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MUSEUM OF
THE FUTURE

GEMS
EDUCATION

SCHOOLS OF THE FUTURE

GEMS INTELLIGENCE UNIT

FEBRUARY 2016

CONTENTS

Executive Summary

The 20th century ushered in the industrial revolution which has brought a great change in the way people live, work and study. The needs of an industrial workforce changed the way students were educated. The schools and curriculum were designed to resemble and prepare the children for factory style workplaces and offices. The 21st century, with its technological and communication innovations, is changing the paradigm of 'factory style' workforce where repetitive manual jobs are rapidly being replaced with automation and applying knowledge is valued over acquiring it. These changes are part of the transformation of the industrial economy which dominated the 20th century to the knowledge economy which will dominate the 21st century.

In order to sustain, improve and utilize benefits of the growth provided by the 'knowledge economy', nations and societies need to transform the way their citizens live, work and study. As citizens prepare to contribute to the growth and development of the communities they live in and tackle complex problems like global warming, conflict, migration etc. which have interlinking effects both locally and globally. In uncertain and rapidly evolving complex world, the purpose and nature of education needs a paradigm shift. The "School of the Future" report is an attempt to showcase some of the broad trends and features of schooling for the 21st century. It is not intended to serve as a comprehensive and complete document but serve as a blueprint for discussion. So, it is presented as an anthology of thoughts and opinions based on current literature review.

The report starts with a brief historical context of how schools and their role in society were influenced by the religious, political and economic forces of their times. This provides the basis for understanding the potential drivers for the School of the Future. The report is based on certain assumptions about the needs of the nations in the 21st century which provides the basis for the framework. The framework for the 'School of the Future' outlines the three essential pillars – Practice, Partnership and Environment, which are integral to functioning of each school.

The Practice pillar consists of the curriculum and pedagogy of the future. It delves into the skills and tools required by learners and the instructors of the 21st century. It also emphasizes on skills beyond the traditional 3R's like financial and entrepreneurial education, which are very much necessary in the knowledge economy.

The Partnership pillar describes the relationships between the various stakeholders and the school. The 21st century education should enable the learners to pursue their interests and passions by personalizing the learning experience. The partnerships which the learners' cultivate with their instructors, peers, communities and other stakeholders enable a rich and authentic learning experience while preparing for the future, where interconnectedness and co-creation are absolutely crucial. This elevates the learning experience from an 'isolated' to a social journey. The School of the Future enables and develops these partnerships creating a learning eco-system for educating the citizens of the future.

The Environment pillar deals with the physical infrastructure and social systems designed to support future learners. The physical infrastructure will allow the schools to be flexible in meeting the needs of the learners by providing spaces which allows collaboration, innovation and personalization. It also allows the schools to rapidly respond to the growing demands of resource constraints, technology inclusion and the changing nature of learning. The social systems, in forms of the ethos, mission and vision, dictate the beliefs and values to be included as part of every learner's experience, to truly appreciate and participate in the learning journey with others. The interplay and synergy between the physical infrastructure and social systems ensure that the School of the Future is successful and sustainable.

Further, the report contains thought provoking chapters by some of the leading thought leaders on the role and types of learning technologies in the future. It also discusses the role of design and its implications in the School of the Future. The report hopes to provide a base for discussion and help formulate policy through which the educational systems can truly serve the citizens of the 21st century.

This report has been made possible through the efforts and contributions of the GEMS Intelligence Unit team, and its advisors - Dr. Rose Luckin- Professor of Learner Centred Design, UCL Institute of Education, London, Dr. Will Venters – Asst. Professor of Information Systems, London School of Economics, and Dr. Carsten Sorensen – Asst. Professor of Information Systems and Innovation, London School of Economics. Also, a special acknowledgement to Ms.Kanika Saraff for editing and proof reading this report.

Chapter 1: Introduction

The Shaping of Schools

For many centuries, schools were only for the benefit of the wealthy. The oldest continually active school was founded in the 6th century in Canterbury, England. It was designed for the children of wealthy families to put them on a trajectory to a University education. Today, the global net enrolment ratio[1] for primary schools is estimated to have reached 93%, and whilst much has changed, the legacy of the early schools is clear. When education for poorer students first appeared, it mainly took the form of religious tuition or more commonly apprenticeships to instil the skills necessary for earning a living. It was not until the 19th century that public school systems opened its gates for all. The purpose of these schools was sometimes religious, but for the most part it was to offer students either an academic education to prepare them for University or to offer a practical or technical education that would prepare students for the world of work. The industrial revolution had changed the requirements of the workforce which provided a significant impetus for bringing all children in the fold of schooling. This growing need of the industry affected what was to be taught in schools and how. The '3 R's' of Reading, Writing and Arithmetic were dominant, as was Science. The culture of discipline, punctuality and obedience to be instilled in students, were ideas closely linked to creating a suitable workforce for the factories and workplaces of the time. Education, unapologetically, was designed to suit the needs of the market. Over time, a few renowned intellectuals and philosophers have influenced the understanding of schooling and education. Rudolf Steiner, Montessori and Dewey among others, have made a mark and changed the linear, assembly-line inspired thinking about schooling.

Largely, the nature of schools even today reflects this early heritage, with priority given to Science, Math and Literacy in the curriculum and with schools following philosophies such as Steiner and Montessori thriving around the world in small pockets.

The Drivers of Schools of the Future

Society, Academia and Work

Looking into the future, the workings of schools look complex and even more intriguing. The early and contemporary forces will continue to play their part, though in a renewed fashion; with a host of new influencers joining in.

In the future, the nature of needs at universities and workplaces are likely to see shifts and uncertainties, which in turn will make it much harder for the education system to prepare the students in tandem with these changes. Universities will be required to prepare their students for work as well as intellectual rigor - with skills and abilities far beyond the current expectation. They will, therefore, require students to leave school/university with certain skills and abilities in addition to those reflected in their examination scores. When it comes to preparing students for the world of work -both at school and at university- the lack of certainty about the future of work , will make the education process challenging. The foreseeable changes are going to make the education process more demanding and complex.

Levy and Murnane (2004) demonstrate that the skills that are easiest for schools to teach and assess are also those that are less in-demand within the workforce. These are the routine cognitive and manual skills (both routine and non-routine) that also happen to be the ones that are easiest to automate. The skills increasingly in demand are the non-routine analytic skills and interactive skills. And it isn't hard to extrapolate that members of the modern workforce will need to be even more versatile, capable of abstraction and other higher order thinking. This evolving demand for a workforce with a different skill-set will turn the wheels of a change in curriculum that still carries the legacy of the early schools. The demands of the 21st century will force us to re-imagine and rearrange what is taught in schools and how.

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[1] *The enrolment of the official age group for a given level of education expressed as a percentage of the corresponding population.*

Assessment and Resource Allocation

Success in schools is often measured by student performance alone. The introduction of exam systems and competition between public schools within and beyond a single nation has led to a situation where schools are driven by the success of their students' in the various forms of assessment they undergo. Recent research by the OECD (through the PISA assessments conducted every 3 years) has paved the way for new parameters for what makes a school successful.

There are clear indicators within the PISA data that will be essential drivers for the future of schools. The OECD findings stress the need for organizing the learning environment which is influenced by decision-making both within and beyond the school itself. Another idea which is advocated for is that financial resources alone are insufficient to improve educational outcomes, but its allocation can have an impact- high-performing countries tend to allocate resources more equitably across socio-economically advantaged and disadvantaged schools. There is also evidence that school autonomy is important; with high performing schools tending to have more responsibility for their curricula and assessments (OECD 2012).

Scientific Advances

There have been significant advances in how we understand learning; and that should drive the way we design schools in the future. For example, an LSE report (2013) revealed that, "The most powerful childhood predictor of adult life-satisfaction is the child's emotional health... The least powerful predictor is the child's intellectual development". The importance of emotional health has also been confirmed by psychologists (Pekrun 2002) who have explored how a student's learning is mediated by a student's motivation to learn, a student's learning strategies, and a student's cognitive resources. Emotion influences each of these constructs in different ways. For example, emotion directs attention and cognitive resources towards an object or a task; emotion triggers, sustains or reduces academic motivation; and emotion influences the learning strategy adopted by a student. An emotional experience such as enjoyment of learning can, therefore, direct a student's full attention to the learning task, enhance a student's academic motivation, and enable the student to adopt flexible learning strategies such as elaboration or critical evaluation. Neuroscience has also studied the nature of the relationship between emotion and learning and has, for example, demonstrated that emotions have a fundamental role in decision-making.(Damasio, Tranel and Damasio).Other drivers for the School of the Future arise from more challenging scientific developments. For example, targeted pharmacological enhancements will cause tensions and the ethical implications of such possibilities will demand care and attention.

Technology and the Changing Population

The world population is growing and is expected to reach 10 billion in 2050(World Bank). Not only is it growing, it is also shifting as people move from country to country. This changing population will put pressure on schools, particularly with respect to educating the most vulnerable and disadvantaged. According to Andreas Schleicher, Director for the Directorate of Education and Skills at the OECD (2015), "technology is the only way to dramatically expand access to knowledge." This means that providing latest information to students and giving access to teachers to upload, share and offer feedback on the same will be essential.

The need for constantly updated teachers who are skilled and confident with technology will be a key driver for Schools of the Future. Schools of the Future will need to offer comprehensive and up to date continual professional development to its staff. Technology is also an ally in the implementation of the new types of learning that Universities and the workplaces demand. Technology will also provide the means to assess learning through smart learning analytics to enable teachers and learners to better understand their progress and learning needs. Vigilance and constant attention to ensure that students are e-safe through training and safeguarding will also remain essential. The rising population and the growing enrolment in schools will be matched by a fall in the number of teachers. This will put pressure on governments to build teacher capacity , explore how technology can help make the best use of available human resources and to offer additional artificially intelligent teaching assistance.

Economic Growth

No matter how it is measured, there is a clear connection of the cognitive skills and learning of a country's population to that of its economic growth. For example, empirical growth research demonstrates a statistically and economically significant positive effect of cognitive skills on economic growth (Hanushek, Eric and Kimko 2000).This can act as a driver for countries to improve the educational attainment of their citizens by investing in schools to bring about change. It can also drive educational change by raising the demand from within the population for education, provided investment has been equitable (UNESCO 2015). Continued investment in schools is required for continued economic growth. Initially, investment in schools may come from International Aid funding. The changing attitudes towards and levels of International Aid will drive future school development in some parts of the world. Improvements in schooling and increases in the percentage of the population who attend school will lead to a more knowledgeable population who will have increased expectations of what schools will provide. The demand for personalized learning to meet their individual needs, therefore, might go up.

Community and New Partnerships

The future will demand more from schools, learners and teachers alike. Students will need subject specific knowledge and build understanding in a manner that enables application and synthesis in a flexible and interdisciplinary manner. In addition, they will need to develop a diverse pool of skills like communication, collaboration, critical thinking and resilience. At the same time, there is and will be an inadequate pool of good quality, well-trained and motivated teachers and this situation is set to continue (UNESCO).Schools will need to look beyond their current teaching force for the resources they need to provide high quality education. They will need to explore the use of technology to work with teachers who are geographically distant, explore the resources available within their local community and develop new partnerships with individuals and organizations that can provide the expertise required.

Physical Space and the Institution

The growing population will require a significant investment in building physical infrastructure if all students are to be accommodated in the traditional way. This pressure combined with the costs of aging school buildings may result in a willingness to consider new models of education. For example, students may attend school in shifts through a blended approach whereby technology could enable students to learn at home for some of the time and at school for the rest. New providers of schools are likely to emerge, some of whom will offer work-based and informal education as well as formal teaching and learning. The boundaries between school, home, work and leisure are likely to erode and inter-generational learning will be increasingly important for social cohesion and educational provision (NFER 2009). The shift within schools and colleges away from books as knowledge resources to eBooks and online content will put publishers in a powerful position to control access to these resources. New providers that involve a publisher are likely to thrive.

Globalization and Cultural Distinction

The increasingly interconnected world has brought increased trade and cultural exchange. Globalization has increased the production of goods and services and freed up the movement of resources, capital and people. It has also resulted in a greater dependence on the global economy. As a driver for Schools of the Future, it brings challenges and opportunities. It provides a real possibility of global education and citizenship with learning taking place across the globe. However, it also masks the deep-seated cultural distinctions that exist between and within populations, and which require different approaches. The rapidly expanding mix of cultures and ethnicity within populations will require major efforts to prioritize disadvantaged and marginalized children.

Vision

The key drivers mentioned in the introduction provide the base for a holistic vision that future schools will be benchmarked against. The School of the Future must build upon the important national imperatives needed for any nation in the 21st century. Some of those imperatives are:

- Create and sustain a cohesive society and establish preserved identity.
- Create a safe public infrastructure and fair judiciary.
- Build and sustain a competitive knowledge economy.
- Build and sustain a first rate education system.
- Provide world class healthcare.
- Create a sustainable environment and infrastructure.

This vision could result in an education strategy which includes the following broad educational outcomes.

Students	Teachers
Proud model citizens	Role models
Knowledgeable students	Knowledgeable instructors
Students proficient in needed skills	Creative educators
Fit and active individuals	Trained professionals
	Attentive counsellors

Table 1: Education strategy

The School of the Future must reach for, build and sustain these outcomes by developing key performance indicators (KPI) based on external benchmarking assessments(PISA,TIMMS), internal benchmarking assessments, metrics of access, equity and inclusiveness, and graduation rates.

Chapter 2: The Framework for the School of the Future

The McKinsey study (2010)-on high performing regions as measured by educational outcomes- and Fullan (2011) enumerate the systemic nature of educational performance, i.e. how each aspect of education is closely related to another. The diagram presented below represents distinct levers of an education system that will have to work in tandem with each other to achieve required outcomes (Fig 1.).

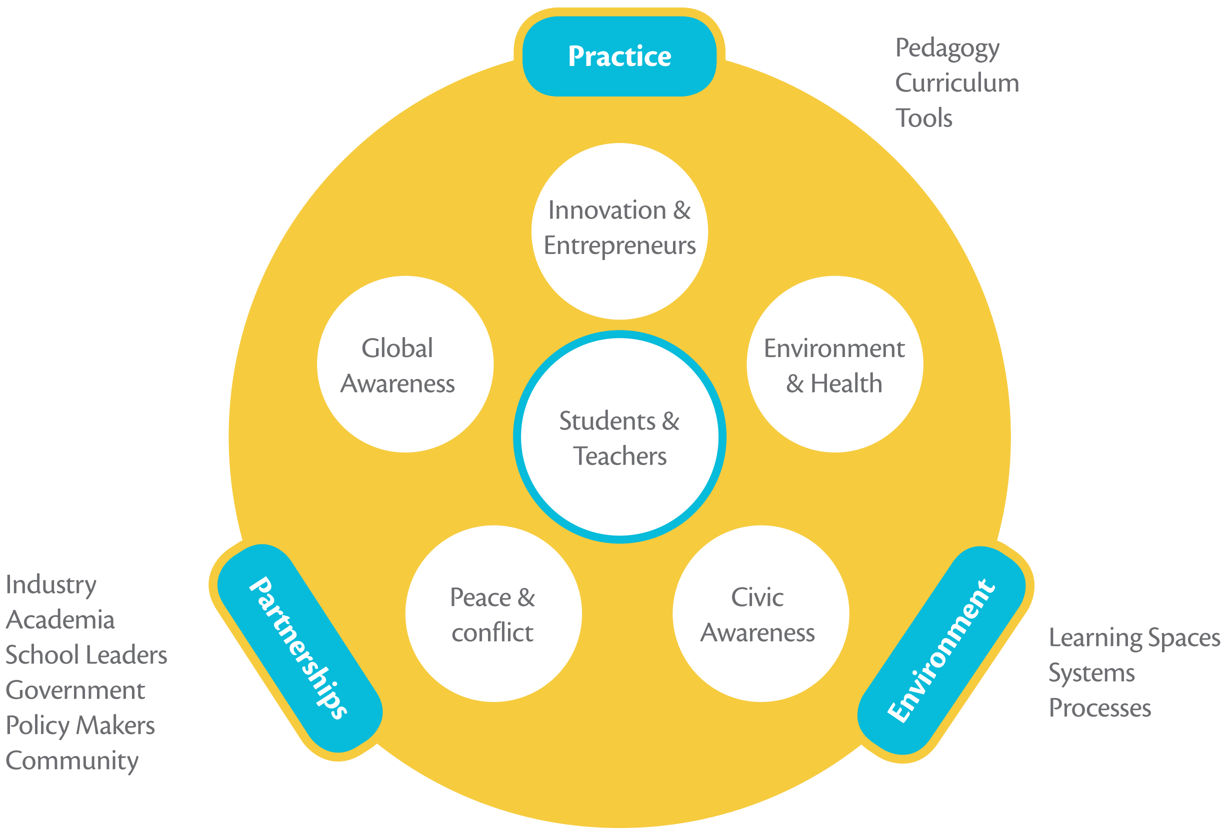


Fig. 1: Distinct levers of an education system that have to work in tandem with each other to achieve required outcomes

The School of the Future is centred on the learner and the educator. The 21st century is contextualized by learning themes which reflect important issues facing the global economy of the future.

Learning themes:

1. Innovation and entrepreneurship.
2. Environment and health
3. Global awareness
4. Civic awareness
5. Peace and conflict

These learning themes provide the context for the three foundational pillars which are essential to the functioning, organization and partnerships required to achieve the vision. These three foundational pillars are:

1. Practice
2. Partnerships
3. Environment

We discuss each of these pillars in detail below.

Practice

This section expounds on the practice module of the modelled system, providing high- level overviews of how this pillar could be leveraged to achieve and sustain educational goals outlined. Rather than providing in-depth reviews of a narrow set of topics, this section provides a tour of key topics that define the practice module of the School of the Future.

21st century skills

According to the World Economic Forum (WEF 2015) the nature of available jobs, especially in developed economies, has evolved considerably from routine manual work to those requiring majority of non-routine collaborative and non-routine analytical methods. Addressing these needs requires specialized skills and competencies defined below (Fig 2).

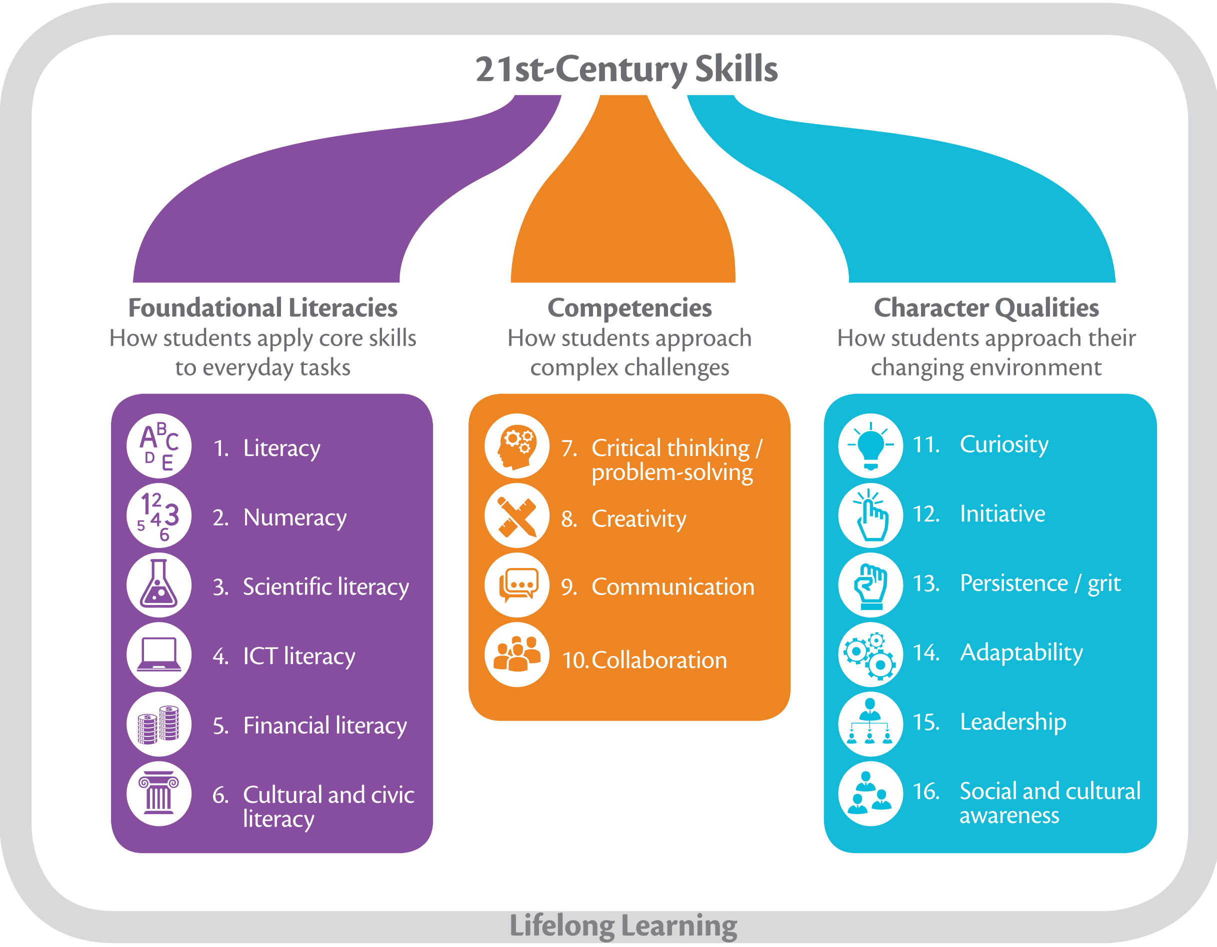


Fig. 2: Skills, Competencies and Qualities of the 21st century

Source: World Economic Forum (2015). New vision for Education: Unlocking the Potential of Technology. World Economic Forum- Industry Agenda

The above framework serves as the canon for our overall design of the practice module of the School of the Future.

