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The Future of ICT in Education: Opportunities and Recommendations

A report for Save the Children

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This chapter gives a brief overview of the future of education, both from a pedagogical and technological standpoint, to inform the reader of innovations that hold promise for improving the lives of learners around the world. It concludes with a summary of general recommendations for ensuring the success of Save the Children's future ICT4E projects.

Pedagogies of the Future

New research in learning science is showing that there is great promise in changing the methods by which teachers teach and students learn. More and more research demonstrates that the classic "transmission" model of teaching that is employed in most traditional classrooms today is a vastly inferior method compared to many other forms of active, student-centered, hands-on learning. Lectures and rote memorization are ineffective at helping learners to develop higher-order skills such as critical thinking, inquiry, and autonomy, all of which are crucial twenty-first century skills. In 2011, 50-60% of middle school students reported being bored or disaffected by school, a side-effect of the passive nature of their learning environment.[2]

Experts argue that formal education needs to undergo a systemic transformation in order to enable effective learning of these types of higher-order skills and competencies to keep up with the ever-evolving global challenges of a technological world.[3]

Effective twenty-first century teaching is based on three principles: personalization, participation, and productivity.[4] As such, educational technology innovations should be focused on supporting these types of pedagogies, emphasizing active learning, real-world problem solving, peer collaboration, and creativity, in order to support deeper learning and promote higher-order thinking skills. Digital literacy, inventive thinking, global awareness, creativity and risk-taking, teamwork, and learning to learn are the six key skills that should be at the forefront of modern learning.[5]

Above all else, the most effective pedagogies are first and foremost student-centered. A 2016 report determined that marginalized children benefit the most from pedagogies that are active and student-centered (i.e. "hands-on, minds-on learning")[6]. In fact, the ISTE has referred to student-centered learning environments as "the schools of the future"[7]. Educational technologies should therefore strive to find ways to provide genuine, authentic student-centered learning opportunities, rather than merely trying to digitize traditional transmission-based educational practices.

The following sections discuss several pedagogies that research indicates are promising directions for educational reform and improved learning outcomes. In particular, we highlight five key areas: adaptive and personalized learning, collaborative learning, gamification, flipped classrooms, and project-based learning.

Adaptive and Personalized Learning

Every individual student learns differently. Certain teaching methods are more effective for some students than others. Some students might advance through a particular set of materials quickly, while others take more time to fully absorb the same concepts.

The Standards for Teachers published by the International Society for Technology in Education (ISTE) specify that educators need to adopt personalized learning activities to accommodate students' diverse learning styles and abilities. According to the ISTE guidelines, students not only need to be given multiple ways of accessing and learning content, but also need to be given personalized methods of demonstrating their mastery, by way of personalized formative and summative assessments.[7] Personalized learning would allow every student to be able to approach learning tasks in the ways that are most effective for them, improving their autonomy and allowing them to take control of their own learning, while not penalizing them for taking a different approach.[8]

However, traditional classrooms are largely unable to address these differing needs due to a lack of resources and an inability to cater to the fine-grained needs of every individual student. Teachers often teach at the level of the most advanced students in the class,[9] and school-mandated curricula is often too advanced for the majority of learners to effectively keep up with.[10] As a result, studies suggest that only a fraction of students actually progress at grade level over the course of several grades: most students end up falling behind somewhere along the progression, putting them at a major disadvantage for all subsequent learning as they struggle to catch up.[11]

Software systems are capable of addressing these problems through adaptive learning systems. Where traditional learning management systems act as a "repository of information and a tool for the training administrator to assign modules and track progress,"[12] an adaptive learning system automatically assigns modules to each student based on their demonstrated needs and competencies. Experts at the 2014 EDUCAUSE Annual Conference collectively determined that self-paced, personalized learning is one of the ten most important features that should be incorporated into the educational software systems of the future.[13] Adaptive systems can effectively model the cognitive needs of each individual user, engage students in inquiry-based learning as appropriate, and increase motivation and engagement.

