGBL on these three dimensions, but much remains to be done to help educational systems and institutions in these countries provide learning experiences targeted to the specific needs of particular groups of learners typical of their regions. Also, understanding the impact of DGBL on equity in the Global South will require longitudinal studies to determine how games affect education completion rates, transitions from one educational level to another, and overall educational achievement across different groups based on factors such as gender, income, geographic location, minority status, and disabilities. Unless designed carefully and implemented uniformly, DGBL could easily worsen equity by privileging relative-haves over relative have-nots. Also, DGBL too heavily focused on basic skills could improve equity in the Global South, but worsen those countries' educational gap with the Global North.

Cost-effectiveness in the Global South will also take time to assess. Early evidence indicates that simple, teacher-proof games played on devices to which students already have access are likely to be efficient and effective. Whether this is true for complex DGBL requiring more sophisticated technology infrastructure is less certain; more design-based research is needed to resolve this issue.

7

CONCLUSION

This report documents that DGBL is a proven educational innovation effective in the Global North and is showing early promise in the Global South. However, the conditions for success are quite different in the latter; many regions need games that emphasize foundational skills, with outcomes that do not depend on effective instruction, and that run on low-end cellphones and tablets under conditions of limited electric power and Internet access. Where feasible, repurposing mobile apps designed for entertainment, but potentially useful for education, may be a way to rapidly build capacity and enhance cost-effectiveness.

However, the Global South cannot rely on hand-me-down games from the Global North to achieve its educational ends. Immediately building capacity on four dimensions is essential for DGBL to improve quality, equity, and efficiency in the Global South. First, increasing the number of DGBL designers familiar with the challenges of this region is crucial so that games tailored to typical educational conditions are available. Second, improvements in the technology infrastructure of the Global South are vital for success in both education and economic development. Third, while teacher-proof games can help, building the capacity of a professional teaching force in Global South countries is critical for achieving equity with the Global North. Finally, additional research on the conditions for the success of DGBL in the Global South will aid in accomplishing these other three advances.

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Appendix: The Power of Immersive DGBL

1. Immersive vs. Non-immersive Games

Psychological immersion is the mental state of being completely absorbed or engaged in something. For example, a well-designed, complex digital game can draw viewers into the world portrayed on the screen, and participants can feel caught up in that virtual environment. The use of narrative and symbolism creates credible, engaging situations (Dawley & Dede, 2013); each participant can influence what happens through his/her actions and can interact with others. Via richer stimuli, head-mounted or room-sized displays can create sensory immersion to deepen the effect of psychological immersion and can induce virtual presence (place illusion), i.e., the feeling that one is at a location in the virtual world (Slater, 2009).

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

- *Virtual Reality (VR)* interfaces provide sensory immersion, at present focusing on visual and audio stimuli with some haptic (touch) interfaces. Participants can turn and move as they do in the real world, and the digital setting responds to maintain the illusion of presence of one's body in a simulated setting.
- *Multi-user Virtual Environment (MUVE)* interfaces offer students an engaging Alice-in-Wonderland experience, going "through the screen" to a simulated setting in which their digital avatars convey psychological immersion in a graphical, virtual context. The participant represented by the avatar feels remote presence inside the virtual environment—the equivalent of diving rather than riding in a glass-bottomed boat. The Radix Endeavor and Portal 2 are examples of MUVEs.
- *Mixed Reality (MR)* interfaces combine real and virtual settings in various ways to enable psychological immersion in a setting that blends physical and digital phenomena. For example, an outdoor *augmented reality* (AR) experience using mobile devices can superimpose information, simulations, and videos on a through-the-camera-lens view of natural phenomena (Dunleavy & Dede, 2013). EcoMOBILE is an example of augmented reality.

The range of options is complex because new sub-types of VR, MUVEs, and MR are constantly emerging. Each has unique strengths and limits for aiding learning, so understanding how to choose the right medium for a particular educational situation is important in realizing the potential of immersive learning. However, some aspects of effective instruction apply across all these media.

Immersion in a mediated, simulated experience (VR, MUVE, or AR) involves the willing suspension of disbelief. Inducing powerful immersion for learning depends on designs that use actional, social, and symbolic/narrative factors, as well as sensory stimuli (Dede, 2009a):

- *Actional Immersion*: Empowering the participant in an experience to initiate actions that have novel intriguing consequences. For example, when a baby is learning to walk, the degree of concentration this activity creates in the child is extraordinary. Discovering new capabilities to shape one's environment is highly motivating and sharply focuses attention.
- *Symbolic/Narrative Immersion*: Triggering powerful semantic associations via the content of

an experience. As an illustration, reading a horror novel at midnight in a strange house builds a mounting sense of terror, even though one's physical context is unchanging and rationally safe. The narrative is an important motivational and intellectual component of all forms of learning. Invoking intellectual, emotional, and normative archetypes deepens the experience by imposing a complex overlay of associative mental models.