Core Pedagogical Principles

The practice module defines the so called "instructional core," detailing the interaction between the teacher and student via curriculum and pedagogy, instructional resources and the larger ecosystem, in order to achieve sound learning outcomes. Here, the core literacies, key competencies and character education are delivered via the Innovative Learning Environment framework (OECD, 2013) (Fig. 3).

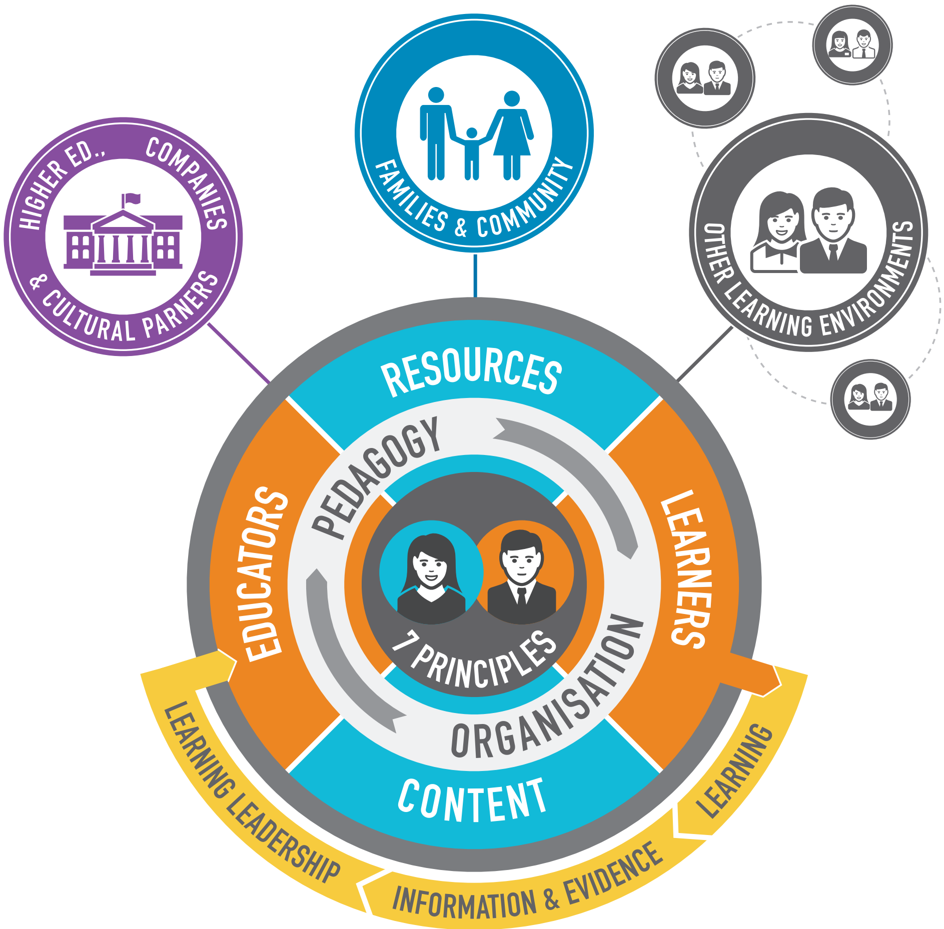


Fig. 3: The Innovative Learning Environment framework (OECD, 2013)

Source: OECD (2013), Innovative Learning Environments, Educational Research and Innovation, OECD Publishing, Paris.

The interaction between the various layers of the above framework represents core learning principles of the practice module as mentioned in Fig 1. They are (OECD 2013):

1. Making learning and engagement central
2. Ensuring that learning is social and often collaborative.
3. Be highly attuned to learner's motivation and emotions.
4. Be acutely sensitive to individual differences in learning style including prior knowledge and cultural background.
5. Be demanding of each learner, without excessive overload.
6. Assessment is critical, but must underpin learning aims and strong emphasis on formative feedback.
7. Promote "horizontal connectedness," across activities and subjects, in and out of school.

These research based pedagogical techniques enhance the classroom experience by facilitating higher order thinking as well as providing opportunities for developing core 21st century competencies and character traits.

21st century learning

Educational objectives as defined in the 2021 strategy document detail the requirement of achieving strong core programs in Literacy, Science and Mathematics as measured by the TIMMS and PISA scores. They constitute the so-called Universal Basic Skills (OECD, Hanushek and Woessmann 2015) and are especially important as they are strong predictors of future economic growth of a country. UNESCO-IBE, 2015, (Amadio, Operttiy and Tedesco) defines Reading literacy, Science and Mathematics as “hard- core subjects” around which the “soft- core skills,” such as ICT literacy, Entrepreneurship and Global Awareness can be integrated.

Core 21st century skills

a. Literacy

The PISA 2015 reading framework (OECD 2015) benchmarks the complexity and the breadth of reading tasks that define reading literacy in the 21st century. The framework classifies reading literacy in terms of:

- Situation, or the context in which students engage with a text (personal, education, occupational and public).
- Text, which denotes the range of material read by students (print/digital, authored/message-based/ mixed, description/narration etc.).
- Aspect, which represents the “cognitive approach” taken by students while reading said text (access/ retrieve, integrate/interpret, reflect/evaluate).

These are similar to the hierarchical levels of the Bloom’s taxonomy of learning objectives (Bloom, et al. 1956).

The 21st century literacy program, therefore, takes into account the various factors mentioned above in its design. More specifically, a well-designed program would include curriculum that increases in complexity with time while providing opportunities for individual learning differences and is designed as a tour across the Bloom’s levels.

Cultural considerations

The knowledge economy of the 21st century requires instruction that takes into account various aspects of reading literacy mentioned above. Further, given the multicultural demography of UAE, it is imperative to take socio-cultural differences into account when planning for second-language acquisition. For example, Wheeler and Swords (2004) emphasize the importance of contextualizing language teaching when dealing with a multicultural cohort. According to them one such strategy for achieving cultural appropriateness could be “code-switching” or comparing and contrasting various dialects of that particular language (as against right vs. wrong) and bucketing them into appropriate contexts of usage. The alternative, corrective learning, is shown to have a detrimental effect during language acquisition.

b. Numeracy

Mathematical literacy, apart from being fundamental to any economic transaction, is also a strong predictor of annual earnings. Hanushek and Woessman (2008) suggest that a 1 standard deviation in Mathematics high school graduation scores translates to 12% higher annual earnings. In the 21st century knowledge economy, the nature of mathematical problems that need to be solved have evolved from those of a simple, formulaic nature to those that are complex, unfamiliar and non-routine (CUN problems). And this, invariably, is the nature of mathematical problems in authentic, real life settings.

For such CUN problems, experimental and quasi-experimental evidence suggests that the so called meta-cognitive or thinking about thinking strategies of instruction combined with a robust framework for cooperative peer learning provide a significant boost to students’ ability to comprehend and solve such problems (Mevarech and Kramarski 2014). The future school system, having recognized the importance of training students for increasingly complex situations, will need to build capacity for meta-cognitive and cooperative instruction.

c. Scientific Literacy

Quinn et al (2012) describe the framework for the next generation standards of K-12 scientific learning. The framework is based on an inquiry-based and experiential approach to science education and is summarized below (Table. 2).

Scientific practices	Disciplinary core	Crosscutting concepts
Skills and knowledge specific to each practice that scientists and engineers use to a) Build and test theories b) Build and tests engineering models E.g. –Developing and using models, analysing and interpreting data	Core knowledge for scientific understanding that increase in complexity across K-12. This forms the foundational scientific fact base for students. E.g.- Earth and solar system, interdependent relationships in ecosystems	These are major themes that occur across scientific the disciplinary core ideas. Crosscutting concepts provide the underlying pedagogical bridge to complicated scientific concepts. E.g. - Cause and effect, stability and change

Table 2: Framework for the next generation standards of K-12 scientific learning (NGSS)

Such a curriculum provides a pedagogically sound and rigorous set of standards for the School of the Future and is an excellent tool to benchmark science instruction against. Further, each aspect of such a curriculum is closely integrated with each other, for e.g. interpreting scientific data requires knowledge of the disciplinary core, the ability to bucket knowledge by using crosscutting themes and finally developing models of understanding. This provides for a complex, coherent and complete pedagogical experience.

Considerations for English Language Learners

The next generation science standards demand complex reception, production and argumentation skills of language learners for describing and predicting scientific phenomena (Schweingruber, Keller and Quinn 2012). Without sufficient scaffolding (breaking down large goals into objectives of increasing complexity) novice language learners are likely to be left behind. In order to prevent this, targeted instructional strategies are necessary. Quinn et al. (2012) suggest the following themes of support:

- Literacy strategies
  E.g. - Sentence prompts, activating prior knowledge through word wall, concept maps.
- Language support strategies
  E.g. - Key vocabulary
- Discourse strategies
  E.g.- Building conventions like asking for clarification and repetition, providing multiple redundancies like paraphrasing complex sentences and using synonyms.
- Home language support
  E.g. -Translanguaging key ideas.
- Home culture connections
  E.g. - Balancing cultures where cross talk is accepted and those where respectful discourse is the norm.

Soft skills in the 21st century

The so-called soft 21st century skills include ICT and financial literacies, socio-emotional competencies and character education. These go above and beyond the basic literacies and provide the value addition core and are central to learning in the School of the Future.

Cross-curricular competencies

These competencies define the various modes by which students solve complex challenges of 21st content (see Fig.2). These competencies are neither new nor specific to the 21st century (Future Tense 2013).However, with the advent of the knowledge economy they have become basic expectations of knowledge workers.

In this regard, the Quebec model of competency integration serves as an excellent benchmark. Fig. 4 presents the competency "Exercises Critical Judgment." The Quebec model[2] further breaks down said competency into smaller scaffolds and each such competency is assigned an overall evaluation criteria for close monitoring of progress.

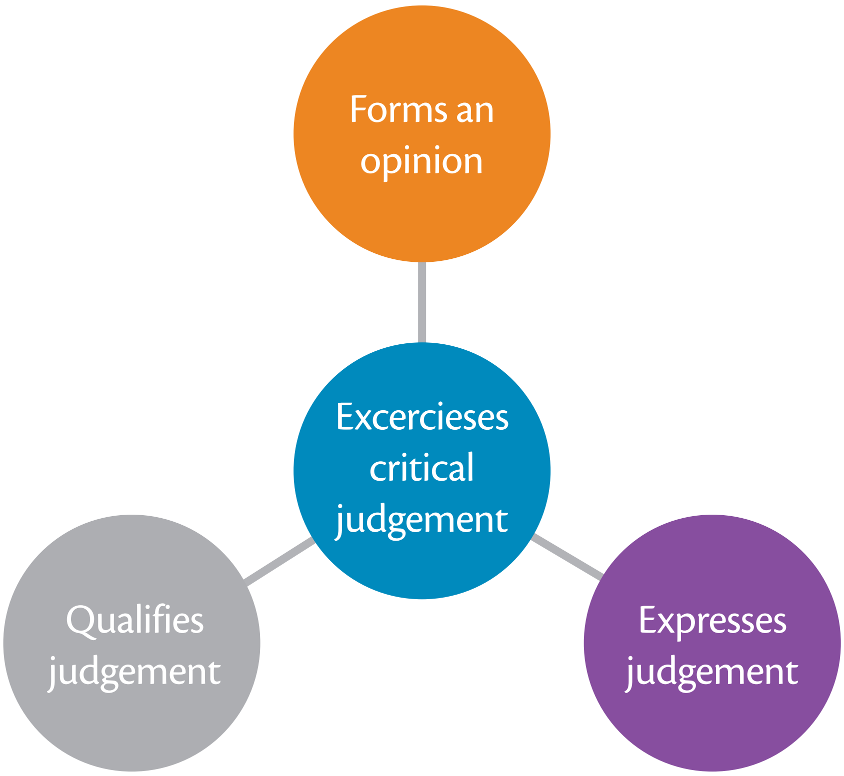


Fig. 4: The competency "Exercises Critical Judgment"

Source: Quebec Model of Competency (http://www1.mels.gouv.qc.ca/sections/programmeFormation/secondaire1/pdf/qepsecfirstcycle.pdf)

The evaluation criteria for this particular competency include observable behaviours such as:

1) Proper formulation of a question and its implications.
2) Openness to questioning of judgment.
3) Appropriateness of the criteria used.
4) Well-reasoned justification of judgment.

[2]*http://www1.mels.gouv.qc.ca/sections/programmeFormation/secondaire1/pdf/qepsecfirstcycle.pdf*

Entrepreneurship education

The foundational base of entrepreneurship education for the School of the Future would be formed by ICT and financial literacies. However, this alone would not suffice.

Entrepreneurship education would also involve ingrained competencies that form core entrepreneurial mind-sets such as risk-taking and self-insight. The following framework could be used to design such a program (Lackéus 2015).

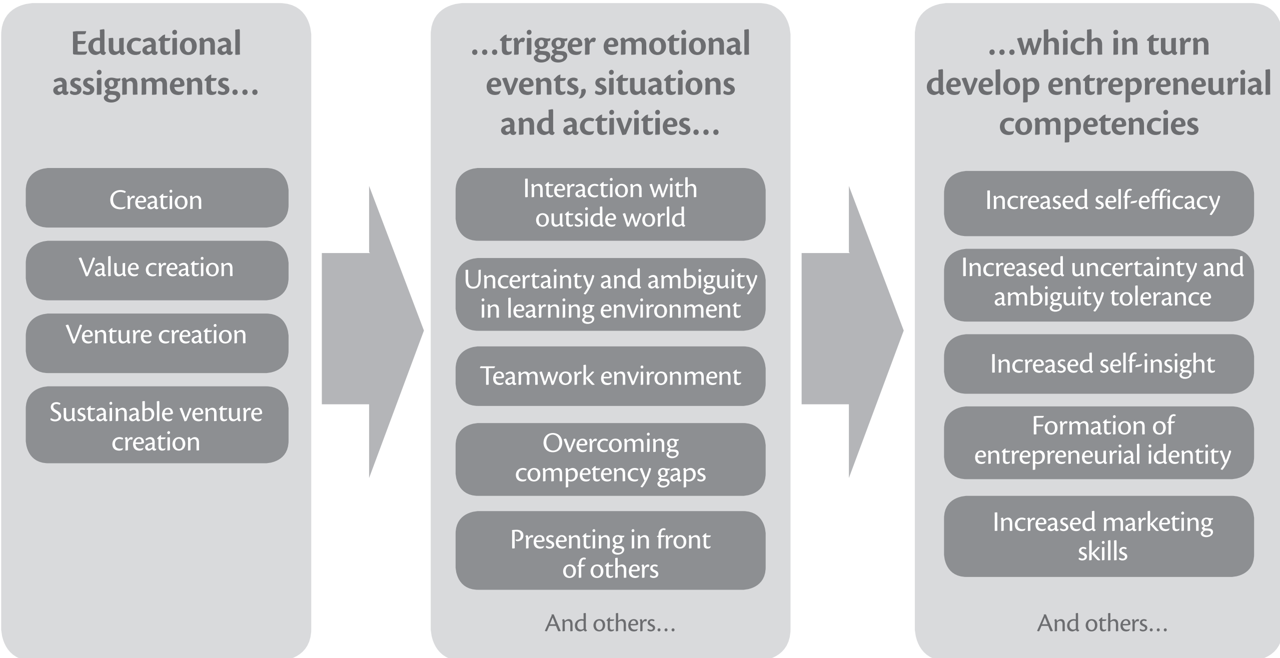


Fig. 5: Framework for entrepreneurial education

Source: OECD Entrepreneurship 2015- Martin Lackéus, Martin Lackéus (2015), Entrepreneurship in Education: Why, What, When, How: Entrepreneurship 360 Background Paper. OECD Publishing, Paris.

The educational assignments (mentioned above) themselves could be embedded as projects in ICT and financial literacy programs in schools.

ICT Literacy

Partnership for 21st century skills –P21 (2015) - defines ICT literacy in the following way:

- Ability to use technology as a tool to research, organize, evaluate and communicate information.
- Ability to use digital technologies (computers, PDAs, media players, GPS, etc.), communication/ networking tools and social networks appropriately to access, manage, integrate, evaluate and create information to successfully function in a knowledge economy.
- Ability to apply a fundamental understanding of the ethical/legal issues surrounding the access and use of information technologies.

Further, P21 has also created a rigorous set of standards that map content to ICT standards. These can then be used to develop a closely integrated curriculum document. Over and beyond basic ICT literacies, a self-contained entrepreneurship education in ICT would also involve lessons on programming. Organizations such as code.org have developed scaffolded and comprehensive elementary, middle and high school curriculum for teaching coding where online tools are provided but devices would need to be locally sourced.

Financial literacy

Financial literacy is widely recognized as a key life skill, given that students are required to handle complex financial packages right out of school in the form of student loan repayments and other products (OECD 2014). OECD PISA (2012) states the importance of providing financial literacy in schools, given the ingrained disparity in financial knowledge between socio-economically advantaged and disadvantaged students. Financial literacy is also a foundational literacy for entrepreneurship. In this regard, financial literacy and business strands of the national entrepreneurship education standards provide an example of integrating financial and ICT literacies in entrepreneurship education **(Fig 6.)**.

FINANCIAL LITERACY

Understands personal money-management concepts, procedures, and strategies

BASICS	COMPETENCY AWARENESS
****Money Basics**	
G.01 Explain forms of financial exchange (cash, credit, debit, etc.) G.02 Describe functions of money (medium of exchange, unit of measure, store of value) G.03 Describe the sources of income (wages / salaries, interest, rent, dividends, transfer payments etc.) G.09 Use money effectively	G.04 Recognize types of currency (paper money, coins, banknotes, government bonds, treasury notes, etc.) G.05 Read and interpret and pay stub G.08 Explain legal responsibilities associated with use of money
****Financial Services**	
	G.10 Describe services provided by financial institutions G.11 Explain legal responsibilities of financial institutions G.12 Explain costs associated with use of financial services
****Personal Money Management**	
G.15 Set financial goals G.16 Develop savings plan G.17 Develop spending plan G.18 Make deposits to and withdrawals from account G.25 Develop personal budget	G.23 Explain types of investments

Fig. 6: Financial literacy and business strands of the national entrepreneurship education standards provide an example of integrating financial and ICT literacies in entrepreneurship education

Source: National Entrepreneurship Education Standards (n.d). Retrieved 28 December 2015, from http://www.entre-ed.org/Standards_Toolkit/

Chapter 2: The Framework for the School of the Future *continued*

Global education for sustainable development

In order to build a sustainable future, the global, Education for Sustainable Development imperative is delivered in the School of the Future under the following themes (UNESCO ESD)

- Biodiversity
- Climate change education
- Disaster risk reduction
- Cultural diversity
- Poverty reduction
- Gender
- Health promotion
- Sustainable lifestyles
- Peace and human security
- Water
- Sustainable urbanization

For achieving these objectives, Education for Sustainable Development (ESD) is best delivered in an integrated fashion where the themes mentioned above are combined with core content areas as shown below (McKeown, et al. 2002).

Figure 1. Education for Sustainability as an Individual Discipline

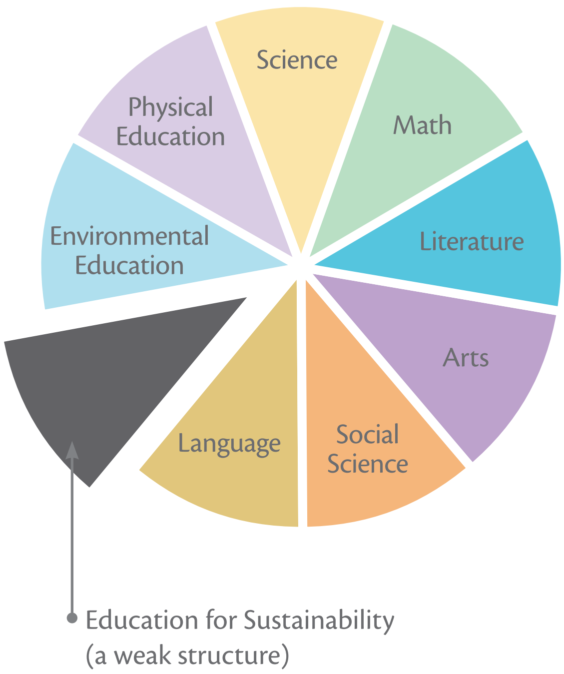


Figure 2. Education for Sustainability as a Multidisciplinary Subject

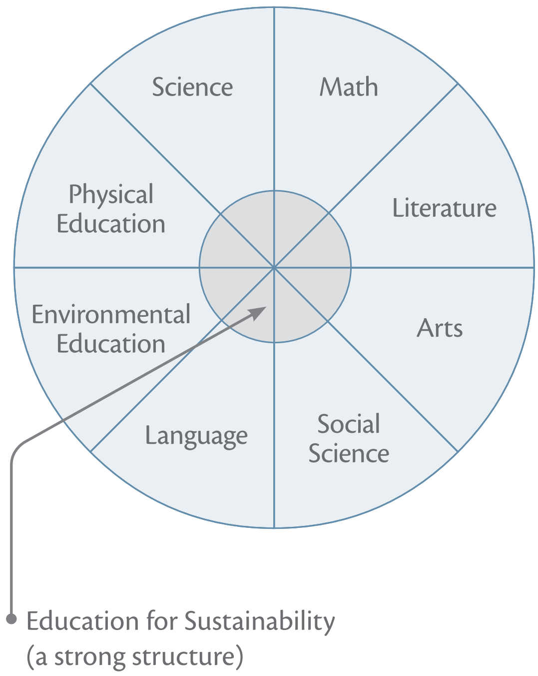


Fig. 7: Education for Sustainable Development (ESD)

Source: McKeown, R., Hopkins, C. A., Rizi, R., & Chrystalbridge, M. (2002). Education for sustainable development toolkit. Knoxville: Energy, Environment and Resources Center, University of Tennessee

In this regard, the U.S partnership for Education for Sustainable Development (McKeown, et al. 2002) has developed an integrated set of standards that can be leveraged by the School of the Future.