Experts believe that the learning systems of the future will have a robust method of learning assessment which synthesizes traditional formative assessments with adaptive learning and analytics, embracing competency-based education with tools such as mastery-based gradebooks.[13]

Collaborative Learning

The concept of collaborative learning has been studied for decades, and research has definitively shown that collaboration between students, whether in pairs or at a community level, fosters higher learning outcomes than learning in isolation.[14] Students have consistently been shown to achieve higher grades and retain information longer when participating in small-group learning

compared to traditional classroom instructional methods,[15,16,17] a pattern which holds true across grade levels, gender, ethnicity, and achievement levels.[18] Collaborative learning encourages students to justify their thinking, articulate their thoughts to convey them to their peers, reflect on outside perspectives, and constructively resolve conflicts and disagreements, all of which enhances motivation and engagement in the learning process.[19]

The internet has made collaborative learning substantially more accessible by allowing students to socialize and interact with peers from around the world in real time. Online learning systems such as MOOCs capitalize on this concept for educational purposes, but even more generic tools such as forums, VOIP platforms, and SMS can be harnessed to increase collaboration between students. Research has shown that collaborative learning does not happen spontaneously, and must be encouraged and integrated in authentic ways as part of the educational process.[17] As future education shifts ever more towards student-centered approaches, collaboration and cooperation between students must become more ingrained in the learning process, and technology is poised to enable this both in and outside the classroom.

Collaborative learning is also essential for teachers. The OECD found that, in a survey of 34 countries, “most teachers” say that they are teaching largely in isolation, and nearly half of all teachers neither engage in teaching with their colleagues nor ever receive any feedback on their teaching from school leaders.[20] Teachers can benefit from peer learning and collaboration in their professional development just as effectively as students, substantially improving their abilities to teach effectively.[21]

Gamification

Gamification is defined as “the process of using game thinking and game mechanics to engage audiences and solve problem”[22]. Gamification leverages many of the elements that make games fun and engaging and applies them to areas other than games. It has great potential when applied as an educational intervention, enhancing students’ cognitive, emotional, and social skills.[23]

As defined by the Quest to Learn program,[24] game-based learning embodies seven key principles:

1. Everyone is a participant
2. Challenge is constant
3. Learning happens by doing
4. Feedback is immediate and ongoing
5. Failure is reframed as "iteration"
6. Everything is interconnected
7. It feels like play

Gamification's primary advantage is that it allows students to engage in the "four freedoms of play": freedom to fail, freedom to experiment, freedom to assume different identities, and freedom of effort (i.e. periods of intense activity followed by periods of lower concentration to prevent burnout).[25] Gamification is also very beneficial in that it is able to automate many elements of the teaching process,

evaluating correct answers and providing immediate feedback without the instructor needing to be engaged in the process.

However, gamification must be implemented with care in order to ensure its effectiveness.[25] A poorly-designed game will serve as a distraction rather than an effective learning tool. Social features can also create tension and stress for students if they rely too heavily on competition or unfairly balanced group activities. Gamification should not be treated as "a universal panacea": projects must be carefully designed to address the authentic challenges faced by schools, be grounded in sound research, and be used in tandem with meaningful assessments to determine their effectiveness.[23]

There are currently a lack of methodologically-sound studies that have examined the effectiveness of gamification as a long-term educational intervention. However, experts agree that gamification is "on the cutting edge of innovation in the ever-changing education system,"[25] and it will only be enhanced by further technological innovation.