- *Social Immersion*: Rich social interactions among participants in a shared virtual or mixed reality deepen their sense of immersion. In the real world, people participate in shared processes of reasoning and leverage their environment to make decisions and get things done. To the extent that a virtual or partially virtual environment supports this, it draws the user in and makes him or her feel more a part of it.
- *Sensory Immersion*: This occurs when the student employs an immersive display, like a head-mounted display, a CAVE, or a digital dome. The display presents a panoramic egocentric view of some virtual world, which the student leverages to imagine himself or herself to be there.

Psychological immersion is achievable in any of these interfaces through design strategies that combine actional, social, symbolic, and sensory factors.

Immersion is intrinsically helpful for motivation and learning in some ways, but not necessarily useful in others. In mastering complex knowledge and sophisticated skills, students learn well in a Plan, Act, Reflect cycle, in which first they prepare for an experience that involves doing something they want to master; then they attempt that performance; and finally they assess what went well, what did not, why, and what they need to learn in order to execute a more successful repetition of the cycle. Immersion is great for the Act part of the cycle, but unless used carefully, can interfere with the Plan and Reflect parts of the cycle. This—and numerous other factors—make effective instructional design for immersive learning, including digital games used for education, complex.

2. Situated Learning, Transfer, and Identity via Psychological Immersion in DGBL

The capability of immersive media to foster psychological immersion enables technology-intensive educational experiences that draw on a powerful pedagogy—situated learning.

Situated learning takes place in the same or a similar context to that in which it is later applied, and the setting itself fosters tacit skills through experience and modeling. For example, in a medical internship, both the configuration and coordinated team activities in a hospital surgical operating room provide embedded knowledge.

Situated learning requires authentic contexts, activities, and assessment coupled with guidance from expert modeling, mentoring, and legitimate peripheral participation (Wenger, 1998). An example of legitimate peripheral participation is when graduate students work within the laboratories of expert researchers, who model the practice of scholarship. These students interact with experts in research and with other research team members who understand the complex processes of scholarship to varying degrees. While in these laboratories, the students gradually move from novice researchers to more advanced roles, with the skills and expectations from them evolving.

Related to situated learning is *embodied cognition*, an instructional strategy that posits retrieving a concept from memory and reasoning about it, and is enhanced by creating a mental perceptual simulation of it (Barsalou, 2008). For example, research shows that second grade students who acted out stories about farms using toy farmers, workers, animals, and objects increased their understanding and memory of the story they read. Steps involved in a grounded cognition approach to learning something include having an embodied experience (which immersive digital games can create), learning to imagine that embodied experience as a mental perceptual simulation, and imagining that experience when learning from symbolic materials.

Potentially quite powerful, situated learning is seldom used in formal instruction because creating tacit, relatively unstructured learning in complex real-world settings is difficult. However, VR, MUVE, and MR experiences can draw on the power of situated learning by creating immersive, extended experiences with problems and contexts similar to the real world. This is especially important as a strategy for educational equity, as it aids students who are marginalized in society and often have little experience with real-world settings outside their impoverished communities. In particular, all three types of immersive media provide the capability to create problem-solving communities in which participants can gain knowledge and skills through interacting with other participants who have varied skill levels, enabling legitimate peripheral participation driven by social and collaborative interactions. Immersive games often take advantage of this strategy.

Situated learning is important in part because of the crucial issue of transfer.

Transfer is the application of knowledge learned in one situation to another situation, demonstrated if instruction on a learning task leads to improved performance on a transfer task, typically a skilled performance in a real-world setting. For example, statistical reasoning learned in a classroom can potentially aid with purchasing insurance, or with gambling.

A major criticism of instruction today is the low rate of transfer generated by conventional instruction. Even students who excel in schooling or training settings often are unable to apply what they have learned to similar real-world contexts. Situated learning addresses this challenge by making the setting in which learning takes place similar to the real-world context for performance in work or personal life. Learning in well-designed digital games can lead to the replication in the real world of behaviors successful in simulated environments (Fraser et al., 2012; Mayer, Dale, Fraccastoro, & Moss, 2011).

Moreover, the evolution of an individual's or group's ***identity*** is an important type of learning for which simulated experiences situated in immersive digital games are well-suited (Gee, 2003; Turkle, 1997). Reflecting on and refining individual identity is often a significant issue for students of all ages. Learning to evolve group and organizational identity is a crucial skill in enabling innovation and in adapting to shifting contexts. Identity "play" through trying on various representations of the self and the group in digital games provides a means for different sides of a person or team to find common ground, and an opportunity for synthesis and evolution (Laurel, 1993; Murray, 1998). Immersion is important in identity exploration because virtual identity is unfettered by physical attributes such as gender, race, and disabilities (Slater, 2009). One's identity can be an intriguing experience of almost any role because digital games can simulate interactions and activities not possible in the real world. These include, for example, teleporting within a virtual environment, enabling a distant person to see a real-time image of one's local environment, or interacting with a (simulated) chemical spill in a busy public setting. Developing a successful academic identity is particularly important as a strategy for educational equity, as it aids students who are marginalized in society and who often come to school believing they cannot succeed.