Character education and social- emotional learning

The importance of character education and social emotional learning for students has been widely established (Farrington et al. 2012) (Payton 2008). Effective programs have shown to improve student's attitudes, behaviours and academic achievement.

The KIPP schools place particular emphasis on character development. Based on the research of Martin Seligman (2011) and Angela Duckworth[3] a model for delivering effective pedagogy for character education has been developed. It consists of:

- Macrostructures for character education: These include unit and lesson plans with objectives and progressions for including character education.
- Microstructures for character education: These include unplanned/unscripted, minute to minute interactions that can be used for character building. This is done by: (Coursera 2015)
    - Responding constructively.
    - Building and sustaining a growth mindset in students.
    - Defining, explaining and using character behaviour language explicitly (E.g. Defining grit, what grit means and how it looks like in the classroom setting, positively reinforcing when the correct indicative behaviours are shown.).
    - Supplement macro and micro practices in classroom with rigorous social-emotional learning curricula such as the PATH.

Learning and Technology

Technology has radicalized the delivery of education in at least three separate instances- Chalk and slate, the printing press, and computing and internet, have all played disruptive roles. In each of these occasions, the delivery of education has seen fundamental shifts. However, as Beetham and Sharpe (2013) note, while the mode of delivery may have undergone considerable change, both the learner and her/his learning characteristics have not. As research about learning transform our understanding of underlying processes involved (Coffield 2004), it is crucial for education technology to closely track our pedagogical understanding; that fundamental learning characteristics ought to determine delivery of education is the source of the adage, "Pedagogy before Technology."

Research by Shields (Shields 2011) and Linden et al. (Linden 2008)-as cited in Muralidharan (2013)-present an interesting picture of the use of ICT based educational interventions. Such programs seem to be effective under specific circumstances and conditions and completely ineffective or less effective than alternatives, when used otherwise. For example, Linden notes that a technology based intervention which is effective as an after school program, facilitated by a tutor, has net negative effects when said program replaces time meant for in-class instruction by teachers. Synthesizing mentioned and other research one can conclude that both the process of designing the intervention and the design of the Ed-Tech product are essential.

[3] https://sites.sas.upenn.edu/duckworth/pages/research

For the purpose of sound pedagogical design, we formalize Naismith's (Naismith 2004) pedagogical lens:

Behaviourist: New knowledge is formed as the learner makes explicit associations between present, past and future knowledge.	***Constructivist:*** Activity based learning where new knowledge is constructed from syntheses of present and past learning.	***Situated:*** Situated learning happens when the learner is placed in an authentic and immersive context. Knowledge formed during this process fits within a situational framework ready for wider application.
Collaborative: The process of learning is facilitated by a series of supplementary and complementary interactions with peer knowledge.	***Informal and Lifelong Learning:*** Learning that is facilitated outside a formal curriculum. Conversations (Nair, 2014), T.V programs, standalone apps are a few examples of informal learning contexts.	***Learning and Teaching Support:*** Classroom, school and system wide supporting and coordinating resources.

Table 3: Naismith's (Naismith 2004) pedagogical lens

These pedagogical attributes provide for an understanding of how, what and if certain design constraints are necessary for technologies in the classroom. It is also imperative to take into account the context in which the learner is placed and how diverse factors affect the ecology of learning. For example, from a purely instructional perspective, using immersive technology (E.g. Oculus rift) to facilitate situated pedagogy would be an excellent learning method for ESD and SEL, while it may not facilitate learning in subjects that require a more behaviourist approach like Numeracy. The School of the Future, thus, takes into account the context closely when deploying technology in classrooms.

The 21st century teacher

The School of the Future requires that the 21st century teacher

- Is seen as a role model.
- Is a knowledgeable instructor.
- Is a creative and innovative educator.
- Is a trained professional.
- Is an attentive counsellor.

Much is known about ideal teacher/teaching characteristics that school and system (district) level leaders ought to look for (Marzano 2007)(Danielson 2011). However, scaling up effective characteristics and pedagogical programs has been a consistent challenge (Lewis 2015). The 21st century teacher, therefore, needs effective systemic support for scaling up innovative and effective practices. One such methodology under consideration is the large-scale use of Improvement Science. The Improvement Science methodology has been shown to work in a wide range of industries like automobile manufacturing and healthcare and is showing promise in education as well (Lewis 2015), especially for providing effective structures for scaling up successful programs. The following figure (Fig. 7) explains the use of Improvement Science in lesson study and lesson improvement groups in Japan (Lewis 2015).

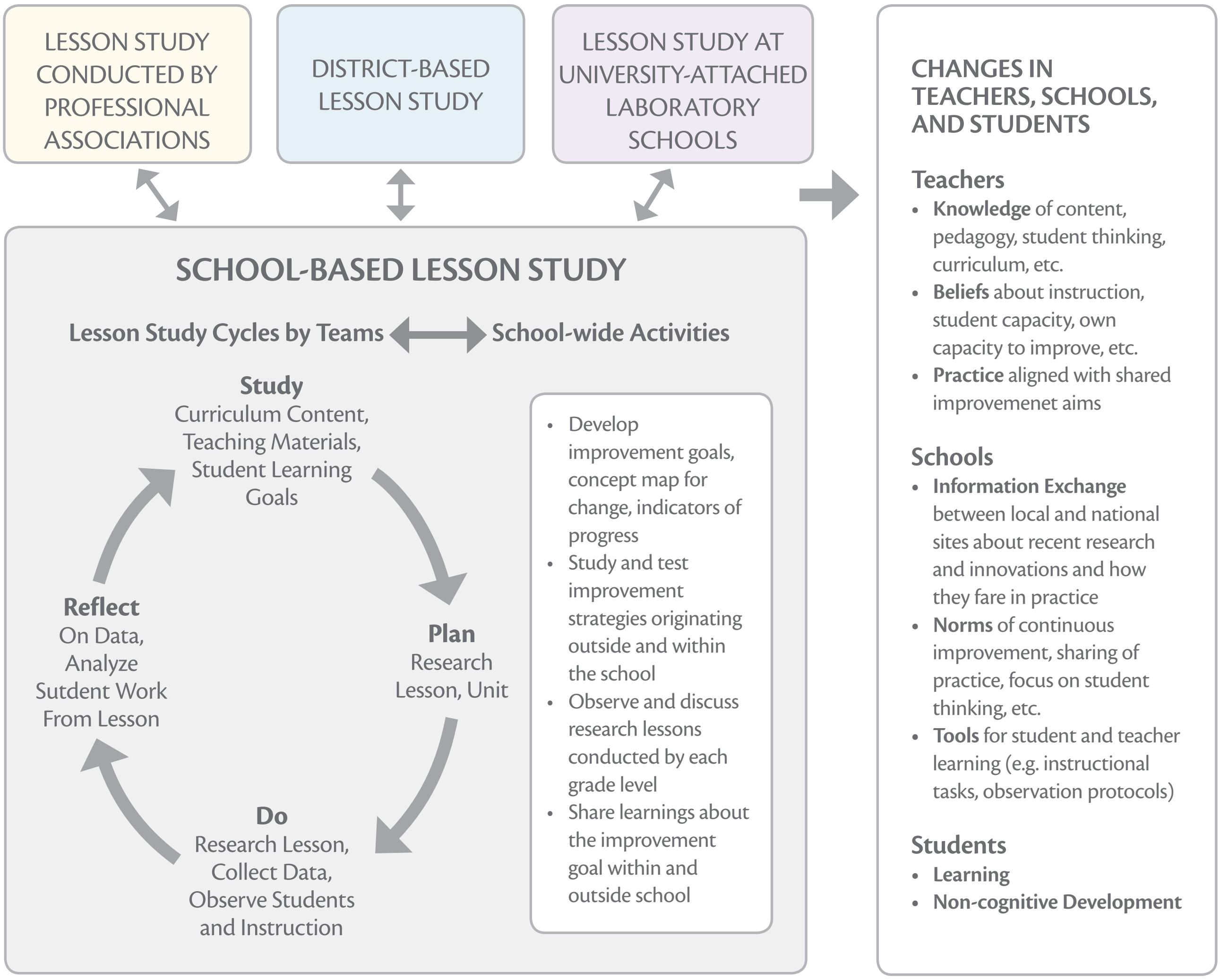


Fig. 8: Use of Improvement Science in lesson study and lesson improvement groups in Japan

Source: Lewis, C. (2015). What Is Improvement Science? Do We Need It in Education? Educational Researcher, 44(1), 54-61.

The potential of Improvement Science is in building a networked improvement program that leverages indigenous knowledge to build on top of knowledge created by experimental research. With the design of appropriate systemic checks and balances an improvement network following the PDSA (Plan-Do-Study-Act) cycle could well provide the School of the Future quality teachers and teaching at scale.

Partnership

Education for the 20th century has been the product of serving an industrial era where factory style standardized training was required to power the economic engine. This is reflected by the factory style classrooms and schools, where standardized knowledge is imparted to sets of students segregated by age. This system was designed for providing an efficient way to create workforce which met the needs of the rapidly industrializing economy. The 21st century economy with its advancements in technology has created a hyper networked society where information is created at astronomical rates and is ubiquitously accessible. Thus, more emphasis is placed on applying than acquiring knowledge. This requires the workforce to be equipped with the skills to analyse, think creatively, innovate and communicate. At the same time, it brings with it a host of problems like sustainable growth, climate change, managing conflict etc. which are not only complex but are dynamic, forcing the future citizens and leaders to think and respond appropriately to effectively counter them. This requires not just inclusion of 21st century skills in the traditional classroom, but to re-imagine the education system altogether. It needs to place the learner at the centre and build support systems which can change based on needs, passions and interests of the learner.

The 20th century education system is centred on the concept of school being the only place where learning happens. This has its advantages in controlling the quality of delivery of instruction and content. However, it creates an artificial and controlled environment which is removed from the realities of the world. However, the learners are devoid of rich learning opportunities which can help them build meaningful relationships with individuals and groups, apply their knowledge and skills to solve some of the most pressing needs and contribute to their communities. All these are very essential in the 21st century economies where the workforce is expected to collaborate and communicate with a diverse population and identify and solve 'wicked' problems (Education Reimagined n.d.) in their communities where no ready-made solution is available.

21st century education should recognize that all learners are instinctively curious about the world around them and the system should support this innate and perpetual curiosity to develop them into passionate individuals and life-long learners who are eager to explore. The learning environment should continuously evolve and adapt to help every individual learner create a meaningful and rich learning experience based on his/her abilities, aspirations, interests and passion. To enable learners to truly become empowered and productive members of the societies, they should be aware and capable of utilizing the power of communities. This can be achieved by inclusion of family, peers, employers, civic organizations and experts from varied facets from within and outside the community to create stable, constructive and meaningful networks and social interactions. This helps enrich learning through independent and collaborative exploration, mentor support, transfer of cultural, artisanal and historical knowledge and skills, group work, cooperative learning and play among other things. It also provides a more authentic experience of 'real world problems' and appreciation of how problems are solved in the 'real world'.

The School of the Future leverages on the expansive, diverse and rich learning opportunities made available to the learner from the communities, context, and settings. Learning from all experiences - intentional, incidental or otherwise - are valued, supported and integrated into the learner's journey. It provides the environment both physical and virtual to ensure that learning is not an isolated experience but a collaborative adventure, through which the learner journeys through the complex social space with the help of peers and knowledgeable adults. The learning is uncoupled from the school and instead learning happens anywhere -virtual or physical - through a learning ecosystem. This ecosystem provides support to learners to personalize their learning experiences and with skills to not only tackle the current problems but also ones that are unseen and in the future. The school is no longer an entity for transferring knowledge for the future but it is an epicentre of innovation, diversity, collaboration, and inclusiveness among the population. It is the place where ideas, knowledge, skills and culture are exchanged for generating solutions to problems- present and future. This is possible only if the schools nurture partnerships among the various stakeholders- learners, educators, parents, employers, civic bodies and community.

Learners

The Learners play a very important role in the School of the future. In contrast to the present traditional schools, the learners are treated as active and equal contributors of knowledge rather than passive receivers. The school allows the learners to choose, design and pursue learning experiences with the help of peers and adults in the learning ecosystem. This allows the learners to have a voice in their educational experiences. Harnessing intrinsic motivation helps develop a sense of ownership over their learning journey and ultimately allows learners to be absolute owners of their own learning. As they become more independent learners and active consumers of learning, they will seek out new and innovative methods and approaches which suit their needs and context. This, in turn, puts pressure on the supporting systems and the ecosystem to evolve. Thus, it creates a mutually reinforced feedback loop which helps in a more flexible education system to cater to individual needs and helps each and every learner attain full potential. It also creates innovative solutions to individual needs; adding to a growing bank of knowledge and informing better educational practices.

The School of the Future allows the students to learn according to their ability and interest. By utilizing technology, the school allows the students to learn from anywhere. As the 21st century education is based on skills and competencies, the learners have the choice to demonstrate application and understanding of the knowledge through a portfolio of projects based on problems which resonate strongly with them. Peer, community and mentor networks provide the support required by the learners to achieve mastery over competencies and provide feedback for improvement. By working on real world problems, they get to experience authentic, rich and diverse environments to practice problem-solving and collaboration.

By interacting with personalized learning technology, learners will learn to evaluate their progress and decide on their future growth path. Based on individual paths and needs, the school can dynamically allocate resources. This has a two-fold impact; it allows for efficient allocation of scarce resources like tools etc., to the schools where they are required and at the same time it encourages resourcefulness on the part of the learners, as they will be forced to work with available resources to find solutions to problems, thereby, resulting in creative and innovative methods.

The school also grants the learners greater autonomy to participate in the vision and mission for the school. They will be part of the committee consisting of other diverse actors on the learning ecosystem to chart the way for the school. This allows the decision making to be distributed beyond few centres of power and lets students' perspectives and voices be part of the decision making process. By being part of the school committees they become empowered decision makers and bring transparency and accountability to the school.

Educators

The School of the Future incorporates a learning ecosystem of which the role of the educator is most crucial. As the system moves from standardization to personalized learning, the role of the educator will evolve from customizing content for accommodating varied pace and ability to being able to tailor customized learning relationships with an expanding range of learning partners that encourage learner reflections and other meta-cognitive practices (Katherine and Jason 2015).The educators in the School of the Future would possess a range of professional expertise and backgrounds. In addition to expertise in a given field, they would bolster their skills in using and integrating technology and other digital learning tools with services and resources required for working with the learners.

The educators would also create professional global networks to develop and strengthen their skills in ensuring that the learners are well supported on their learning journeys. These networks become the hubs for innovation as best practices across contexts are shared for enhancing student learning. As smart technologies like artificial intelligence and machine learning become providers of learner-profiles, which provide information and possible pathways, the educators will be able to use such information to better guide learners.

The educators also play a crucial role in the administration of the school. Due to their proximity to the learners they would be able to understand and provide context for guiding the school in meeting its vision. Further, as learning becomes more networked they will be responsible for ensuring equitable access to learning. Further, in the face of scarcity they will through a process of collaboration, innovation, collecting evidence and continuous improvement; will challenge the existing practices and evolve more effective ones.

The pool of educators in the School of the Future would extend beyond the traditional educationists and administrators. It might have people who are specialists in their own fields like doctors, lawyers, artists, entrepreneurs, civic leaders, scientists, and media among others. In fact, the learning ecosystem would be an ad-hoc network of learning-enablers who would support the learner goals and help them achieve mastery over the competencies they choose. The technology for personalized learning would help match the learners to the networks when the need arises, creating a truly flexible and inclusive system which can help even the communities with low socio-economic status with scarce resources.

The roles of the educators in the School of the future might need to be re-imagined to contribute to learner centered learning ecosystem paradigm. The educator roles as reported by a report on the future workforce are (Price, Saveri and Swanson 2012):

- **Learning Pathway Designer** – Works with students, parents, and learning journey mentors to set learning goals, track students' progress and pacing, and model potential sequences of activities that support learning experiences aligned with competencies.
- **Competency Tracker** – Tags and maps community-based learning opportunities by the competencies they address in order to support the development of reconfigurable personalized learning pathways and school formats.
- **Pop-Up Reality Producer** – Works with educators, subject matter experts, story developers, and game designers to produce pervasive learning extravaganzas that engage learners in flow states and help them develop relevant skills, academic competencies, and knowhow.
- **Social Innovation Portfolio Director** – Builds networks in support of meaningful service-based learning and community impact by linking student action-learning groups, seeking to develop core skills and knowledge with organizations seeking creative solutions.
- **Learning Naturalist** – Designs and deploys assessment protocols that capture evidence of learning in students' diverse learning environments and contexts.
- **Micro-Credential Analyst** – Provides trusted, research-based evaluations and audits of micro-credential options and digital portfolio platforms in order to provide learners and institutions with comparative quality assurance metrics.
- **Data Steward** – Acts as a third-party information trustee to ensure responsible and ethical use of personal data, to maintain broader education data system integrity and effective application through purposeful analytics.

The School of the Future would also enable the educator to choose the best resource based on the learners' interest. This creates distribution of authority from the central school boards to the educators, giving greater autonomy to experiment and innovate. It also enables them take on leadership roles both collectively as part of the learning ecosystem and individually to develop their own skills. It also enables the educators to have better control over their career plans and increased accountability and transparency to the other stakeholders in the learning ecosystem. As the learners' mastery over competencies is audited independently, teaching is uncoupled from a narrow set of assessments and standards, and the bar for effective learning experiences is raised. Also, the systems that prepare the educators for success can transform according to their needs.

Parents

The School of the Future ensures that parents play an important role in the learners' educational experience. Primarily, as potential customers of the services, they can create pressure on the services to ensure the system meets the needs and aspirations of their children. Further, as part of the school committees they can hold educators and mentors accountable. Their interests can dictate educational practice and allocation of public resources. As part of the learning ecosystem they play a crucial part as mentors for the learners. The School of the Future, through technological and digital tools, ensures that learning can happen anywhere. However, technology can have its own ill effects which can be effectively countered by the families. By setting rules and mentorship on the use of technology in consultation with the mentors, they provide an additional safeguard against misuse. Also families and care-takers provide environments at home for developing social and emotional competencies. The value systems of the learners are intricately linked to the experiences in their places of residence and people in their proximity. By providing values and building social-emotional competencies, families can provide the learners with tools which can help them navigate the complex and intricate future.

The School of the Future, as part of the community, also enables the parents to become lifelong learners by providing access to continuing education, re-skilling and providing learning experiences to help them better support the learners in their journey. The School of the Future will provide parents with skills and competencies, to integrate learning technologies and other approaches informed by best practices. Parents also provide the context to the learning experience; they can effectively bring their knowledge and skills as contributors to the learning ecosystem as mentors. In communities with rich and diverse artisanal skills and indigenous cultures, these can be passed on and preserved through the involvement of families.

Businesses and other organizations

The School of the Future has a network of businesses, social and civic organizations which play an important role in creating a rich and personalized experience for the learner. Businesses which play an important role in driving the economic engine in the communities will ensure that the learning ecosystem is evolving to serve the needs of the present and the future. Being direct beneficiaries of a quality workforce, their interests are aligned with that of the school in ensuring that the learners achieve their full potential. Businesses in collaboration with the school will engage the learner in their learning journey by providing mentorship and guidance through internships and projects. The rapidly evolving economic conditions require dynamic and prompt action to remain relevant in the global competition. This requires businesses to quickly retool the workforce with the requisite skills and competencies. By being part of the learning ecosystem, through collaboration with the other organizations and individuals in the network, the learners can quickly be mentored to adapt to changing needs.

Businesses can also facilitate collaboration and discussion among various actors of the communities, including the learners, to help understand global and local context and provide a platform to test relevant competencies through application on real world problems. Also, they can provide to the school; funding and other resources for research and development of innovative and creative ideas to improve value, sustainability and community.

Museums, libraries, other cultural institutions and social/community based learning organizations can provide additional support to learners as part of the learning ecosystem. Access to these organizations allows for a rich experience to the learners. The School of the Future ensures that all the educational experiences of all learners are effortless and equal by ensuring that access to all individuals and organizations in the ecosystem are fluid and seamless. These are treated as natural extensions of the school itself and help provide a diverse context to the learning experience.

Chapter 2: The Framework for the School of the Future *continued*

Organizations entrusted to develop educators and other learning enablers in the ecosystem, like universities and academies, will work with the schools to ensure that the evolving needs of the educators are met. By incorporating the latest research in education practices and use of real time data flowing out of the learning ecosystems they should be able to customize and equip educators and other mentors with the skills required for effective learner education. To ensure that learners learn in the context of their community, educators will be sourced from the communities and placed in local schools. They will receive funding and/or intensive training in required skills based on the needs of the learners and the community.

Local entrepreneurs will team up with the learners and the learning ecosystem to help design products and services which will help in better learning experience and improved outcomes. By deeply engaging with the ecosystem they will gain the experience and context to develop meaningful and relevant solutions. At the same time, by utilizing the systems and professional networks of mentors, educators and learners, they would get robust feedback for improvement and sustainable scale.