Flipped Classrooms

A "flipped" classroom is one in which the traditional flow of learning and reinforcement is reversed: rather than learning new concepts in lectures and then applying this information to homework assignments, students are introduced to new concepts at home, and use their class time to actively apply these concepts in assignments. This method allows students to do the less intensive cognitive work of comprehension and knowledge retention independently so that they can focus on the more cognitively intense tasks of analysis, synthesis, and evaluation in an environment where their peers and instructors are there to support them.[26]

A successful flipped classroom must embody four key features:[26]

1. Allow students to gain first exposure to materials prior to class
2. Incentivize students to prepare for class
3. Provide an effective mechanism for assessing student understanding
4. Provide higher-level cognitive activities in class to reinforce what was learned at home

Research has shown that flipped classrooms can produce significant learning gains compared to traditional classroom environments.[27] A study conducted by Knewton in 2011 found that a class of high school freshmen experienced a 50% failure rate in English and 44% in math over the course of a semester when taught by traditional methods, which were reduced to 19% and 13% failure rates (respectively) after a flipped classroom model was introduced.[28]

Flipped classrooms are growing in popularity. In a survey of over 500 faculty at colleges across the United States, 55% of college instructors say they have already incorporated flipped learning into some or all of their classes, and an additional 25% are interested in incorporating it in the future.[29] Technology is perfectly poised to assist the flipped classroom new model, providing students with access to multimedia materials such as video lectures at home, and incorporating activities to introduce and enhance deeper cognitive challenges within the classroom.

Project-Based Learning

Project-based learning is a dynamic, student-centered, inquiry-based pedagogy that encourages learning through the active exploration of solutions to authentic real-world problems. Students spend a significant amount of time thoroughly researching a single topic, developing a solution over time through iteration and thorough investigation.

There is substantial evidence that project-based learning is an effective pedagogy for building twenty-first century skills. Cognitive research suggests that depth-based approaches to learning result in deeper understanding and greater mastery of core subject matter when compared to traditional breadth-based teaching.[30] Studies have also shown that project-based learning increases students' long-term retention of the learned content, improves problem-solving and collaboration skills, and improves attitudes towards learning in general.[31] Many organizations have already embraced project-based learning as the way of the future: a number of schools and school networks have been established in recent years that embrace project-based learning as their primary pedagogy, including the Deeper Learning Network and THINK Global Schools.

Technology can facilitate project-based learning by providing students with access to the resources needed to thoroughly investigate topics, organize their findings, and present them through a variety of multimedia outlets.

Innovative Technologies

Artificial Intelligence and Machine Learning

Artificial intelligence is an extremely powerful tool to leverage in the field of education. Its applications are capable of providing deeper understanding of the learning process and how it applies to individuals, opening the metaphorical "black box of learning" to provide valuable new insights into the learning process.[32] Artificial intelligence can enhance computer learning environments by integrating cognitive and emotional modeling, knowledge representation, natural language systems for question answering, and machine learning methods, all of which provides greater knowledge about the teaching domain, the students within, and the strategies being employed.[33]

Artificial intelligence systems are capable of collecting, processing, and interpreting vast amounts of data far more quickly and efficiently than any human could achieve. This data can be processed and utilized to make dynamic modifications and improvements to the learning process, as well as providing valuable insights into learning patterns both at the individual and group level. Artificial intelligence is the key to providing more efficient, personalized, contextualized learning environments.[33]

Artificial intelligence and machine learning systems can provide an enormous array of valuable tools for future education, many of which have only begun to be explored. With a well-trained AI, collaborative groups can be assigned automatically to ensure an optimal distribution of achievement

levels amongst their members.[33] Assessments can be conducted automatically to identify weaknesses, and early alert systems can identify students who are at risk of falling behind or dropping out.[34] Virtual chatbots can be created to answer questions about assignments, freeing up significant instructor time and resources.[35] Automated grading and personalized learning can also be realized through AI systems.[36] Machine learning algorithms can even be used to supplement and enhance randomized controlled trials designed to test the efficacy of interventions, which can save substantial time, money, and resources while helping to further enhance our knowledge of what works and what does not in education.[34] The process of predictive modeling through machine learning "rapidly converges to ideal learning solutions that iteratively build on themselves," and the algorithms only continue to improve as more data is collected, further enhancing the predictive power of the proposed learning model.[34]