Government and policy

Creating a leaner centric ecosystem for the School of the Future requires a larger concerted systemic change. As schools become flexible networks of learners and learning agents, there is an increased need for change in educational policy and thinking. While formulating the policies, a comprehensive approach needs to be adopted to ensure that the systems and learning pathways are designed to support personalized learning. This requires the policy makers at the all levels to completely re-imagine and rewrite policies which can help sustain and grow the personalized learning ecosystem in communities. Some of the ways the policy makers can achieve this are:

Collaboration and networking:

The policy makers should evolve a comprehensive strategy and implementation plan through an inclusive consultation involving all the stakeholders of the learning ecosystems. This strategy should aim towards creating seamless integration among various organizations, people, programs, services and platforms so that they are inter-operable and easily integrated. This helps increase the rate of adoption, ease of use across communities and better access to information. Further, professional networks among various learning ecosystems must be facilitated for exchange of information on best practices and innovative techniques which can help improve learning experiences and bring in efficiency. The community based inclusion of organizations into the learning ecosystem should be encouraged through public-private partnership.

Support and accountability

Educators in the learning ecosystems should strive towards ensuring that the learners reach their short term and long term goals. In ensuring that learners get adequate support, the educators should in turn be provided with similar support to enable them to succeed. By equipping the educators with skills of working in a flexible learning environment along with customized competencies, which leverage the strengths of each individual, the learners can have access to highly knowledgeable team of mentors to provide guidance. To provide accountability and measure progress, policy makers should work with diverse players and establish objective, understandable reports of performance. Further, they should ensure that all the stakeholders in the ecosystem have access and skills required to understand and use the performance reports to ensure quality in learning. Meaningful interventions and learning pathways should be designed to address the gaps reported in performance.

Equity and Access

While the networked learning ecosystem can create a flexible learning environment, which can meet the needs of all learner, there is an equally critical possibility that this might only be available to communities that have the time, money and resources to customize or supplement their learning journeys (Prince 2012). The policy makers need to ensure that all the communities and learners get access to the same quality irrespective of their socio-economic status. Though technology like MOOCs and blended learning can alleviate some of the constraints, one must ensure that access is driven by learner interests and not by commercial strength. This is absolutely important as widening gaps in access can lead to widening gaps in quality. This could acutely affect the competitiveness of a society in the global economy.

Environment

Learning Spaces

As Schools of the Future transition from the traditional fixed hours of classroom learning to becoming centers for lifelong learning, the concept of 'learning spaces' becomes more crucial than ever. Learning spaces can be defined as "a physical space that supports multiple and diverse teaching- learning programs and pedagogies, including current technologies; one that demonstrates optimal, cost-effective building performance and operation over time; one that respects and is in harmony with the environment; and one that encourages social participation, providing a healthy, comfortable, safe, secure and stimulating setting for its occupants" (Kuuskorpi, Gonzalez, 2011).

As creativity, innovation and independence become key 21st century skills, the students of the future need to be allowed to satisfy their immense curiosity on their own. And for that to happen it is imperative for schools to build capacity for independent learning. This would be an essential skill for their future well-being since they are likely to move between various jobs and would be expected to continually learn new skills self-reliantly. In order to achieve this outcome, learning spaces as defined above must be designed accordingly. Below are some contemporary examples that could form a basis for the design of the future classrooms:

The Architecture Studio

This is an American adaptation of the Atelier based learning of the 19th century at the Ecole des Beaux-Arts in Paris.The Atelier Studio is an approach based on participation, interaction with local art, environment and community and active citizenship. Interactions and activities involving the child, teacher facilitator and parent are documented at many levels providing ownership and voice to the parents, teachers and the child. At the Architecture studio all work in progress is made public. Even the critique is made in public. As a consequence every student can see what every other student is doing or designing and the strategies being used to design it. Other students act as the peripheral participants through the entire process. They too, understand the nuances of the design and how it leads to the final outcome.

TEAL (Technology Enhanced Active Learning) project: This model was created by John Belcher wherein the facilitator moves seamlessly between lecture, experiments and discussions. Most of the students' work involves building, running, and experimenting with simulation models and then solving problems. Although there is some recitation, there is no real lecturing. Instead, the professor and teaching assistants walk from table to table, look at what interesting issues are unfolding, and occasionally interrupt the entire studio to discuss some glitch a particular table encounters.

These are great examples of how different strategies and processes can be used in different settings. The physical space needs to be appropriately matched to our vision and learning goals. Below we introduce the concept of the modular design which provides flexibility in terms of pedagogical processes and learning requirements.

Modular Design

The concept of a flexible modular design is one in which the learning spaces go beyond the limitations of walls and buildings. Driven by new educational concepts, the architectural design creates an internal communication core, a core module, with direct access to functional modules (Fig 9). The idea behind the functional modules is to respond to future replications of the design elsewhere and therefore, create adaptable and self-contained spaces linked by structure. These modules can be transportable and are easily configurable to allow quick setup and scale up. The modular design also ensures that the schools can be configured both horizontally and vertically (multi-floors). The main core and the functional module can expand, contract or integrate based on the program requirements.

It is important for the learning spaces to be flexible to suit the needs of pedagogy and instruction. Classrooms designed for flexibility liberate teachers and students from fixed seating, thus allowing the room to adapt and adjust to a variety of instruction methods. Flexibility within the learning space is also realized via wireless technologies which provide untethered access to internet and one to one internet enabled devices. A study done by the Herman Miller Company (2011) stated that adaptable learning spaces make it easier to engage students by allowing for a quick and easy configuration of classrooms to facilitate different kinds of activities. Students who participated in classes held in classrooms designed around the idea of adoptable spaces reported being 24% more engaged in class and 23% more likely to feel that communication was better facilitated, while teachers described how it was easier to integrate teaching methods (22%) and easier to use technology while instructing.

MODUPOD DYNAMIC

Modupod© is a dynamic 21st century learning environment that creates an inspiring IMPLICIT CURRICULUM©, the 3D text book – spatial forms that promotes interaction and critical thinking for 21st century students. Fast assembly, smart simulating interiors and flexible PODS place students and teachers at the heart of learning. MODUPOD embodies a new approach to learning; THE LEARNING CONTINUUM© which responds to the plastic possibilities of environments which are fluid and transcendental in nature. The new physical components form to blend a seamless integrated environment which maximizes the learning experience. MODUPOD DYNAMIC multimodal clusters are built around an ACTIVE-CORE®; a permeable student resource centre which supports unique pedagogical solutions by incorporating five standard learning modes. The Studio, Project, Breakout and Social PODS and the Outdoor Spaces support the modes of teaching and learning and are specified to the meet a spectrum of curriculum needs, site topographies and climatic conditions. With MODUPOD educationists can achieve a fast, smart, and flexible 21st century learning environment.

ACTIVE CORE©
CIRCULATE CONVERGE CONNECT
Permeable student resource centre

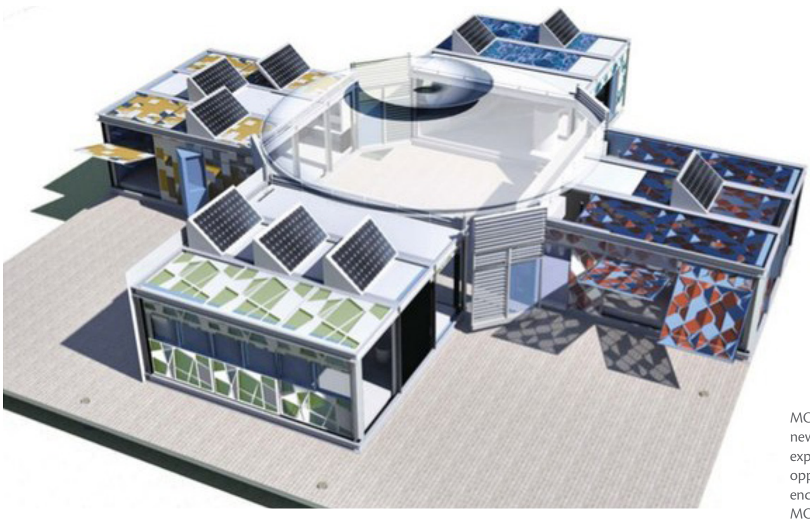
STUDIO POD
INSTRUCT INTERACT RESPOND
Controlled information exchange

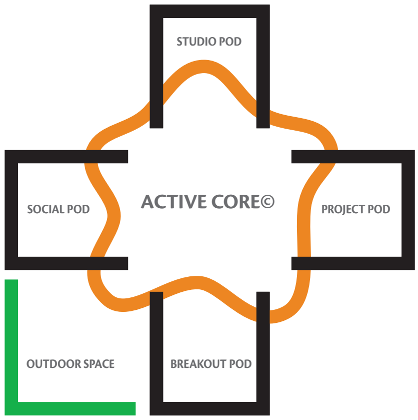
PROJECT POD
ENGAGE EXPLORE REACT
Student team investigation

BREAKOUT POD
Relax Observe Reflect
Passive student environment

SOCIAL POD
CONGREGATE CONNECT SHOWCASE
Collaborative public presentation

OUTDOOR SPACE
CHALLENGE DISCOVER REALISE
Uninhibited student's environment





MODUPOD DYNAMIC Clusters are spaces that support modes of learning. This new IMPLICIT CURRICULUM instead of prescribing uses for spaces suggests experiential learning possibilities through subtle cues and the presentation of spatial opportunities as opposed to spatial demands. Immersive learning environments encourage grounds that can inspire students with a willingness to learn. The MODUPOD DYNAMIC Multimodal Pods with an ACTIVE CORE creates a seamless, collaborative environment to that moves learning beyond the classroom.

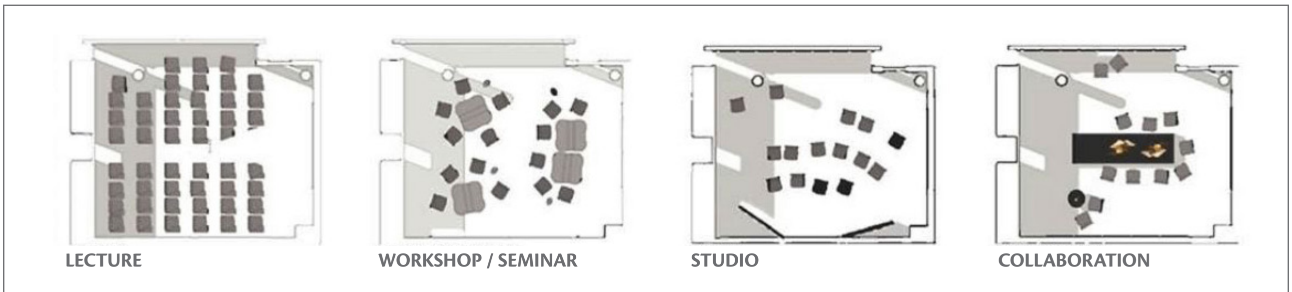


Fig. 9: According to the need of the pedagogy and instruction, alternate seating plans are used for the same space

Source: What the schools of the future could look like. 2015. http://www.gizmag.com/classroom-of-the-future/21295/)

Some distinct features of a modular design are:

a. It is Collaborative: In the modular design, the central core provides access to other additional modules and also creates a community where the students can interact and work with each other. This configuration allows both small and large learning areas available for group or solitary instruction ideal for project based learning. If used well, these areas will create interactions that allow students to gain a sense of community. Moreover, the school must try to connect the learning to real world experiences by not confining learning within a building. Field studies, community service, internships and consultation with outside experts are a few activities that would help achieve this outcome. School's building must also represent the culture of accountability, transparency and the way it interacts with the rest of the community through the way its interiors are designed.

b. It is Technology enabled: The functional modules provide access to 3D printers, biotechnology labs, prototyping components, augmented reality devices. This helps the students of the future acquire skills relevant for the requirements of the future. The ultimate aim of a futuristic school must be to become a paperless environment wherein the need for books as instructional means will be eliminated to make way for digital curriculum. Each student will have a tablet or e-device to store instructional content. Recording equipment will allow pupils to assess themselves in real time.

Furthermore, in today's internet environment, literacy in multiple digital media is an indispensable requirement. While we look for new methods to teach internet literacy to students, the school's design must also be a catalyst for this learning. Schools of the future must be designed to enable productive inquiry into things that were inaccessible before. Learning must be more globally interactive with virtual trips and collaborations with other schools.

Apart from the modular design, the school space must satisfy the following criterion in order to be futuristic:

Sustainability

The School of Future will understand the importance of being sustainable and in turn encourage sustainability as a way of life. In this context, the power usage in the building of the School of the Future must rely entirely on sustainable sources of energy such as solar panels. It must also incorporate energy efficient lighting and mechanical systems, environment-friendly building materials, water and energy conservation mechanisms, and the use of sunlight and natural ventilation throughout the school building. Building orientation and shading devices can minimize heating, cooling, lighting and air circulation requirements. Pre-fabricated construction minimizes material waste. Technology can be leveraged in order to make the school a paperless environment to reduce waste and enhance sustainability.

Fig.10: Using solar panels in schools and using laptops instead of notebooks thereby going paperless

Source: (Chapter 10.Human-Centered Design Guidelines.http://www.educause.edu/research-and-publications/books/learning-spaces/chapter-10-human-centered-design-guidelines)

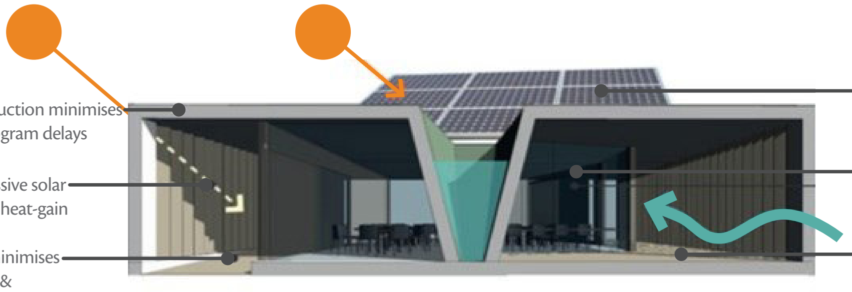


Fig. 11: A model of what a future school can look like
Source: (What the schools of the future could look like, 2015, from http://www.gizmag.com/classroom-of-the-future/21295/)

Catering to multiple intelligences

Learning spaces in the School of the Future will also be designed to facilitate varied learning styles or 'intelligences'. New technologies should transform the 'feel' of spaces to create safe and stimulating environments for learners. Lights activated by sensors, pre-programmed sounds, pictures, videos or even smells can be embedded in learning spaces and also programmed by those people who will 'inhabit' and use the space. Most researches (Dunn, 2002; Fuboni, 2007) show that schools that are geared to just two of the seven-or- more intelligence traits do not necessarily support the best learning. In the School of the Future, we envision differentiated learning by enabling thematic teaching. This can be achieved by creating stations or centres around the learning spaces that cater to each of these learning styles.

Safety

A safe learning environment is essential for students of all ages as it gives them the opportunity to learn and achieve in a nurturing environment. Schools of the Future must ensure that students feel safe and secure in the school environment. It is, hence, extremely important to develop and implement a plan to support safety and security services. For instance, the classroom design could be that of Steiner schools which offer an alternative educational approach. Many of their spatial designs focus on nurturing young people through a holistic approach to early development by promoting environments that feel 'safe' and comforting. The design of new learning spaces should have tactile, sensory and playful learning tools firmly within the design process which could create both different and non-threatening environments.

The design of the space, however, essential is not adequate for fostering and driving the vision for the School of the Future. Below, we describe how the ethos can be envisioned in the School of the Future.

Ethos

Ethos is a term with Greek origins and it refers to the morals, values and beliefs of a person, or even an entire culture. A definition of ethos which covers all the uses and meanings given to the term must be tripartite. It includes:

- **The perceived atmosphere and environment in school:** The atmosphere that is evident as soon as one walks into a school forms the part of the ethos of the school. It reflects in the behaviour, attitudes and the conduct of the students and the teachers and one which comprises the social system of the organization.
- **The underlying beliefs or culture:** The vision, mission and the values of the organization are the factors that determine the culture and therefore, outcomes in an organization. These are not easily articulated or measured and may differ with contexts.
- **Practice, action or activity to build ethos:** The activities an organization undertakes in order to build the culture and the values within its members reflects its commitment toward achieving the same.

Within the purview of ethos, multiple aspects such as the mission, vision and values are included. These are explained in greater detail below:

a. Mission: A school's mission statement says all the things the school intends to do. The following forms the part of the belief of the School of the Future while framing the school's mission.

- Learning is continuous. With the digital tools available with every student in the School of the Future, learning is not confined within four walls.
- Learning is relevant. Students in school learn skills that are required in the world today. They are not studying in isolation from the rest of the community.
- Learning is adaptive. Learners manage their own learning within school and outside. With twenty-first century competencies and individual learning plans, learners themselves decide how to use their skills to shape the future.

b. Vision: The School's aim (vision) is what the school hopes to achieve. The School of the Future is about redefining the 'norm'. It is about demonstrating what learning must look like in the 21st century for all students. We envision a school that works to close the technology gap in education and provides learners with the skills and competencies necessary for problem solving and lifelong learning. We also envision a post-secondary school opportunity for each one of our learners that facilitates continued education and the achievement of personal goals. Although the broad framework in forming a vision for the School of the Future remains the same, it needs to be contextualized as per the requirement.

c. Values: Values of a school are its moral code. If moral leadership is to be exercised and pedagogy re-engineered with any degree of success, then future leaders will need a firm set of personal values. Values like integrity, social justice, humanity, respect, loyalty and a sharp distinction between right and wrong will need to be internalized by the students in future schools. Strategic relationships will soon flounder unless such a value system is held with conviction and exercised on a regular, consistent basis.

Chapter 2: The Framework for the School of the Future *continued*

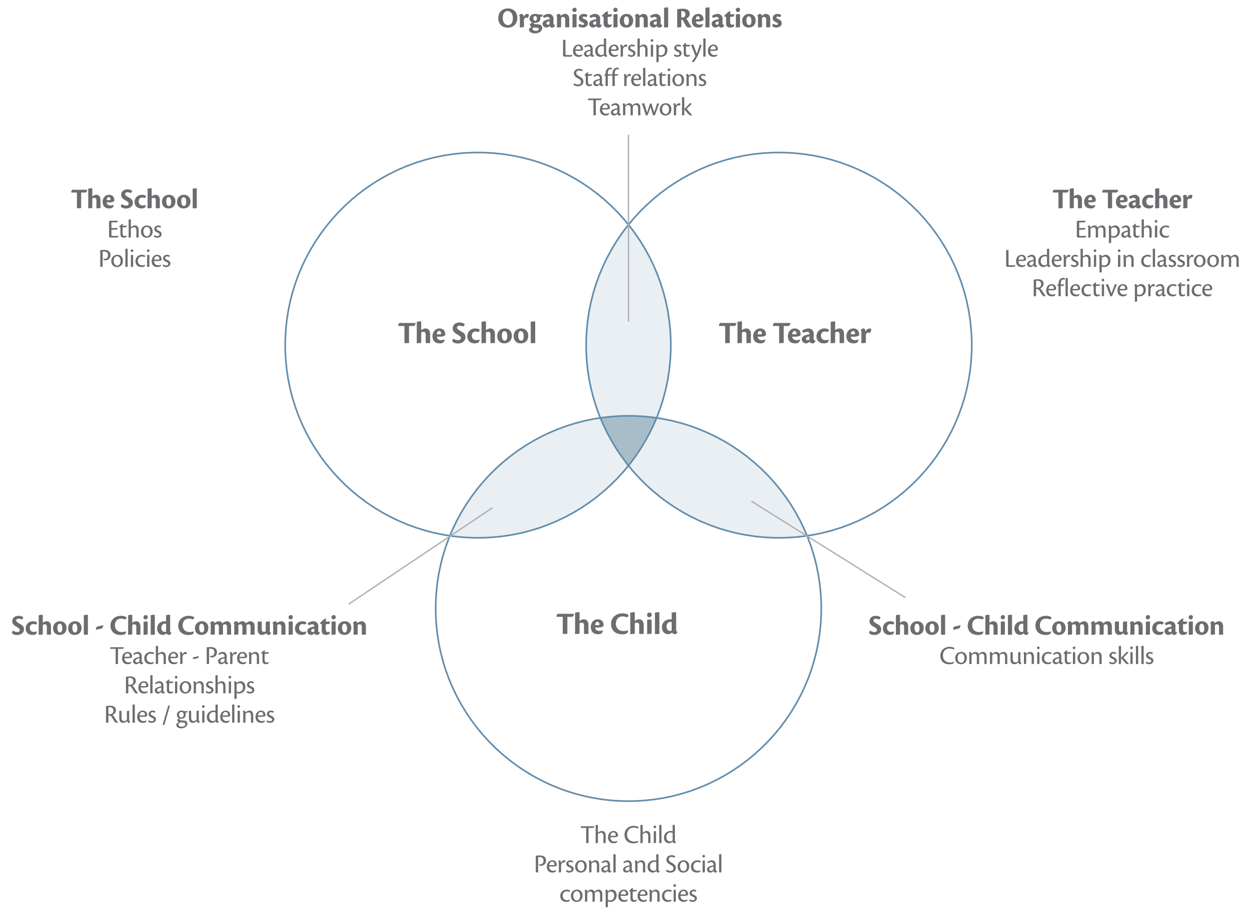


Fig. 12: Ethos in the context of the school
Source: Killik (2006)

The figure above (Ethos in the context of school) shows us how the school, teachers and students interconnect and overlap. The emotional life of a child does not exist in a vacuum but is determined by the environment in which he/she interacts. In education, this translates to the context of the school as a whole. This ethos must be modelled and demonstrated so that it is caught as much as taught. The values of cooperation, consideration and respect for others must exist within the structures of the school. This means developing emotional literacy on multiple levels. The ethos of the whole school is all about the school's relationship with the outside world and the relationship between the staff. The school as a team must work together toward the same shared goal and should be able to measure its progress toward the goal (Killick, 2006).

How does ethos map out in the School of the Future?

We discuss school ethos under the headings considerate, convivial and capacious – single words, each with many meanings. They will serve as a way to discuss issues from different perspectives , appreciating that they are multi-dimensional and complex, and that one's perspective is inevitably partial (Richardson, 1998).

a. Considerate:

Being 'considerate' would mean appropriate kinds of care, discipline and relationships in school, emphasizing the importance of mutual, reciprocal civility, fairness and sensitivity, of safety and intelligibility. Being considerate implies that students matter and feel they matter and that they are taken into account and can account for them. It also involves reflective practice by staff who consider what they do.

Fig.13: The dimensions of a considerate school ethos
Source: (Bragg 2011)

Some characteristics of a considerate school are:

- Structure, reliability and consistency are the building blocks in such a school that enable everyone in a school to feel more comfortable to experiment, make and learn from mistakes.
- Constantly reflecting on and considering practice is a priority in Schools of the Future. All the classes could set time aside at the end of every school day for informal, on-going reflections on their practice, in addition to the staff meeting that could be held one afternoon a week. At these meetings staff would discuss individual children, group dynamics, activities and the nursery environment.
- Involving students in decision making of the class like deciding topics of field work, choosing their own class representative and making their own schedule. When the teacher involves the students, the equation between them changes.
- Supporting particular students that are often invisible or overlooked so that they "matter" and demand consideration, e.g., by having work publicly displayed or publicly sharing success stories.

b. Convivial:

The concept of conviviality asserts the importance of fun and enjoyment in learning processes; that teachers and students can enjoy being sociable, and take pleasure in each other's company. Conviviality therefore requires reflective, ethical accountability for the school's and teacher's role in creating particular situations or behaviours. The convivial foregrounds the ethos by stressing interdependence and interrelatedness; one relies on others to develop one's own identity and agency.

Fig. 14: The dimensions of a convivial school ethos
Source: (Bragg, 2011)

Some characteristics of a convivial school are:

- Children have freedom of movement and make their own choices about how and when to participate in activities from a wide range of options; staff aims to value, support and extend their viewpoints through participating with them in activities.
- The schools provide many examples of lessons in which everyone seems to feel they have something to offer or that they could ask questions without fear of mockery; supported by confident teaching that involves knowing how to listen and to adapt teaching flexibly in response.
- The school focuses on the experience and curiosity that a child brings to learning and recognizes that learning is about creating knowledge together through activities like story telling or "draw my life" painting competitions.

c. Capacious:

Dictionary definitions of capacious refer to "being able to contain"; able to hold much, roomy, spacious, wide; having the capacity of. This indicator helps us refer to the space-making aspects of creative school ethos which allow more range, more room for learning in school and also to increase capacity or capability of both teachers and students, a taking-out to a further horizon.

The capacious school allows us to discuss space-making through creative school ethos, which has several dimensions. These include the idea of having range and room for flexibility and diversity in what kinds of teacher or student one can be or what kinds of teaching are valued, rather than a narrow enforced consensus.

Fig. 15: The dimensions of a capacious school ethos
Source: (Bragg, 2011)

Some characteristics of a capacious school:

- Capacious schools encourage and allow difference rather than demanding conformity amongst staff as well as children. For example, the staff of the School of Future does not have to conform to one method or approach to teaching and learning. The teachers who believe firmly in providing opportunities for physical activity through traditional games and sports can use such an approach and so can another who believes in teaching Spanish through Salsa; whilst a third teacher can bring his/her interest in the natural world into school to share with the children.
- Such schools also stress on the knowledge that children bring to school - from their families, their culture and their experiences - as a building block from which to extend and expand learning.

Chapter 2: The Framework for the School of the Future *continued*

Drawing from the above observations, we envision the emerging future models as a significant departure from the current system in multiple ways. These have been presented in the tabular form below:

	TRADITIONAL MODELS?		EMERGING MODELS?
SPACE	Dedicated teaching space	>	Non-dedicated space (shared with other uses)
	Specialised teaching space	>	Multi-purpose teaching space
	Centralised accommodation	>	Dispersed accommodation
	'Within' school (under school control)	>	'Beyond' school (outside of school control)
	Fixed infrastructure (equipment and facilities)	>	Flexible infrastructure (adaptable, portable, individual - e.g. ICT)
CULTURE	Process-focused (managmenet and measurement)	>	Student-focused (individual development)
	Student-centric (11-18)	>	Community-centric (lifelong learning)
	Defined subjects (traditional curriculum)	>	Flexible subjects (broad suite of subjects and vocationsl studies)
	Inward-looking (school boundary and remit defined)	>	Outward-looking (involvement, links and partnerships beyond the school)
LEARNING	Social interface (educator-student relationship)	>	Technological interface (access to learning via ICT)
	Pupil-teacher relationship	>	Learner-mentor relationship (other adult, specialist, peer mentor)
	Place-centric (specific learning is located at specific venues)	>	Student-centric (flexible access to learning is not location-specific)
	Generic mode of teaching and learning	>	Customised modes of teaching and learning
	Didactic ('delivery' of knowledge from educator)	>	Interactive (2-way learning transaction)
TIME	Permanent (design life)	>	Temporary (design life - short-term residency)
	Traditional school day (fixed hours of attendance)	>	24/7 (flexibility in hours of attendance; 'shifts')
	Generic timetable	>	Modular and customised timetable (individualised learning programme)
	Fixed lessons	>	Flexible lessons

The 2004 DfES publication, 'Schools for the Future: Exemplar Designs', identifies certain emerging themes for schools of the future. These include: flexibility, adaptability, linear cloisters (extendable linear forms), learning clusters (clusters of classes), indoor courtyards, outdoor classrooms, comfort and sustainability.

Fig. 16
Source: (Ultralab, 2015)

Conclusion

While much has changed since the beginning of formal education a lot more needs to be done, and very differently than before. The industrial revolution had changed the requirements of the workforce and was a significant impetus for the development of schooling. The drivers that shape our school system then had been threefold: religion, academics and work. However, when we talk about what needs to drive the School of the Future, some additional drivers come into play. Apart from changes in the curriculum to integrate 21st century skills such as critical thinking and collaboration, other key aspects in shaping the School of the Future are technology advancement, efficient resource allocation, and innovative physical spaces. Keeping in mind the key takeaways from the vision for nations, the report summarizes the framework for the School of the Future which includes practice, partnerships and environment. The practice module expounds on how the various 21st century skills- ranging from numeracy and literacy to creativity and leadership -are required to address specific demands of the job market. Further, various aspects of the core skills as well as the soft 21st century skills have been discussed in detail. The report argues the integration of ICT literacy, entrepreneurship education and financial literacy within the curriculum. It also expounds on the introduction of global education of sustainable development in the Schools of the Future, subsuming within it the different themes UNESCO lists down.

The partnership module argues that in the future, when the school ceases to be an entity for transferring knowledge, but becomes an epicentre of innovation, diversity, collaboration, and inclusiveness among the population, it becomes imperative to nurture partnerships with the various stakeholders such as the learners, educators, parents, employers, civic bodies and the community. The report, in this context, exemplifies how each of these partnerships can be leveraged to make future of education a reality.

As far as the environment is concerned, it includes the physical learning space and the ethos that runs it. The School of the Future is a collaborative, flexible and open space which encourages, personalized and differentiated learning by fostering innovation, creativity and collaboration between the student and community of peers, teachers, and society. Facilities have been designed to support key program elements: team teaching, integrated curriculum, project-based learning, community-based internships, frequent student presentations, and exhibitions. It is characterized by the modular design that is not only geographically flexible but also responds to the future replications of design elsewhere and therefore, creates adaptable self- contained spaces.

Ethos takes into account the perceived atmosphere and environment in school and the underlying beliefs and culture that drive its mission and vision. In order to be considerate, convivial and capacious, dimensions that form a part of the ethos in context, the school of the future must undertake various activities which are significantly different from the current system in multiple ways.

References

" http://cdn.nmc.org/media/2015-nmc-horizon-report-k12-EN.pdf."

" http://www3.weforum.org/docs/WEFUSA_NewVisionforEducation_Report2015.pdf."

Amadio, M., R. Operttiy, and J.C. Tedesco. The Curriculum in Debates and in Educational Reforms to 2030: For a Curriculum Agenda of the Twenty-first Century. Geneva: UNESCO-IBE.

Beetham, H., and R. Sharpe. Rethinking Pedagogy for a Digital Age: Designing for 21st Century Learning. Routledge, 2013 .

Bloom, B.S., M.D. Engelhart, E.J. Furst, W.H Hill, and D.R. Krathwohl. Taxanomy of Educational Objectivs: The Classification of Educational Goals. Handbook 1: Cognitive Domain. Ney York : David McKay Company , 1956.

Coffield, F., Moseley, D., Hall, E., & Ecclestone, K. Learning Styles and Pedagogy in Post 16 Learning: A Systematic And Critical Review. The Learning and Skills Research Centre, 2004.

Cornford, J. " The Virtual University is... the University Made Concrete?" Information, Communication & Society, 3(4), 2000: 508-525.

Coursera. "https://www.coursera.org/learn/teaching-character."

Damasio, A.R., D. Tranel, and H.C. Damasio. "Ch. 11: Somatic Markers and the Guidance of Behaviour: Theory and Preliminary Testing"." In Frontal Lobe Function and Dysfunction, by Harvey S. In Levin, Eisenberg, Howard M. and Arthur Lester. Benton. Oxford University Press, 1991.

Danielson, C. Enhancing professional practice: A framework for teaching. ASCD, 2011.

—. Enhancing Professional Practice: A Framework for Teaching. ASCD, 2011.

Education Reimagined. "A transformational vision for the education in the US." Washington DC.

Fullan, M. "Choosing the Wrong Drivers for Whole Education Reform." Centre for Strategic Education Seminar Series (Vol. 204). 2011.

Future Tense, Canada. Future tense: Adapting Canadian Education Systems for the 21st Century. Action Canada, 2013.

Hanushek, A. Eric, and Dennis D. Kimko. " Schooling, Labour Force Quality, and the Growth of Nations." American EconomicReview, Vol. 90, No.5, 2000: 1184-1208.

Hanushek, E.A., and L. Woessmann. "The Role of Cognitive Skills in Economic Development ." Journal of Economic Literature , 2008 : 607-668.

Helsinki, and A. Schleicher. "GEIS 2015- Transcript of dinner speech." 2015.

"http://www.beyondcurrenthorizons.org.uk/wp-content/uploads/final-report-2009-executive-summary.pdf." 2009.

"http://www.nesta.org.uk/publications/decoding-learning."

K, Prince. "Glimpses of the future of education." 2012.

Katherine, Prince, and Swanson Jason. The Future of Learning-Education in the era of Partners in Code. KnowledgeWorks, 2015.

Knowledge Works; Saveri Consulting. “Recombinant Education-Regenerating the Learning Ecosystem.”

Lackéus, M. Entrepreneurship in Education: Why, What, When, Howr. Paris: OECD Publishing, 2015.

Lee, O., H. Quinn, and G. Valdés. “Science and Language for English Language Learners in Relation to Next Generation Science Standards and with Implications for Common Core State Standards for English Language, Arts and Mathematics.” Educational Researcher, 2012.

Levy, F. & Murnane, R. J. The New Division of Labor: How Computers are Creating the Next Job Market. New York: Sage Foundation, Princeton University Press, 2004.

Lewis, C. “ What Is Improvement Science? Do We Need It in Education?” Educational Researcher, 44(1), 2015: 54-61.

Linden, L. L. Complement Or Substitute?: The Effect of Technology on Student Achievement in India. InfoDev, 2008.

Luckin, R., Bligh, B., Manches, A., Ainsworth, S., Crook, C., & Noss, R. “ Decoding Learning: The proof, promise and potential of digital education.” 2012 .

Macnamara, J.G. “Multiple Depth Plane Three-Dimensional Display Using a Wave Guide Reflector Array Projector.” Google Patents, 2014.

Malone, T. W. The Future of Work: How the New Order of Business Will Shape Your Organization, Your Management Style, and Your Life. Harvard Business School Press, 2004 .

Marzano, R. J. The Art and Science of Teaching: A Comprehensive Framework for Effective Instruction. 2007.

McKeown, R., C. A. Hopkins, R. Rizi, and M. Chrystalbridge. Education for Sustainable Development Toolkit. University of Tennessee.: Knoxville: Energy, Environment and Resources Center, 2002.

Mevarech, Z., and B. Kramarski. Critical Maths for Innovative Societies:The Role of Metacognitive Pedagogies. Paris: Educational Research and Innovation, OECD Publishing , 2014.

Mourshed, M., C. Chijioke, and M. Barber. “How the World’s Most Improved School Systsems Keep Getting Better.” 2010: 7-25 .

Muralidharan, K. “Priorities for Primary Education Policy in India’s 12th Five-Year Plan. .” India Policy Forum (Vol.9) (India Policy Forum (Vol. 9)), 2013: 1-46.

Nair, Rahul (2014), Theatres of Enquiry: Reimagining Learning and Development in organisations, Thesis submitted to the London School of Economics

Naismith, L., Lonsdale, P., Vavoula, G. N., & Sharples, M. Mobile Technologies and Learning. futurelab, 2004.

Norman, D. The Invisible Computer: Why Good Products can Fail, the Personal Computer is so Complex and Information Appliances are the Solution. Cambridge:MA : MIT Press, 1999.

—. The Design of Everyday Things. London : The MIT Press , 1990 .

OECD. Innovative Learning Environments, Educational Research and Innovation. Paris: OECD Publishing, 2013.

OECD. Reading Framework in PISA 2012 Assessment andAnalytical Framework: Mathematics, Reading, Science, ProblemSolving and Financial Literacy. OECD Publishing.

—. “What Makes Schools Successful? Resources, Policies and Practices – Volume IV OECD.” http://www.oecd.org/pisa/keyfindings/.

OECD, E. Hanushek, and L. Woessmann. " Universal Basic Skills: What Countries Stand to Gain ." OECD Publishing, Paris., 2015.

(P21.org,) ICT Literacy - P21. (n.d.). Retrieved December 28, 2015, from http://www.p21.org/about-us/p21-framework/350

Partnership for 21st Century Learning. Framework for State Action on Global Education. Partnership for 21st Century Learning, 2014.

Payton, John, et al. "The Positive Impact of Social and Emotional Learning for Kindergarten to Eighth-Grade Students: Findings from Three Scientific Reviews. Technical Report. Collaborative for Academic, Social, and Emotional Learning, 2008.

Pekrun, R. et al. Educational Psychologist, 37, 2002: 91-106.

PISA Result 2012, OECD. Students and Money (Volume VI): Financial Literacy Skills for the 21st Century, PISA. Paris: OECD Publishing, 2014.

Price, K, A Saveri, and J Swanson. Exploring the Future Education Workforce: New roles for an expanding learning ecosystem. Knowledge Works, 2012.

http://www.nytimes.com/2011/10/23/technology/at-waldorf-school-in-silicon-valley-technology-can-wait.html?_r=0. 2011.

Schweingruber, H., T. Keller, and H. & Quinn. A Framework for K-12 Science Education: Practices, Crosscutting Concepts and Core Ideas. National Academic Press , 2012.

Seligman, M. E. Learned Optimism: How to Change Your Mind and Your Life. Vintage, 2011.

Shields, R. "ICT or I see tea? Modernity, Technology and Education in Nepal." Globalisation, Societies and Education, 9(1), 2011: 85-97.

The Ministry of Education. "Strategy 2010 – 2020." 2010.

UNESCO. "Education for All Global Monitoring Report ." 2015 .

UNESCO ESD. "http://www.unesco.org/new/en/education/themes/leading-the-international-agenda/education-for-sustainable-development/." (accessed 2015).

UNESCO. "http://unesdoc.unesco.org/images/0023/002327/232721E.pdf."

Vargo, S. L., and R.F Lusch. " Evolving to a New Dominant Logic for Marketing." Journal Of Marketing,Vol.68,No.1, 2004 : 1-17.

Vision 2021. "http://www.vision2021.ae/en/national-priority-areas/first-rate-education-system."

Vision 2021, V. "http://www.vision2021.ae/en/our-vision."

WEF. New vision for Education: Unlocking the Potential of Technology. World Economic Forum , 2015.

Well-Being, What Predicts a Successful Life? A Life-Course Model of. "http://cep.lse.ac.uk/pubs/download/dp1245.pdf." 2013 .

Wheeler, R. S., and R. Swords. " Codeswitching: Tools of Language and Culture Transform the Dialectally Diverse Classroom." Language Arts,81(6), 2004 : 470-480.

World Bank. http://datatopics.worldbank.org/hnp/popestimates.

Chapter 3: Technology in the school of the future

Introduction

In this section we explore how changes in technology, in the medium to long term, might influence the school of the future. It considers four themes evident in discussions of education technology: (1) Tailoring: technology that helps tailor education to individual pupil's needs, (2) Enriching: technology that enriches and expands teaching possibilities, (3) Socialising: technology to support learning through social interaction. And finally, turning away from the pupil, we consider (4) Supporting: technology that supports the underlying practices of education. Within these sections examples of current prototype or emerging technologies are included, and their implications discussed.

Tailoring: Technology that helps tailor to the individual pupil's needs

Individualised, personalised teaching, in which the teaching activity is tailored to the student, has long been a desire within education. Such tailoring requires a mechanism to **more continuously evaluate pupils' needs** and a means of delivering **a more personalised learning experience.** Achieving this would in turn **increase the flexibility of education to support universal access** and avoid marginalisation.

More continuous evaluation of pupils needs

Evaluation of a pupil is commonly done through a mixture of tests and informal teacher monitoring. The technology of the future will be able to support a richer and more continuous ongoing process of teacher-evaluation – through both capturing and assessing pupil's work. For example, pupils might write with digitising pens, such as today's Livescribe pens[4], ensuring a digital record of their work. Such digital records might then be automatically read (data-mined [1]) to identify areas where an individual pupil needs further support or more challenging work. A range of analysis techniques will be available, from simple metrics such as number of metres of writing per hour, to sophisticated algorithmic reading of the content of the work (using improved handwriting recognition systems[5]), with the results of this analysis fed either into information dashboards [2] which teachers can easily understand, or fed automatically into systems which adjust the next work the student is given. However, such monitoring through learning analytics comes with considerable ethical challenges including interpretation of the data, consent, privacy and the classification and management of the data [3].A more personalised learning experience.

In future, technology will better enable students to receive personalised and differentiated materials. For example, electronic teaching materials coupled with input data from continuous monitoring and the use of new forms of authoring languages[6] will allow common but differentiated materials to be generated for use in mixed ability classes. Moreover, materials do not have to be limited to those that a student would receive only from their class. One-to-one tailored tutoring can provide significant benefits over classroom teaching only, but is "too costly for most societies to bear on a large scale" (Bloom 1984). Technology can reduce such costs by enabling offshore lower-cost tutors to operate via video-conferencing, telephone or even text/IM messages[7] such that in the future tutoring becomes increasingly common in the more affluent countries.

The school of the future may also enable more fluid transitions between school years and even schooling stages. For instance, an advanced student could begin elements of their university education while still completing elements of their high school education. This would require agreeing technical standards to integrate Learning Management Systems for such pupils, and Identity Management Systems to allow them access[8] to university systems. A pupils' transition to university might be more fluid, with their school providing continued

[4] *http://www.livescribe.com/uk/*

[5] *https://en.wikipedia.org/wiki/Handwriting_recognition*

[6] *Rather than writing a fixed static document, we envisage authoring languages which allow documents to be written where elements are altered depending on the pupil's ability. For example the sums in a worksheet might change depending on the student's competency, while other elements remain the same. Rather like an advanced mail-merge.*

[7] *E.g. tutor.com*

[8] *This might be achieved through Single-Sign-On solutions such as Facebook and Google provide for many websites.*

basic support or the foundational knowledge, such as Mathematics (which they are better able to provide), during their start at university, whereas universities might support learning of more advanced Mathematics during school education so addressing the challenge of teaching such subjects in schools [4].

Increase the flexibility of education to support universal access

More on-line material, standards, integration between systems, a unified identity-management solution and the opportunity for detailed and accessible up-to-date assessments of a student's progress would bring many benefits, particularly for those often marginalised in education. For example, hospitalised children could continue their education by accessing their own school systems; itinerant communities, and children who move home could be supported as document-standards would enable support materials and their education records to move dynamically with them and their families. This may be significant as in many parts of the world itinerant communities receive poor education limiting their potential.

Enriching: Technology that enriches and expands teaching possibilities

Perhaps the greatest opportunity for technology is in providing new experiences to students within the confined walls of the classroom and school through **enriching the architecture of the school** and **enriching the education experience within the school.**

Enriching the architecture of the school

The basic architecture of the school can have a significant impact on knowledge acquisition [5], and many schools have begun to recognise the need to move from traditional dour institutional designs to modern, airy architectural spaces designed to provide support for different forms of learning[9]. Heating, cooling are important to learning environments [6] and technology can enable these to be optimised in the school of the future. For example, these systems might be linked to camera-based attention-tracking systems [7], adjusting the environment (and informing the teacher) when the class's attention wains. Lighting is also significant [8] and new LED lighting[10] will be dynamic and focused on improving learning by setting itself optimally for the tasks and avoiding glare on screens for reading. For example, if linked to the teachers' dashboard, lighting might automatically dim if videos are being watched, or brighten when individual work begins. Similarly dynamic windows[11] that adjust their opacity can ensure a light, airy environment which reflects individual's needs.

Enriching the education experience within the school

Drawing on Japanese philosophical tradition, Nonaka and Takeuchi [9, 10] recount how Samurai education focuses on knowledge being acquired and integrated into one's personal character in contrast to Western philosophy's separation between body and mind. They use the example to emphasise that learning is not simply a memorisation of facts to be stored in the separate mind but rather a human sensory experience in which all senses are involved. Even abstract thought (such as mathematics) is often learnt though imagined sensory experience[12]. For subjects such as arts, dance, drama, science, sport, craft and design the necessity of sensory engagement – including experiment and practice - is obvious. Schools must provide necessary resources (e.g. studios and laboratories) for this. The school of the future will be able to use new technologies to enhance and expand this experience, including areas where safety or expense would curtail activity in the real world.