Artificial intelligence is a highly promising field with numerous potential applications, and innovations will surely continue in this domain in the coming years. A recent study suggests that the use of AI in education will grow by almost 50% through the year 2021 as new innovations take place.[37]

3D Printing

3D printers have a wide array of innovative educational applications. Teachers can use 3D printers to create models and structures that allow students to visualize concepts that are traditionally difficult to convey through illustrations, such as geometric shapes, molecular structures, strands of DNA, and even more abstract concepts such as area and volume. Interlocking puzzles and other interactive structures can be created to allow students to build spatial awareness and problem-solving skills through hands-on interaction. 3D printers can also serve as a creative outlet for encouraging student innovation and skill-building, allowing them to model, build and create their own physical structures. 3D printing opens up a variety of new avenues to promote hands-on, active learning.

Augmented Reality/Virtual Reality

Recent technological innovations have introduced groundbreaking new ways for humans to interact with the world around us. Augmented reality (AR) systems are capable of superimposing computer-generated images over the real world, while virtual reality (VR) systems generate a simulation of an entire three-dimensional world to replace our own. Like 3D printing, AR and VR technologies show major promise in educational applications, providing students with new ways of visualizing the world in physical, interactive ways. Recent studies have shown that students are better at recalling information when it is presented to them in a virtual environment,[38] leading to enhanced educational outcomes[39] and even having the potential to improve lower performers' self image by removing them from the potential stressors holding them back in the real world.[40]

Blockchain

As defined in the book *Blockchain Revolution*, blockchain is "an incorruptible digital ledger of economic transactions that can be programmed to record not just financial transactions but virtually everything of value."[41] In essence, blockchain allows digital information to be distributed, but not

copied.[42] Blockchain technology uses public key infrastructure to establish a secure, encrypted platform for data sharing that is virtually hacker-proof,[43] creating a permanent, secure, immutable record that can be safely shared and distributed. It was first developed within the realm of cryptocurrency, but experts see the potential for the technology to be applied all over the digital world.

Many organizations are already exploring how to apply the blockchain to education. Sony Global Education has adapted blockchain technology into a so-called *open data exchange* protocol, allowing two parties to securely share official academic records.[44] Initiatives such as BadgeChain (a blockchain implementation of OpenBadges) and Blockcerts are exploring ways to award educational credentials for skills that are learned in any setting of life, even outside the classroom (everything from mastering new tools at work to learning how to change a tire). The MIT Media Lab is developing a system for hashing its own digital certificates on the blockchain to permanently record individuals' membership status and contributions.[45] The Institute for Blockchain Studies is exploring the idea of MOOC accreditation and "pay for success" models using blockchain, which can provide a trustworthy record for confirming that courses were completed and mastered, a secure mechanism for payment, and "smart contracts" for holding learners accountable for completing requisite work and paying them accordingly.

Blockchain technology can also provide a secure and robust platform for creating a so-called "global network" of learning, allowing for greater opportunities for content exchange, collaboration and co-innovation between individuals and institutions while maintaining a fixed record of attribution and identity: in essence, resolving the issue of schools operating as independent scholastic "islands."[43]

Blockchain is particularly promising in a global context. According to UNESCO, 1 in 7 people worldwide are unable to prove their identity, a problem which is particularly severe for refugees and other displaced individuals. Approximately 20% of Syrians aged 18-24 were enrolled in higher education before the war, but that number has now dropped to less than 5%, due in part to their education credentials being lost as a result of their displacement.[46] Blockchain technology has the ability to maintain a permanent, fixed, secure record of an individual's entire history, ensuring that displaced refugees will never be able to lose such integral documentation and proof of identity.

Blockchain technology is still in its infancy, but according to IDC, blockchain spending is expected to grow substantially in the coming years, with a total investment of $9.7 billion in 2021.[47]

General Recommendations

The following recommendations are adapted from several previous reports published by Save the Children, listed in Appendix A. Please refer to those reports for a more thorough account of how Save the Children can maximize the success of its future ICT programs in the education sector.