Microsoft Hololens[13] is one of the most interesting

[9] *For example the Finish Saunalahti school: http://www.archdaily.com/406513/saunalahti-school-verstas-architects*

[10] *http://origin.www.futureoflight.philips.com/*

[11] *http://www.digitaltrends.com/home/smart-windows-dim-smartphone/*

[12] *Immanuel Kant explores the need for sensory experience in his philosophy of mathematics. Teacher's belief in sensory experience is reported in 11.Hughes, M., C. Desforges, and C. Mitchell, Teachers' Beliefs about Concept Formation and Curriculum Decision-Making in Early Mathematics, in Mathematics for Tomorrow's Young Children. 1996, Springer. p. 272-284.*

developments in this area. This advanced technology couples 3-D scanning cameras, which model the real-environment the wearer is looking at, with a projection system onto glasses so providing the wearer with three-dimensional pictures augmenting the real world. This allows virtual three-dimensional objects to be projected within the physical space giving the wearer the illusion of three-dimensional holograms that form part of the real environment.

Fig. 17: Microsoft Hololens

Existing virtual reality headsets[14] are immersive so isolating the wearer from the physical environment. While this allows a full "virtual reality" it requires the wearer to be separated from others –which may not be appropriate or useful in an educational environment - and faces significant hurdles in avoiding motion sickness (particularly through the lack of depth of field, though the MagicLeap augmented reality solution seeks to address this [12]).

In a classroom environment, such an augmented reality would allow students to collaborate around 3-D models of experiments and observations; including those impossible in reality. Imagine, for example, a nuclear experiment where students pushed simulated fissile materials together in order to explore the resultant chain reaction! As pupils can continue to see their classmates and the furniture around them, so the 3-D models are not disconcerting but can become central to the learning experience which continues to be led by a teacher (albeit also wearing a headset). Currently, Case Western Reserve University is exploring the use of the HoloLens system in collaborative teaching of anatomy to medical students in this way[15] – allowing students to, for example, examine a beating heart.

Where these systems have yet to go is in the provision of a virtual presence in a distant location. Coupling 3D VR Cameras (such as the Nokia Ozo[16]) with movable robotic wheels could perhaps provide a full immersive real-time telepresence experience (i.e. a full 3D version of DoubleRobotics system)[17]. While the challenges are significant (in particular the bandwidth of the communications needed and latency), if achieved such robots might allow a class of students to "virtually" visit remote locations – from museums around the world to jungles in Africa or the volcanos of Iceland. Software might convert the images of these robots into "virtual classmates" so that the pupil visiting sees their classmates instead of the robots in situ.

Such technologies are not without their faults. They can distance the teacher from the students – eye-contact is lost, and the user can become more trapped into "interaction bubbles" [13] such that they disengage from the reality around them during the interaction (and thus disengage with the learning).Even taking excessive risks [14] which would be problematic in a school (for example, if fire-alarms are missed). Socialisation (our next topic) among pupils will be inevitably altered by such technologies as they create new contexts for interaction.

[13] *Similarly Magic Leap http://www.technologyreview.com/news/532001/how-magic-leaps-augmented-reality-works/ and http://www.magicleap.com*

[14] *E.g. https://www.oculus.com/en-us/*

[15] *http://case.edu/hololens/*

[16] *https://ozo.nokia.com/*

[17] *http://www.doublerobotics.com/*

Socialising: Technology to support learning through social interaction with peers

Education is fundamentally a social experience. In this section we explore how technology provides **new opportunities for community interaction** among peers (including peer support among teachers), then consider how this might enable **building networks around schools,** and ultimately **connecting our education world.**

New opportunities for peer interaction

Considerable anthropological research [15-18] has pointed to the role of informal relaxed community interaction in aiding learning and innovation through the emergence of "communities of practice". This research highlights the importance of building social identity, social collaborative participation, and reification. Social identity is the importance of others recognising a participant's place in the community; social collaborative participation is the involvement of all within the community but with different levels of interaction; and reification is the act of formalising and abstracting activity such that it can be easily shared (for example, documenting a good way of doing something).

In the school of the future, technology can provide new opportunities for community interaction to enhance learning. While many learning management systems, e.g. Moodle[18], provide simple discussion spaces or forums, in the future these may also focus on identity building, allowing different levels of interaction, and documenting learning within the social, communicative act of learning. One might look to social media for examples of where this innovation may come from. For example, "Badges" and "Likes" could be used to build recognisable identity and reward those engaged in recognisably useful knowledge-sharing within the community. We should also recognise the limitations of virtual systems in the support of collaborative learning practices [19, 20] and continue to focus on providing physical space for social interaction within schools – and recognition of its importance.

Such a focus on collaborative learning should also extend to collaborative learning among teaching staff. Teaching itself is collaborative with discussion of practice undertaken in staffrooms and discussion forums, online and with teaching materials widely shared[19]. Considering the role new technology can play in improving teaching expertise is vital. While services such as 'twinkl'[20] provide useful worksheets and resources, they risk turning education into a transactional activity where resources are professionally produced and the teacher is simply the delivery agent. Innovating on such services, for example in the way Wikipedia has created a collaborative self-built platform for learning [21] and developing social networking among teachers would increase innovation.

Building networks around schools

In the school of the future, technology can enable greater collaboration with entities such as libraries, museums, innovation labs, life-long learning centres, businesses and universities -less "place" and more "network". It can link pupils up so that they can learn and evolve their place within society safely and productively. For example, a local coffee-shop or religious/ civic centre might be connected to provide space for collaborative learning such as homework clubs or innovation labs. Achieving this will require complex administrative systems to be invented to ensure that children are safe and that learning is effective when outside the safe-space of the school.

This highlights the role of schools in helping their pupils mediate and engage safely and effectively with the wider world. This is particularly true online where schools need to support their pupils in developing their skills and critical awareness of the internet's risks and opportunities. One can envisage systems in which the pupils' online activity is monitored and supported by their school – wherever they are – to help keep them safe.

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[18] *https://moodle.org/ a widely adopted open source learning management system.*

[19] *E.g. https://www.edmodo.com/ or http://www.classroom20.com/*

[20] *http://www.twinkl.co.uk/*

Connecting our education world

In a globalised world there is a need to bring together students from different societies, cultures and countries. In the school of the future, increasing use of technologies such as video-conferencing and collaboration systems may enable schools to link together and help pupils from around the world collaborate. However there are social implications of such connectivity. Social life is created by the repeated performances of practices or behaviours which establish rules [22, 23, p.21]. This means that, as we globally connect pupils together, so new social norms are likely to be created as pupils re-orientate their society in subtle ways. This will have positive benefits by increasing understanding, but may lead to new forms resentment or other darker consequences. Any focus on global social interaction through technology should be meaningful within the curriculum such that all parties are genuinely collaborating on a shared goal.

Supporting: Technology to support the underlying practices of education

In this section we turn away from the pupil to consider how technology might improve the underlying operations of education, including **better information discovery and collation** of digital resources and **support for portfolios of web-services** used in modern teaching.

Better information discovery and collation

We live in a world of information overload and for over 20 years there have been calls for new technologies to help reduce this challenge [e.g. 24]. While search engines such as Google provide generalist searches; within education there is a need for catalogued[21], checked repositories of materials[22]. This role was previously performed by the publication industry which evaluated, selected, collated and catalogued teaching materials [25]. As we move into a world of information profusion we must ensure other means exist to undertake this important work (and at lower cost), perhaps drawing on industry techniques such as Artificial Intelligence (AI) and data-mining [1].

Advanced AI technologies such as IBM's Watson[23] might offer a means of automatically performing this role given its specialism in distilling, isolating and presenting materials. The benefits might go further – for example, the massive open online course provider Coursera[24] is able to use data analysis of homework results and forum discussions to tailor its materials and its support through "Big Data" techniques [26]. This form of information management and data analysis activity will become more important given the tailoring agenda (discussed above) and the school of the future may see an expanded role for data analysts and librarianship (albeit focused on digital rather than physical artefacts). Without qualitative librarianship, teaching skills and critical data-analysis skills to evaluate and understand material/data in light of pedagogy and education policy, there is a risk of poorly understood algorithms gaining power [27, 28] and thus commercial interests potentially dictating education policy.

That said, we must continue to see an important place for physical books within the school of the future. Booksellers in the UK report increases in physical book sales, with pupils connecting emotionally with physical books in their learning[25]. They are a technology which connects to the experiential nature of learning; we often remember the weight, smell, texture and aesthetic of a book long after we remember its content.

[21] *http://www.youtube.com/education is one initiative in this regard.*

[22] *http://www.iprofindia.com/ is an example of a collated digital education library in India.*

[23] *http://www.ibm.com/smarterplanet/us/en/ibmwatson/*

[24] *https://www.coursera.org/*

[25] *http://www.huffingtonpost.com/2015/02/27/print-ebooks-studies_n_6762674.html*

Support for portfolios of web-services

For many, the work of teaching is increasingly mediated by portfolios [29] of diverse tools that might not be traditionally labelled "teaching support" tools but which are deeply embedded within teaching practice (e.g. YouTube, Google, Email, DropBox). This is in addition to a huge range of web-based teaching support "apps" like ones around homework management[26], work-sheet production[27] and mathematics support[28]. Given the importance of these web-based tools it is worth reflecting, finally, on the changing nature of computing infrastructure and the impact this will have on education.

Schools previously invested heavily in expensive networking and computing infrastructure and locally based software, often employing staff specifically to manage these resources. Innovations such as cloud computing technology [30, 31] and improvements in cellular networks (e.g. 4G and 5G[29] connectivity) will shortly allow schools to operate without this expensive technical infrastructure, relying instead on 5G connected tablets, computers and screens[30]. This will reduce cost, but more significantly allow centralised management and organisation of resources for many schools, for example, around local federations of schools or education districts. Expensive technology (such as the Hololens above) might be easily shipped by courier between schools for lessons rather than needing to be held by the school and centralised identity management will ensure they can be quickly introduced into the classroom.

[26] *E.g. showmyhomework.com*

[27] *E.g. http://www.twinkl.co.uk/create*

[28] *E..g. http://geogebra.org/*

[29] *5th Generation mobile connectivity allowing 1gigabit/second connections in equipped buildings, and 10s of Megabits/second in the general environment.https://en.wikipedia.org/wiki/5G*

[30] *E.g. Google Chromebook seeks to provide cloud-based managed PCs which dispense with local management. See http://www.google.com/chromebook/static/pdf/Chromebooks_for_Education.pdf*

Conclusions

In considering technologies for the school of the future we must avoid technological utopianism whereby it is perceived that technology offers all the solutions to education's failings. We must also not assume that new technology will deterministically lead to beneficial outcomes [32]. While technology may incorporate a designer's "script" which leads to (affords) particular usage patterns [33] (a chair for example affords sitting), they often also afford unanticipated usages (e.g. in a riot a chair affords throwing through windows). For complex, IT based systems such affordances are far from clear; and usage is as much emergent as it is designed [34, 35]. Technological design also inscribes designer's political assumptions and biases [36] so potentially altering carefully crafted balances within schools and classrooms. For example, technologies can include gender-bias through use of colour or design, or assume left-to-right reading directions. Poorly designed systems can inhibit use by those with certain disabilities[31]. Prescriptive approaches to learning can be reinforced by a lax attitude in some teachers, and innovation stifled through conformity – such that the future school becomes more "concrete" [37] and standardised than those of today.

Finally, it is worth reflecting that a technology's meaning is constructed not by the designer but by the user. Whether a technology is successfully adopted by a class as exciting depends on complex interrelationships between the technology and the expectations of classmates. However, these pupils make this interpretation based on personal experience of perhaps more impressive technology at home (e.g. mobile phones, games consoles, social-media)[32]. This is a worry, particularly, as many learning technologies seek to mimic these home experiences (for example, gamification systems seeking to mimic Xbox and Playstation games but with an educational component) but without the finances to effectively compete. When evaluating the technology of the school of the future we must also critically evaluate the technology of the home of the future.

What is required is a pragmatic, innovative approach in which local education needs are considered alongside national standards and demands, in the context of global competitors and expectations. The digital age is perhaps best represented by portfolios of different technological solutions both at home and in schools connected by motivated teachers who can help the individual pupil build their own robust learning environment and excel.

[31] *E.g. poorly designed websites can make it impossible for the blind to read using their screen-reader systems. Certain user-interfaces are hard to use with reduced-mobility. The Web Content Accessibility guide provides advise on website accessibility: http://www.w3.org/WAI/intro/wcag.php*

[32] *This problem is discussed with regard to corporate systems in 38. Gannon, B., Outsiders: an exploratory history of IS in corporations. Journal of Information Technology, 2013. 28(1): p. 50-62.*

Chapter 3: Technology in the school of the future *continued*

References

1. Romero, C. and S. Ventura, Educational data mining: a review of the state of the art. Systems, Man, and Cybernetics, Part C: Applications and Reviews, IEEE Transactions on, 2010. 40(6): p. 601-618.
2. Few, S., Information dashboard design. 2006: O'Reilly.
3. Slade, S. and P. Prinsloo, Learning analytics ethical issues and dilemmas. American Behavioral Scientist, 2013. 57(10): p. 1510-1529.
4. Hoyles, C., K. Newman, and R. Noss, Changing patterns of transition from school to university mathematics. International Journal of Mathematical Education in Science and Technology, 2001. 32(6): p. 829-845.
5. Sclater, I., Environmental Concern, in Knowledge Management. 1999. p. 13-20.
6. Wargocki, P. and D.P. Wyon, Research report on effects of HVAC on student performance. ASHRAE journal, 2006. 48(10): p. 22.
7. Stiefelhagen, R. Tracking focus of attention in meetings. inProceedings of the 4th IEEE International Conference on Multimodal Interfaces. 2002. IEEE Computer Society.
8. Anderson, K. The problem of classroom acoustics: The typical classroom soundscape is a barrier to learning. inSeminars in Hearing. 2004. Copyright© 2004 by Thieme Medical Publishers, Inc., 333 Seventh Avenue, New York, NY 10001, USA.
9. Nonaka, I. and H. Takeuchi, The knowledge-creating company: how Japanese companies create the dynamics of innovation. 1995, New York: Oxford University Press. xi, 284.
10. Nonaka, I., P. Reinmoller, and R. Toyama, Integrated Information Technology Systems for Knowledge Creation, in Handbook of Organizational Learning and Knowledge, M. Dierkes, et al., Editors. 2001, Oxford University Press: Oxford. p. 826-848.
11. Hughes, M., C. Desforges, and C. Mitchell, Teachers' Beliefs about Concept Formation and Curriculum Decision-Making in Early Mathematics, in Mathematics for Tomorrow's Young Children. 1996, Springer. p. 272-284.
12. Macnamara, J.G., Multiple depth plane three-dimensional display using a wave guide reflector array projector. 2014, Google Patents.
13. Quigley, A. and J. Grubert. Perceptual and social challenges in body proximate display ecosystems. inProceedings of the 17th International Conference on Human-Computer Interaction with Mobile Devices and Services Adjunct. 2015. ACM.
14. Sabelman, E.E. and R. Lam, The real-life dangers of augmented reality. Spectrum, IEEE, 2015. 52(7): p. 48-53.
15. Orr, J., Talking about Machines: An Ethnography of a Modern Job. 1996, Ithaca, NY: IRL Press.
16. Lave, J. and E. Wenger, Situated Learning: Legitimate Peripheral Participation. 1991, New York: Cambridge University Press.
17. Wenger, E., Communities of practice : Learning, meaning and identity. 1st ed. Learning in Doing: Social, Cognitive and Computational Perspectives, ed. R. Pea, J.S. Brown, and J. Hawkins. 1998, Cambridge: Cambridge University Press.
18. Wenger, E., Communities of Practice and Social Learning Systems. Organization, 2000. 7(2): p. 225-246.

19. Henri, F. and B. Pudelko, Understanding and analysing activity and learning in virtual communities. Journal of Computer Assisted Learning, 2003. 19(4): p. 474-487.

20. Duguid, P., "The Art of Knowing": Social and Tacit Dimensions of Knowledge and the Limits of the Community of Practice. The Information Society, 2005. 21(2): p. 109 - 118.

21. Gou, T., et al., Codifying collaborative knowledge: Using Wikipedia as a basis for automated ontology learning. Knowledge Management Research and Practice, 2009. 7(3): p. 206-217.

22. Berger, P. and T. Luckmann, The social construction of reality. 1966, London: Penguin Books.

23. Giddens, A., The Constitution of Society: Outline of the Theory of Structuration. 1984, Oxford: Polity Press.

24. Maes, P., Agents that reduce work and information overload. Communications of the ACM, 1994. 37(7): p. 30-40.

25. Borgman, C., Scholarship in the Digital Age. 2007, Cambridge,MA: MIT Press.

26. Mayer-Schonberger, V. and K. Cukier, Big Data: A Revolution That Will Transform How We Live, Work and Think. 2013: John Murray.

27. Williamson, B., Governing software: networks, databases and algorithmic power in the digital governance of public education. Learning, Media and Technology, 2015. 40(1): p. 83-105.

28. Kallinikos, J. and N. Tempini, Post-material Meditations: On Data Tokens, Knowledge and Behaviour, in 27th EGOS Colloquium - European Group of Organizational Studies. 2012.

29. Mathiassen, L. and C. Sørensen, Towards A Theory of Organizational Information Services. Journal of Information Technology, 2008. 23(4): p. 313–329.

30. Armbrust, M., et al., A View of Cloud Computing. Communications of the ACM, 2010. 53-58(4): p. 50-58.

31. Venters, W. and E. Whitley, A Critical Review of Cloud Computing: Researching Desires and Realities. Journal of Information Technology, 2012. 27(3): p. 179-197.

32. Oliver, M., Technological determinism in educational technology research: some alternative ways of thinking about the relationship between learning and technology. Journal of Computer Assisted Learning, 2011. 27(5): p. 373-384.

33. Norman, D., The Design of Everyday Things. 1990, London: The MIT Press.

34. Norman, D., The invisible computer: why good products can fail, the personal computer is so complex and information appliances are the solution. 1999, Cambridge Massachusetts: MIT Press.

35. Woolgar, S. and G. Cooper, Do artefacts have ambivalence?: Moses' bridges, Winner's bridges and other urban legends in S&TS. Social Studies of Science, 1999. 29(433-49).

36. Winner, L., Do artifacts have politics?, in The Social Shaping of Technology, D. Mackenzie and J. Wajcman, Editors. 1999, Open University Press: Maidenhead. p. 28-40.

37. Cornford, J., The virtual university is... the university made concrete? Information, Communication & Society, 2000. 3(4): p. 508-525.

38. Gannon, B., Outsiders: an exploratory history of IS in corporations. Journal of Information Technology, 2013. 28(1): p. 50-62.

Chapter 4: Role and Future of Technology in the School of the Future

This section initially considers the likely developments in future technology and then considers the learning activities that these technologies will be required to support in the school of the future.

Technology Developments

The scale and nature of future technology development will undoubtedly be vast. The specific nature of the developments is harder to pin down. There are some technology characteristics that will have increasing impact. For example, the ubiquity and proliferation of the 'smart' devices that we carry around with us wherever we go, or that are part of the environments with which we interact, including ourselves and the people we meet, will enable richer and deeper learning both inside and outside schools. The availability of different interfaces is also set to continue. Touch, voice, physiological data, environmental data, and movement, for example, all offer ways for us to input information for technology to process. Audio, visual, and tactile feedback will continue to provide a range of ways to interact with technology. We can already enter virtual worlds where we can see ourselves as avatars within those virtual spaces and we can interact within them in a multitude of ways. The range and sophistication of these interactions that transcend the virtual and physical is set to increase and to support a finer grain and richer set of possibilities. Computing technology costs will continue to fall and capability will keep going up. There is no longer a need for us to be co-located with our technology as demonstrated by cloud computing, which offers vast amounts of computing power and resources from banks of computers as and when we need them.

The combination of mobile technology devices and robust networks will offer an increased network of connections to support learners' interactions with their learning resources and the possibility of richer connections with teachers and peers. At the same time, the boundaries between technology and human will become increasingly blurred. This hybridization of human and machine will also take the form of collaborative networks of mixed human and machine elements, in which one may not be sure at any particular point if one is interacting with a human or an artificial collaborator. The important point is, however, that intelligent learning support will become increasingly available and increasingly ubiquitous.

There are three technology themes that are particularly significant for the role of technology in the school of the future to enable new models of education. These are: Intelligent, Adaptive Technologies and Learning Analytics; Consumerized Technology; and the Internet of Things and Wearable Computing.

Intelligent, Adaptive Technologies and Learning Analytics

Adaptive learning technologies use AI techniques to provide software and online platforms that adjust to individual learner's needs as they learn. The technology collects data about the learner's interactions with the software and uses this to build an interpretation of their progress. This interpretation, sometimes referred to as a learner model, is used by the software to make decisions about the learner's future instruction, the interventions and feedback the software will make, and any additional remediation. In addition to reacting to data about an individual learner, these intelligent adaptive systems can also aggregate data across many learners to produce suggestions for adapting curricula and instruction.

These technical developments mean that the idea of an intelligent assistant for everyone is now a realistic possibility. And it is not just for learners, teachers too can benefit enormously. Imagine how much more effective and satisfying a teacher's job might become if they had their own personal AI teaching assistant who could, under their direction, take over teaching a group of students who need help with a particular area of the curriculum; quadratic equations in math perhaps. AI techniques and applications will also enhance the educational 'big data' produced as learners interact with technology. Tools and techniques that are referred to as Learning Analytics are already analysing this data. To date, these Learning Analytics have tended to recognize patterns in the data that can be interpreted as indicating something of interest educationally. For example, they can predict with good accuracy when a student is likely to fail an assessment or 'drop-out' from an on-line course. The sophistication of these Learning Analytics will quickly be complemented by AI techniques that will build models that are able to provide more detailed and nuanced information about learner success, needs and potential areas of difficulty.

The pace of innovation in general is at its fastest rate ever[33] and the current popularity of AI should mean that innovation in AI is a focus of attention for an increasing number of businesses. In turn, this should lead to greater competition and falling prices, making AI based educational technologies available to more people. In addition to an increase in the scale and distribution of AIED technologies, there is likely to be an increase in specialist developers as businesses try to differentiate their product from that of their competitors. The growth in the AI for education market may spawn a lively open source community with the availability of APIs for developers (Application Program Interface: tools for building software applications). There already exist General AI APIs and there is every reason to believe that AI for education APIs will follow suit. It will not be long before educational AI apps are available through the App store and easily accessible for everyone.

Consumerized Technology

The proliferation in the ownership of sophisticated technology, such as smartphones within society, particularly among young people, is evidence of the consumerization of technology- a trend that is likely to continue beyond the phone to embedded and wearable technologies, for example. This increased ownership has the positive impact of enabling schools to look beyond the provision of hardware and ensuring that learners can be connected to their own devices, wherever those devices happen to be. There will still be a need for specialist technology in schools, but the Bring your Own Device/Technology (BYOD/T) movement will continue and grow. Adoption of BYOD/T is already a reality. For example, in the US a 2014 Consortium for School Networking (CoSN) survey found that 81% of respondents either had a BYOD policy in place or were planning to deploy one.[34] Being able to connect beyond the device the learner brings with them to devices they are wearing and devices in their home will bring new possibilities and challenges, both technical and ethical. In recent times much of the technology in the hands of learners has migrated from the development lab to general public take-up without sufficient understanding of their impact on young people's learning, social interactions, relationships and community engagement. Technology can put young people in control, engage the disengaged and enable the individual to be an active agent. However, enthusiastic technology adoption is not always beneficial. We will, therefore, need to develop new approaches to agile evaluations of technologies to ensure that we know how best to use them to support learning.

The Internet of Things and Wearable Computing

More possibilities for the school of the future come from the continuing development of wearable computing and the Internet of Things (the network of objects or "things" with embedded computing systems, sensors and network connectivity that can be interconnected with any other network enabled object or machine). Wearable technology refers to computer-based devices that can be worn by learners and/or teachers. For example, wearable technology can take the form of jewellery, glasses, shoes and clothes. These technologies offer even more possibilities for tracking behaviours, movement and technology interactions. These technologies can also be used to offer virtual or augmented reality. For example, Google Glass displays information about a learner's environment displayed in front of them as they move around the world. In addition to offering learners new forms of interaction and networking, these wearable technologies have made the notion of the quantified self a reality. This idea combines wearable computing with wearable sensors so that data about a person's daily life can be analysed and states, such as moods and performance, both physical and mental can be tracked. The Internet of Things exposes the hidden data and communication layer of the Internet to reveal the invisible world around us as data for analysis and use.

The continuing spread of small technology, components that can be combined in interesting and creative ways, has fed the Maker movement and the creation of Makerspaces. The introduction of Makerspaces in the school of the future will encourage teachers and learners to be creative, to act on their ideas and to engage with

[33] *FT Bill Gates interview*

[34] *http://cdn.nmc.org/media/2015-nmc-horizon-report-k12-EN.pdf*

design thinking from the inception of the project to the end. Makespaces will be complimented by 3D printing that will enable learners and teachers to build prototypes of almost any object that can be conveyed in three dimensions.

The three themes identified here are not mutually exclusive, but inter-connected. They also sit within a complex system of other developments that will inevitably impact their progress.

Learning Activities Enabled by Technologies in the School of the Future

To thrive in the future economy, workers will need a different set of skills and knowledge than those they required in the past. They will need to be literate, numerate, and technology competent. Their understanding of subject knowledge, such as science, math and geography will need to be deeper and more flexible so that they are able to explain concepts to others and are able to synthesize knowledge across subject domains. In addition, they will need to be creative problem solvers who can work in a team, use their initiative and persist when the going gets tough. These new skills and abilities are often referred to as 21st-century skills[35] and they are increasingly accepted as essential. The newer pedagogies of practice-based and project-based learning where students work in teams to tackle relevant challenges will be more prevalent as will design based activities. These approaches are complex, but they can be broken down into eight core types of learning actions[36] based on the theory of Learning Acts.[37] These actions will be combined into the newer pedagogies and into pedagogies yet to emerge.

Learning from experts

This is the traditional form of learning whereby learners are exposed to knowledge resources, such as books, teachers and the Internet. To be effective, learners need to interact with these resources and enter into a dialogue. Technology can support this dialogue and new forms of representation will offer new possibilities for enriching discussion. The increasing wealth of technology-enabled resources will place demands on teachers and learners to evaluate and filter these, thus, developing critical thinking skills. The Intelligent, Adaptive Technologies and Learning Analytics technology theme will be important for learning from experts as AI techniques will enable us to build adaptive systems to support each learner's individual needs.

Learning with others

Much of our learning occurs through our interactions with other people- teachers, peers, parents and friends for example. But no matter who learners interact with, these interactions will require collaboration to develop mutual agreement or shared understanding in order to solve a problem. Technology can influence the way in which learners collaborate and can provide support for both synchronous and asynchronous interactions. Two technology themes will be particularly important for learning with others, these are: a) consumerized technology which will offer more people the capability to communicate and collaborate wherever they are and b) The Internet of Things and Wearable Computing that will also provide new tools for collaboration and new possibilities for learners to collaborate as they participate in Makerspaces.

Learning through making

The advancement of skills such as **creativity, design, and**

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[35] *http://www3.weforum.org/docs/WEFUSA_NewVisionforEducation_Report2015.pdf*

[36] *http://www.nesta.org.uk/publications/decoding-learning*

[37] *Manches A. Phillips B. Crook C. Chowcat I. & Sharples M. (2010). CAPITAL-6 Curriculum and Pedagogy in Technology Assisted Learning. http://www.icde.org/filestore/Resources/Reports/CAPITALfinalreport.pdf*

engineering has already been identified in the context of Makerspaces. Learning through making is based upon two principles: first, learners must construct their own understanding and second, learners must create something they can share with others. The exploitation of personal technologies combined with appropriately designed construction environments and highly flexible web tools realize the vision of learning through making. Teachers have a crucial role to play in this process and need to be equipped with the requisite knowledge and skills. The technology theme that will drive the future of learning here is clearly The Internet of Things and Wearable Computing.

Learning through exploring

Learners have always searched for information to build knowledge. They do this playfully, spontaneously, by experimenting with learning materials in a way they feel is enjoyable or in a more structured way. Learning through Exploring can take the form of browsing the web for more information about a topic of interest or someone else can engineer it- a teacher or a peer who provides initial materials and goals. Digital technologies provide new and engaging ways to explore information, and offer new ways for teachers to structure the environment that learners explore. Increasingly the digital environment will require learners to discriminate effectively as they are confronted with a large quantity of information. The Internet of Things and Wearable Computing will provide a new blended physical and digital environment for exploration and will provide learners with opportunities to interact with information in novel ways.

Learning through inquiry

Inquiry-based learning, which includes learning through simulations, enables learners to think critically and to participate in the complex, evidence-based debates that will become increasingly important. Inquiry learning "involves a process of exploring the natural or material world [...] that leads to asking questions, making discoveries, and rigorously testing those discoveries in the search for new understanding."[38] Technologies offer new and engaging ways to provide structured inquiry based learning and simulations: to present convincing and relevant problems to learners and to script their inquiry. The technologies that will be developed under the Intelligent, Adaptive Technologies and Learning Analytics theme will enable intelligent structuring within learning environments and simulations that can adapt to each individual learner's interactions and needs.

Learning through practicing

Practice makes a man perfect may be an old-fashioned maxim, but it is nevertheless true. Learners build a solid foundation of knowledge by practising so that this knowledge can later be applied to different problems or subjects. Technologies that involve multimedia, games and multi-modal interactions usually include a need for learners to rehearse or practice an activity or skill. These technologies can be innovative with rich multimodal interactions and challenging problems. Developments within The Internet of Things and Wearable Computing technology theme will offer new opportunities to practice activities such as playing a musical instrument or practicing yoga.

Learning from assessment

Assessment is fundamental to learning. Teachers need to know what learners understand or don'tunderstand and learners need to be able to accurately assess their knowledge and understanding so that they can use appropriate resources effectively. If learners attempt

[38] *National Science Foundation, 2012, p. 2, our emphasis*

tasks that are too complex, they are likely to fail; if they attempt tasks that are too easy they may not progress as they should. If teachers (and learners) have accurate information about learners' current understanding they can provide appropriate feedback and adapt the learning environment to suit the particular needs of a learner. In order for learners to gain a better understanding of their learning they need to be reflective about their learning process and develop the skills and self-awareness to refine their own learning activities. The use of a wide range of technology to support learner reflection offers great potential to assist learners to better know their learning needs. Technology to support learners and teachers includes widely available technologies to record and share multiple media.

In the future technologies, such as Learning Analytics and Big Data combined with AI will revolutionize the way learners are assessed. These technologies will enable us to collect the data we need in order to be able to trace leaner's progress across all subjects and to identify the new data about learners' activities that needs to be collected and analysed. The resulting dataset about learners' activities will be analysed to advise teachers about the learner's emotional well-being, about where they need particular support and also report their level or performance in the key curriculum subjects. The data sets will also be subject to visualization techniques that will provide representations that teachers and learners can use to understand more about the process and products of the learners' activity.

Digital badges are an increasingly popular way to provide learners with credit (or microcredit) for their learning. These badges assess learned skills based on outcomes. Digital badges are also being used to help track, capture, and visualize learning to incentivize students[39]. Badging is gaining popularity in online learning environments and this is likely to continue. Schools will be able to use digital badges as an alternative way to validate achievements for learners and for teachers too.

Learning in and across settings

Learners interact with people, places and things as they learn and these interactions make up the learners' context. The learners' context is a key determinant of the quality of learners' experiences as well as learning outcomes. Learners improve their knowledge and deepen their understanding when they apply their learning across different locations, representations and activities. However, it can be difficult for learners to apply learning from one setting, such as a lesson at school, to another, such as a field trip or workplace. Technology will help as learners capture, store, compare and integrate material from a variety of settings using devices such as mobile recording and communication tools, PDAs, cameras, embedded sensors, phones, and GPS enabled devices.

The Consumerized Technology theme will be important for the development of this learning activity. Stable, readily available technologies, such as cloud storage and handheld devices will be increasingly used individually and in combination to support learning practices that are effective. The connections built by technology will help learners to see how and what they learn in one setting can also be used in another, and to connect the people who are helping them to learn.

[39] *http://cdn.nmc.org/media/2015-nmc-horizon-report-k12-EN.pdf*

Chapter 5: Educating for Digital Service Society Innovation

Introduction

The aim of this section is to outline some of the significant challenges associated with the technological and industrial changes societies are undergoing. While the thrust of the chapter will be to outline these challenges, observations throughout will then draw out some of the possible consequences for teaching and learning of these changes. These observations can help inform discussions on the school of the future. The main contention is that while designing, the school of the future must be achieved by synthesising a number of concerns, and then a comprehensive imagery of fundamental changes in the way organisations interact with customers through digital technology can greatly inform the overall requirements for the school of the future.

The way in which we do business, interact with each other, and learn is undergoing rapid changes as new generations of networked digital technologies and their associated streams of data fuel changing social and economic behaviour. Facebook has overtaken China as the World's largest "country" with 1.44 billion members using the service monthly, and a record-breaking 1 billion people interacting daily [Facebook, 2015]. Apple and Google established in 2009 platforms for smartphone and tablet applications resulting in the globally distributed development of 3 million apps, which are purchased and installed directly by individual customers.

It could be argued that these changes are superficial and that they do not constitute a challenge to the ways in which we teach and learn. However, the increasing direct digital connectivity between people and the increased engagement by consumers in self-serviced and automated service engagements challenges the traditional understanding of work and business. The future scenario shows us the need for constant innovation through recombination; much in the same way as smartphone app developers build a never-ending stream of novel apps from existing software "Lego bricks". This image of the future also places a premium on the ability to conquer new areas of human affairs previously not digitised and carefully carve out aspects for automation and self-service. Based an understanding of the challenges of the digital service society, this chapter argues for a rethink of what we teach each other and the way in which we do so. The proposed changes do not imply a wholesale change, but rather a mindful upgrade of current best practices to be fit for purposes in the 21st century.

This chapter will first explore an era based on tool making with digital material. Then we take a closer look at the service society heralding a shift from production of goods to the provision of service. This leads naturally to a more detailed exploration of the characteristics of digital service work, which is followed by a discussion of teaching and learning in the context of digital service work. The chapter concludes with reflections on both the increased reliance on digital tools, and the challenge to apply it mindfully.

A New Breakthrough Material

> *"The Stone Age did not end because humans ran out of stones. It ended because it was time for a re-think about how we live."*
>
> William McDonough — Architect

The main material used for making tools is of course a simplistic manner characterising periods of human history, but we nonetheless talk about the Stone Age, the Iron Age and the Bronze Age. Each age is characterised by an improved basic material for tool making. One of the absolute dominating materials since the 1950s is plastic. It makes possible very cheap, durable and hygienic mass-produced consumer goods due to its plasticity and abundance. Our current age can increasingly be characterised as the age of the digital material, heralding new opportunities and challenges. Digital material is very flexible and allows a degree of unpredictable innovation of tools, which in comparison makes plastic seem more like stone. This extreme malleability of the digital material along with the capabilities of computer technology gives rise to three important challenges of understanding and leveraging the power of: 1) digitalisation; 2) decentralisation of digital services and associated network effects; and 3) the exponential scaling of computational power, i.e., Moore's Law [Fichman, 2014].

The flexibility stems from the possibilities associated with the rendering of previous analogue data digital [Tilson, 2010; Yoo, 2012]. If we consider music in an analogue form then there will be tight couplings between the vinyl LP storing the music, the turntable processing the music, and the chains of record stores distributing the music. Once the record industry music digitised music and stored it on CDs it laid the foundation for its own disruption. The digital music could be "ripped" off CDs and shared through Napster's peer-to-peer network for free to be played on home computers. More generally, the digitising of the content led to loose couplings between the storage, processing and distribution of the content. Even more generally, once entirely digital, any output from any process can in principle (but not always in reality), be an input to any other process. It is after all simply a matter of piping data. This technical process of digitising can, as argued above, have serious consequences for individuals, organisations, and whole industries, as music, movie, and book publishing companies have experienced.

The fundamental understanding of the possibilities afforded by digital material can be quite difficult to grasp, especially for generations growing up without very early exposure to digital technologies. Back in the 1990s, MSc students studying for a degree in technology management at the London School of Economics would receive a basic course in word processing and spread sheet management. This is, however, not necessary anymore. Children will now typically be exposed to a range of digital technologies from an early age. One of the arguments often forwarded is that children growing up after the widespread diffusion of Internet connectivity and mobile phones will be "digital natives" and inherently able to understand this new material, as opposed to the "digital immigrants for whom the natural stance comes much harder as they did not grow up constantly interacting digitally [Prensky, 2001; Palfrey, 2008; Tapscott, 2009]. The key characteristic of digital natives is the immediate adoption of digital innovations and the use of diverse complex digital technologies in a playful and effortless manner [Vodanovich, 2010].

The class of people that can be characterised as digital natives keeps growing with each new generation, and while they may have an edge on mastering new and complex innovations, the technological development is increasingly able to master the digital material so that its use becomes an increasingly friendly process for even digital immigrants. The most obvious example is the current generations of smartphones and tablet computers, which provide a much simpler means of both computer use, and critically, computer maintenance, compared with previous generations of technology. The automation and self-servicing whereby, the user can easily update data, multi-media, applications, and operating system, makes it a viable technology for even the most hesitant digital immigrant. In a teaching context, the digital material is already becoming an integral element with a large range of educational technology innovations creating new ways to engage and learn.

Decentralization and Network Effects

The wide-spread adoption of mobile phones connected to both global telecommunication networks, and importantly, through these or through WiFi, connected to the Internet and a variety services, has resulted in a significantly more interconnected world than just a couple of decades ago. Technologies that display network effects become much more valuable when adopted by more people – they have network externalities [Shapiro, 1998]. A telegraph station, telephone, or fax machine becomes increasingly valuable as more and more people are reachable through the particular network technology. Digital innovations that are layered on top of existing technology with network externalities may be able to use these to spread the word, such as free email services, based on wide-spread interconnectivity, with each email that is sent containing a signature advertising itself.

One of the consequences of the widespread adoption of a large range of digital innovations with network effects, is the ability for highly distributed users to become coordinated through new services, and even more importantly, to be able to engage in fundamentally new kinds of distributed behaviour only coordinated "at arm's length" [Tilson, 2010]. With digital technologies, individuals are able to express opinions, access information, learn on their own, and contribute with own innovations.

Twitter can provide anyone with an account direct access to a highly decentralised information source as an alternative to centralised information sources. Furthermore, Twitter provides an easy means to coordinate between large groups of people in a highly decentralised manner [Schmidt, 2013].

The lowering entry barrier for contributing with innovations allows a large number of individual software developers to participate in Apple and Google's app platforms as independent developers. Furthermore, even small developers can challenge decisions by large organisations in this arrangement being helped by a global community of commentators calling out decisions deemed unfair, for example on what apps are allowed in Apple's iOS platform [Eaton, 2015].

Breaking into the music business used to rely heavily on music publishers acting as selectors and gatekeepers. No longer so as the digital material enables anyone with the willingness to learn, and a laptop or a tablet computer to start making music [Manning, 2013]. For a few hundred additional dollars, the computer arrangement will provide technical studio quality, which in the 1980s would have required a six-figure investment in professional equipment. The easy participation of course implies increased challenges to find an audience as a large number of hopefuls compete for them.

Kickstarter and other such crowd funding services provide a very low barrier of entry for very small outfits to seek funding for new products based on a working prototype and a video explaining its function.

Wikimedia can perhaps best illustrate the force of loosely coupled and highly distributing activities coordinated through digital innovation. It operates a number of wikis, most famously Wikipedia, based on donations and employs less than 300 people. It has been estimated that the total human effort invested in establishing and maintaining Wikipedia is equal to one month's worth of advertisement breaks consumed by the US population [Shirky, 2010]. This illustrates the dramatic accumulative effect of large-scale distributed contributions coordinated through technology.

The school of the future must have intelligent ways of preparing pupils for a much higher degree of decentralised action than in the past. Decentralised behaviour has of course formed the backbone for all human activities through time, in that most individuals would have some discretion in how they would engage with the world. However, when everyone is continuously connected to others and to complex digital services through increasingly intimate and user-friendly gadgets, then the foundation of decentralised behaviour has shifted. Each person could during the 1800, armed with parchment and quill (assuming they could afford it), annotate facts, experiences, and opinions in a highly decentralised manner. However, the technology would at that time make it exceedingly difficult to distribute what was written to others, and indeed get their writings commented by others.

Scientific discovery and peer-review was originally simply personal letters between academics. The high cost of communicating only allowed the scaling of effort through centralisation, thus producing scientific journals and publishing houses, mirroring the emergence of large centralised bureaucratic organisations that could only increase in size and scope by centralising [Malone, 2004]. Technological innovations starting with the telegraph has over time steadily decreased the cost of communicating, and at present times, it is indeed possible to engage in large-scale, yet decentralised, activities coordinated electronically.

Exponential Scaling of Computational Power

The third important characteristic of digital innovation stems from the exponential improvements in computer technology the past fifty years. Intel's co-founder Gordon Moore formulated what has become Moore's Law. It states that computer chip manufacturers are able to double the number of transistors on a given area of a silicon wafer within an 18 month period. This largely translates into a doubling of processing power and more than a doubling of storage each 18th month. This development has seen the development of smartphones with gigabytes of memory and processor speeds rivalling those of desktop computers just a few years ago.

This exponential scaling has now created a significantly different class of digital innovations compared with previous generation of devices. The power of the computational arrangement of small user-friendly devices offloading the heavy lifting to powerful cloud services through fast connections is reaching capabilities that previously were considered impossible or only partially possible. This can be illustrated using the old story of the inventor of chess asking for the reward of one grain of rice on the first square of the board, and then for each of the remaining 63 squares double the number of grains of rice of the previous square [Wikipedia, 2015]. The growth in number of grains of rice is an example of exponential growth, and making a distinction between the first and the second half of the chessboard can teach us both about exponential growth and about the current state of computational technology [Kurzweil, 2004 ;Brynjolfsson, 2014]. The first half of the chessboard will contain a total of around of 100,000 kg of rice. This is of course is a lot of rice when beginning with just 1, 2, 4, 8 etc. grains, but still an amount most humans can relate to intuitively. However, the total amount on the second half of the chessboard amounts to 461,168,600,000 metric tons, which would be a heap of rice larger than Mount Everest – equivalent to around 1,000 times the global production of rice in 2010 [Wikipedia, 2015].

The argument can be made that in terms of Moore's Law and exponential scaling of computational power, we are rapidly moving into the second half of the chessboard [Brynjolfsson, 2014]. Assuming a start around 1967, then the 576 months until 2015 represents exactly 32 * 18 months doubling, and expects computational capabilities emerging that exceed our intuition. We are already witnessing services that, although not perfect, are practically demonstrating or indeed delivering what for many years was considered major research challenge. For example, the challenge of Simultaneous Location and Mapping (SLAM), which has been a challenging problem for artificial intelligence researchers for decades, yet not a problem for a 2-year old child exactly understanding where tables, doors and stairs are located in rooms he or she has not previously been in. However, with sensor and radar technology innovations and the exponential growth in computational power, much of this problem has in reality been cracked. Self-driving cars essentially rely on this technology and Google's offering has in 2015 driven 1.6 million kilometres [Wikipedia, 2015]. Also Google Translate and Apple's Siri voice recognition are examples of services that are only possible due to exponential growth in computational capabilities.