Supplement, not substitute

There is no one-size-fits-all solution to all educational challenges. Initiatives must first identify the specific problems that need to be addressed in a given context, then identify the appropriate

technologies to support the solution. ICTs must be thoughtfully tailored in a way that is sensitive to the contexts in which they will be applied. Software integration cannot require a change in the learning environment, but rather tools must be used to improve existing educational practices.

Content must be relevant for the students and should not increase the workload required of the teachers by competing or conflicting with the official local curriculum. Positive learning outcomes greatly decrease when software is used to replace formal education.

Use sound methodologies

Educational technology must be constructed around sound pedagogical principles. Technology should be used to support cognition and active learning, not simply for delivering content.

Hardware alone is not enough. Simply providing increased access to ICT in schools or at home is not sufficient to result in improved learning outcomes.

Integrate Monitoring and Evaluation into all programs from the beginning. M&E is crucial to allow for real-time learning during implementation about how to improve, as well as allowing future ICT programs to benefit from the lessons learned in endline reports. Impact evidence must be utilized appropriately while taking existing evidence into consideration.

Work with already-proven technologies. Children should not be treated as experiments, and projects should have a high probability of success to maximize the potential for realizing real educational benefits.

Focus on teachers and caregivers

ICTs cannot and should not be used to replace teachers. Teachers need to be enabled to use the ICTs effectively so that they can maintain an active role in helping the students learn. Adult-led scaffolding is necessary to ensure learner engagement and support. Software cannot tell the difference between a careless error and a deep misunderstanding requiring intervention. Children require guidance and reassurance that can only come from adults to stay engaged and keep from getting frustrated.

Teachers must be engaged and enthusiastic about the proposed solutions: positive teacher attitudes about the solution and its potential are necessary for effective integration.

Teachers must feel comfortable with using the technology. Enhance teacher learning and competence before trying to introduce new technologies in schools. Poor teacher training, and a lack of continued teacher development, leads to poor learning outcomes. Training must factor in the previous technology experience of the facilitator.

Expand beyond ICTs in the classroom. Leverage the indirect educational benefits of applying ICTs for parents and communities. Parents and caregivers must be supportive of the technology to ensure their active engagement in encouraging their children's education outside the classroom. Family support is even more crucial in education in emergency situations.

Provide strong scaffolding

Design ICT programs to be scalable from the beginning. Do not implement small-scale pilot projects just to prove potential innovation. Infrastructure must be carefully considered before any solutions are implemented. Every region has different infrastructure and access to resources, and initiatives must consider this from the beginning to ensure sustainability and cost-effectiveness. It is essential to factor in maintenance costs, connectivity and electricity provisions, and staff training when designing any sort of sustainable ICT initiative.

Staff and anyone else involved in the initiatives must be trained and well-informed in the appropriate application of the ICTs for education to ensure best practices and a strong foundation for future programs. Do not assume that a general understanding of technology is sufficient preparation.

Work collaboratively with relevant stakeholders, governments, organizations, and companies. Do not compete with other organizations, but instead seek to build effective partnerships.

Put the students at the center of the learning process

Educational technology must be adaptive and materials must be context-sensitive. Materials should be the appropriate level for each child, allowing them to progress and learn from mistakes. Children should be able to connect to the examples given to ensure their engagement and understanding; learning that stands by itself is often forgotten because the learner has nothing to "hook" this information into in their current knowledge base.

Children should be allowed to explore technological devices from the beginning. Child learners are typically able to teach themselves how to use technology without the need for heavy-handed guidance and intervention.

Ensure equity and safety for all users

Technology must be free from barriers to access. Economic and societal contexts can result in differences in access to technology for boys and girls, and for those with disabilities and from more marginalized backgrounds. Solutions must not exacerbate this problem and must seek to reduce inequalities as much as possible.

Child Online Protection must be embedded into any and all ICT initiatives to ensure the children's safety and security above all else.

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Appendix A: Further Reading

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