Google and NASA have recently revealed that the experimental quantum computer they are working on is orders of magnitude faster than traditional computer chips, giving hope that Moore's Law will continue [Navarro, 2015]. This continued exponential growth in computational capabilities leads to a number of longer-term challenges in terms of how we manage scenarios where computational capabilities may be superior to those of humans [Bostrom, 2014].

The exponential growth in digital capabilities represents a significant educational challenge even for the digital natives. The increasing technical complexity requires increasingly complex technical skills to master. At the same time, the requirement for increasingly user friendly interfaces means an increasing chasm between the ease of use and the complexity to construct.

Such exponentially increasing capabilities, however, also mean dramatically increased opportunity to continue the process of "digital land grabbing" where computation can be applied in hitherto unproven areas of activity. Computer initially resided in basements and supported the automation of routine organisational processes. They subsequently moved to the desktop and helped first individual then group productivity, for now through mobile computing to form a link between the organisation, customers and individual workers [Sørensen, 2011]. However, a most significant shift happened when computing ceased to be a matter of business utility and became an integrated experiential part of everyday life, for example, through the iPod allowing people to carry thousands of songs in their pockets, immersive computer games, or the smartphone acting as a flexible information portal [Yoo, 2010]. Human existence along the increasingly advanced computer technologies require of us to creatively understand how to design new, interesting, and visceral experiences using this technology, but also doing so in an interesting and socially desirable manner.

The Digital Service Society

With all these technological opportunities, it becomes even more salient to understand the bigger picture of the context into which this technology will play an important role. What is the future of business innovation, and what role will digital technologies play in this future? The following section will seek to provide one image of the future based on the simple notion that the 20th century's successful provision of cheap, yet high quality goods through standardisation, mass-production and the scientific management of work will be repeated in the 21st Century for services. They will be cheap, of high quality, and customised to changes in the individual customer needs. Understanding this dynamics can greatly help inform us about the challenges of the school of the future.

The 20th century has, through industrialisation, delivered the ability for a large part of the population in the developed world to engage in an unprecedented level of consumption. While this incredible success has had significant negative consequences, such as pollution, it has also brought about increased total wealth. Increased division of labour, global distribution of efforts, standardisation, scientific management of work, and the ability to manage large amounts of information, are all important ingredients in this change. As a result, a substantial part of the world's population can afford to engage in consumption by purchasing cheap, yet high-quality, goods. We can have cheap, durable, goods as long as we accept they are manufactured and standardised rather than unique and bespoke. Henry Ford famously stated that; "any customer can have a car painted any colour that he wants so long as it is black".

The challenge facing businesses in the 21st century can, in many ways, be described as doing something similar to on-going service-relationships as the 20th century did for goods to be handed over a counter. Consumers are increasingly focused on obtaining good customer service. There is a desire for on-going support in addition to the goods exchanged through transactions and organisations are struggling to meet such demand as they do not easily fit into the arrangement of work [Zuboff, 2002]. As an example, the customer demand for organisations to meet customers, as and when these have the need, has over the past decades resulted in the wide-spread use of 24/7 customer contact centres supporting direct telephone support.

The shift in importance from selling goods to providing service leads to the challenge of customer interaction. Purchasing a new pair of shoes immediately shifts the responsibility for making shoes fit the feet onto the customer who becomes the owner of a new pair of shoes. The mutual adaptation between shoes and customer feet is not the shoemaker's or shoe storeowner's concern once the transaction has been completed. This is radically different in the case of services where the service provider continues to own the service through the extent of the service relationship. This implies that the service provider will be involved when the customer's preferences change. It is not possible to ask the hairdresser for two additional haircuts for later.

Traditionally, good quality service has been associated with increased paid human effort precisely because the service is owned by the service provider. This has also led to the common assumption intrinsically linking good service to human effort. A five star hotel will have fewer guests per staff than a one star hotel. Similarly, the professions have traditionally offered highly complex and expensive support as it relied entirely on the engagement with highly skilled professionals, for example, solicitors, doctors, and architects.

The increasing adoption of digital products in society allows for meaningful and high-quality service relationships that only in part rely on direct human effort on the part of the service provider. Codifying service relationships and separating parts into computer-supported processes can result in new and innovative ways for customers and businesses to interact. The traditional manner, in which a bank customer in the 1970s would interact with their money, would be for account holders to queue inside the bank and then request for the bank assistant at the counter to either deposit or withdraw funds on behalf of the account holder. The widespread introduction of the Automatic Teller Machine (ATM) since the 1980s heralds an age of customers having direct 24/7 access to withdraw cash by doing part of the work themselves. Such automated customer self-service is currently spreading in the UK to most retail stores.

Automated self-service can dramatically reduce labour cost while maintaining or even improving service-quality. It spans from simple routine elements, such as bank customers withdrawing their own cash, over more complex service relationships where they maintain data, music, movies and apps on their smartphones, to increasingly complex support for work previously residing exclusively with professionals [Susskind, 2015].

There is broad agreement that one of the core developments of the 21st century service society will be the general provision of high-quality personalised service relationships at very low cost to the consumer [Zuboff, 2002 ;Brynjolfsson, 2014 ;Susskind, 2015]. It has indeed been argued that the way in which we understand business activities is far too reliant on a goods manufacturing perspective, and that it instead should shift to a service perspective to reflect how value is created and exchanged [Vargo, 2004]. Even when a good is exchanged, it is argued, then the associated service from its use is the desired outcome for the customer [Vargo, 2004].

Digital Service Work

When considering this future scenario, it seems clear that much of the human economic activity is very different from that of the 20th century. The 20th century saw a wholesale replacement of labour in the primary sector's farming, fishery and forestry replaced by a rapidly growing secondary manufacturing sector. During the later part of the 20th century, most work in developed countries is in the tertiary sector, and the 21st century will further strengthen this development. Service work is concerned with interaction in order for the service provider and customer to engage in mutual adjustment of the service to be provided. As argued above, this has traditionally taken place through service having a human interface. However, assuming a wholesale shift to digital service provision, the customer will adjust the service journey according to preferences through automated self-service against digital technologies of various kinds.

Digital service work is, therefore, at its heart concerned with the design of service experiences and -relationships. Some of these will have goods at the centre, others may not. What is essential to note in comparison with past arrangements, however, is the increased need for design of service relationships at arm's length. This differs from the design of business processes where the end-points of the service delivery are constituted by human to human interaction. Digital innovations will in these self-serviced arrangements support the processes of listening to the changing preferences of the consumer as the service-journey changes, and also much more actively engage the consumer in the direct production of the service [Sørensen, 2010].

Already now a whole range of service relationships are based on the use of digital innovations supporting service providers in listening to and engaging their customers [Sørensen, 2010]. Digital services, such as Google search or the Facebook social network, has automated the process of listening to the changing user preferences for search, status updates, likes and much more. They engage the users so heavily that these, in effect, become an integral part of the product rather than customers in the traditional sense.

The changes resulting from organisations retaining a significant part of the ownership for what is produced implies a dramatic increase in the need for organisations to design the customer experience in a much more comprehensive manner than when this experience is entirely in the hands of the product owner. It will require imagination to create spaces of possibilities, and through data mining patterns of behaviour achieve better understanding of how to improve the customer journey. The 21st century service society will require a rethink of the skills necessary.

Innovation through Recombination

Many of the practices as well as the underlying logic of educational institutions draws heavily on rationales stemming back from the manufacturing needs of the 20th century. While desire for comprehensive education of the masses and not industrialisation, primarily was the driver of the organisation of teaching during the 1800 [Watters, 2015], it is essential to note the connections between the two. The traditional arrangement of teaching can be stylised as an age-based conveyor belt emphasising one-size fits all treatment of pupils with little or no support for non-linear learning and for learning outside the class room [Khan, 2012; Khan, 2015]. In much the same way as it can be argued that management research is overly reliant on perspectives anchored within the challenges of manufacturing goods [Vargo, 2004], it can also be argued that the educational system is too reliant on a similar logic in its arrangement.

The future arrangements will put a premium on the ability to engage in creative digital recombination. As complex processes increasingly black-box knowledge to be made the subject of economic exchange, there will be a premium on the ability to rapidly produce unexpected, yet enticing recombination [Scarbrough, 1995; Brynjolfsson, 2014]. The global distributed production of smartphone apps offers a good example of such arrangement. Whereas systems development processes decades ago would be measured in years, a typical smartphone development projects are estimated to take around 18 weeks for a minimal viable native app [Rice, 2013]. The distributed process of many independent developers mixing and matching amongst a large number of available elements that form a smartphone app, is a rapid, yet highly complex, process requiring very few people with skills in digital recombination. The competition is global and the access to a global audience of customers is almost direct.

The story of 3D Robotics offers a good example of such digital recombination that turned out to be highly successful. Back in 2007, while waiting for his US work permit, Mexican immigrant Jordi Munoz, then 19, did what he characterises as a "Google PhD" and set up a company based on his hobby building remote controlled drones with Wired Magazine's editor-in-chief Chris Anderson, whom he had met on the drone discussion forum Anderson had set up [Morris, 2015]. The company thus formed, 3D Robotics, now employs more than 300 people. Not only was this company built based on intense self-guided internet-study, and connections made on Internet forums, the drones are themselves highly complex digital innovations marrying physical components and several micro-computers.

Measured Measuring

One of the great successes of the 20th century has been the deployment of digital technologies tracking a myriad of components and orchestrating their movements across the globe in order to land somewhere in a container to be purchased and used. Supply-chains criss-cross the Globe with the help of the physical "digitisation" of transportation units into containers. The World's busiest container port in Shanghai handled in 2014 the equivalent of over 35 million containers [Statista, 2015].

This global ballet of goods can be organised knowing full and well that the subjects, or indeed objects, being recorded, tracked and negotiated in the databases do not object. A doll shipped from Shanghai to Manchester does not care how it is represented in the various databases. However, as users of all sorts of digital services form an essential part of the product, the characteristics and actions of people is now increasingly recorded, tracked, and algorithmically negotiated in the databases. As opposed to the Shanghai doll, people tend to care about how they are seen and represented by other. This is indeed one of the foundational aspects of humans – we care very deeply about what other people think about us [Goffman, 1959].

The design of services must be heavily informed by such concerns. The increased measurement of all aspects of the increasing human-machine intimacy raises serious issues of appropriate designs in general and the individual's right to privacy in particular. The challenge is a constantly shifting one where what was considered obvious recently, may no longer be so. Dramatically decreasing cost of a wide array of sensor technologies turning aspects of the analogue world into zero and ones imply a that boundaries for what is possible – and also what is deemed desirable – is bound to continuously shift.

The dramatically increasing amount and diversity of data collected about all aspects of life makes it obvious to take a closer look at the old saying: "What can't be measured can't be managed". Peter Drucker is often attributed to a version of this stating; "what gets measured gets managed", but statement indeed continues; "...even when it's pointless to measure and manage it, and even if it harms the purpose of the organization to do so." [Carr, 2014]. It is essential to note that measurements shape behaviour and that the consequences are not always apparent or indeed desirable, as also Drucker's quote indicates. It is, therefore, essential that the school of the future will help develop the ability for students to analyse and assess complex interrelationships between the digital world of big data and the physical world from where much of this data emerges, and most importantly can have significant direct effect.

This ability to understand complex data relationships is also as important as fundamental innovation, and subsequent new industries emerge when data previously recorded and stored in an analogue form, or indeed not recorded at all, becomes available in a digital form. Monetisation of such new digital data has over the past decades been the foundation of large global enterprises [Yoo, 2013]. As examples, IBM became a global leader in information management when it became technologically feasible to digitise organisational structured data; Walmart was able to shift the vendor relationships by renting out shelf space as point-of-sales transaction data became digital; TomTom became a global brand from early on monetising the digitisation of analogue maps; Google could establish a marketplace for advertisement when it became possible to index globally distributed unstructured data; and Facebook is monetising the digitisation of quite literally the actions of billions of digits pressing "like" buttons representing previously entirely analogue social interaction.

This discussion of the importance of carefully considering what is measured and the consequences of measuring naturally leads to the next topic, namely the ability to engage with complex problems in a critical manner.

Thinking Critically

Possessing fine-tuned critical thinking is an essential ability in order to navigate such a world of constant changes to what can be collected from individuals, systems, and organisations, for subsequent investigation through automated digital technologies. Critical thinking simply implies the ability to shift perspective and to analyse and conceptualise a problematic situation from different vantage points in order to guide belief and action [Critical Thinking Community, 2013].

While the traditional educational system of course seeks to develop the ability to think critically, it can be argued that it does so within a context focused on testing and measurements. For example, test score results on reading, writing and mathematics form the foundation for measuring, communicating, and comparing the quality of UK primary and secondary schools [Department for Education, 2015].

Critical thinking forms the foundation for the ability to ask the right questions – "learning to learn" – and has been found to best develop outside the classroom [Bartles, 2013]. This may not be an inherent feature of learning how to critically assess problems, but perhaps more a feature of what actually goes on in classrooms. One of the key aspects associated with the developing how to think critically is the ability to experiment and in doing so failing [Bartles, 2013]. To the extent that the class room is perceived as a place of testing and of competence rather than one of experimentation, it will not be conducive for developing critical thinking.

One of the reasons it is in particular important for the school of the future to support the development of critical thinking is the future emphasis on the socio-technical engineering of service relationships. Using the shoe versus service example above, designing and manufacturing a pair of shoes is a considerable design and engineering challenge. However, it will not need to consider in great detail what happens as and when the customer is wearing the shoes. As such the challenge can be seen as one bounded by the design and manufacture setting. Obviously, the designers and engineers will imagine and discuss the subsequent use and possibly also disposal of the shoe and may have the design and manufacturing process be influenced by such concerns. However, they will not have to worry in detail about designing a lengthy footwear experience. This is different for services, which likely involves an on-going service relationship.

For the school of the future it will be essential to teach not only the subjects foundational for the design and manufacture of goods, but just as important, subjects foundational for understanding the formalisation of what previously was not formalised. This will involve complex problem solving, empathy, the ability to creatively question common held assumptions, and to a much higher degree reside in a socio-technical domain of insights rather than merely a technical one.

Mindful Technology Design and Use

As the pace of innovation further increases, and as digital technologies merge even more intimately with human activities and interaction, it becomes increasingly essential to mindfully balance the role of technology both in the design and the use of digital innovations.

This should also form a core tenet for the school of the future. The technology is not an end in itself but a means to an end. There will be a premium on design sensitivity understanding how to orchestrate excellent user-experiences through digital innovation. The closer and more intimate connections we seek to design with technology, the more this sensitivity will be essential. The engineering approach of doing something just because it was possible will not suffice. In these highly intimate human-technology arrangements the technology can instantaneously turn from being incredibly useful to being in the way. The process of understanding how to meet such design challenges and how to support learning the essential design skills is a journey we have just begun.

More technology is not always better than less. We still admire a human athlete running fast, even if a car could outpace the human [Bostrom, 2014], and even if it will be possible to automate some professional services, we may still prefer a less effective human-centred process [Susskind, 2015]. Even if we could eat astronaut meal-in-a-pill, we may indeed still prefer a slow-cooked home-made meal. Apple's success can to a large extent be attributed to the care and attention the company spends on designing not only the physical product, but the user experience of using it. The features taken away are almost more important than those left in.

In terms of technology use, then the increasing digital "land-grab" requires careful consideration and adjustment of practices. More and more aspects of life relate to digital data streams being recorded, processed, resulting in changes to the services presented. The process from intent to technology-mediated action is getting increasingly shorter. The instance a question emerges in our heads, we can instantaneously look up the answer in a manner that people a few years from now undoubtedly will find woefully slow. In the past, the challenge was for youngsters to get access to computers when most did not have it. Privileged computer access has been attributed to the successes of both Bill Gates and Steve Jobs [Gladwell, 2008; Schlender, 2015]. With digital services permeating all aspects of life, perhaps one of the key-challenges for the school of the future will be to provide the pupils invaluable digital design lessons exactly through mindful exposure to digital technologies. It is, for example, interesting to note that several of the Silicon Valley entrepreneurs have refused their own children pervasive access to smartphones and tablets [Richtel, 2011; Bilton, 2011].

Intimate digital technologies challenge the way we teach and learn how to interact with others. Decisions about attention and awareness that previously were left entirely to inter-personal situations now happen with mobile technologies playing a part both as a disturbance but also as an integral part of the situation [Weilenmann, 2003; Ling, 2008; Ling, 2012]. A very good illustration of the shift in social behaviour with smartphones can be seen on YouTube in "Video of Girl Alone" in which a girl has forgotten her smartphone and subsequently feels left outside as everyone around her interacts with theirs [deGuzman, 2013].

The physical closeness of the technology to the body of the user seems to create fertile ground for increased levels of constant use and addiction. Years ago the use of Blackberry email-phones led to the concept of the Crackberry emphasising how users became addicted [Mazmanian, 2013]. With smartphones, this seems to have been strengthened further and digital services such as Facebook and Twitter essentially has seen most growth from smartphone usage. However, the next generation of so-called Internet of Things and Wearable Computing will embed digital technologies even closer to the user's body and in various ways provide opportunities for easier interaction. The controversy surrounding Google Glass offers interesting insights into the innovation dynamics when technology seeks to find a place right in-between people interacting socially, and it seems most users are not yet ready for this step [Klein, 2005].

For the school of the future, facilitating both the design sensitivities to these issues will be essential, as will the support for students to mindfully reflect upon their own life with technology. Individual choices in technology consumption will be more and more pressing as the barrier to use will almost certainly be entirely self-adjusted. Technologies that become pervasive will also need to enter a process of mindful use as every technology that sets the user free will also potentially enslave and as tools increasing competence might indeed also increase incompetence [Mick, 1998]. A pocket calculator enables quick multiplication of large numbers, but possibly also deskills the user to a degree where they may find the multiplication algorithm difficult. Using a GPS navigator greatly enhances the driver's ability to find their way, but over time may make it problematic to find anywhere without the GPS. The smartphone allows for instant access to the entire global repository of information, yet can also create addictive need for a constant stream of new information as opposed to quiet reflection.

Reflections on the designed arrangement of how to do things without technology are important. When, for example, critical parts of professional work are computerised, it will still be important for apprentices to learn the skills of doing this work though practice [Susskind, 2015]. For a school child, even if a computer will be able to automatically make an amazing drawing, or even just heavily assist the child in drawing, this does not imply that the child should not draw. Indeed, even for heavily computerised creative processes, such as Pixar's movie making, the physical process of manipulating material, making models, and drawing sketches are all integral to this process. The use of digital technologies does not necessarily improve learning, but requires careful considerations [OECD, 2015].

Summary

This chapter outlined, based on the assumptions of a digital service society, a number of challenges directly related to the design of the school of the future. These challenges relate to the dramatically changing technologies based on digitalisation, support for highly distributed activities, and using the power of computational power at scale. They will also relate to the increased complexity of a designed world of automated self-serviced relationships where more and more non-digital aspects will be sought digitised. This design complexity will further increase the need for critical thinking as a means of challenging the existing to imagine the new. The pervasiveness of digital technologies will raise serious concerns about mindful use.

References

Bartles, D. M. (2013): Critical Thinking is Best Taught Outside the Classroom. Scientific American. http://www.scientificamerican.com/article/critical-thinking-best-taught-outside-classroom/

Bilton, N. (2011): Steve Jobs Was a Low-Tech Parent, http://www.nytimes.com/2014/09/11/fashion/steve-jobs-apple-was-a-low-tech-parent.html.

Bostrom, N. (2014): Superintelligence: Paths, Dangers. Oxford: OUP.

Brynjolfsson, E. & A. McAfee (2014): The Second Machine Age: Work, Progress, and Prosperity in a Time of Brilliant Technologies. WW Norton & Company.

Carr, N. G. (2014): Taking measurement's measure. In Rough Type, http://www.roughtype.com/?p=4970

Critical Thinking Community (2013): Defining Critical Thinking, http://www.criticalthinking.org/pages/defining-critical-thinking/766.

deGuzman, C. & M. Crawford (2013): I Forgot My Phone, https://www.youtube.com/watch?v=OINa46HeWg8.

Department for Education (2015): School and college performance charts, http://www.education.gov.uk/schools/performance/.

Eaton, B. D., S. Elaluf-Calderwood, C. Sørensen, & Y. Yoo (2015): Distributed Tuning of Boundary Resources: The Case of Apple's iOS Service System. MIS Quarterly: Special Issue on Service Innovation in a Digital Age, vol. 39, no. 1, pp. 217-243.

Facebook (2015): Stats, http://newsroom.fb.com/company-info/.

Fichman, R. G., B. L. Dos Santos, & Z. Zheng (2014): Digital innovation as a fundamental and powerful concept in the information systems curriculum. MIS Quarterly, vol. 38, no. 2, pp. 329-353.

Gladwell, M. (2008): Outliers: The Story of Success. London: Allen Lane.

Goffman, E. (1959): The Presentation of Self in Everyday Life. New York, NY: Bantam. Khan, S. (2012): The One World Schoolhouse: Education Reimagined. Hodder & Stoughton. 0009-4056.

Khan, S. & M. Noer (2015): The History of Education, https://www.youtube.com/watch?v=LqTwDDTjb6g.

Klein, M., A. Freitas, S. Elaluf-Calderwood, & C. D. Pedron (2005): Who is afraid of Google glass?: Mapping the Google glass controversy. In 75th Annual Meeting of the Academy of Management, 7-11 August 2015, Philadelphia, USA: http://eprints.lse.ac.uk/63876/1/Binder1.pdf

Kurzweil, R. (2004): The law of accelerating returns. Springer. 3642057446.

Ling, R. (2008): New Tech, New Ties: How Mobile Communication is Reshaping Social Cohesion. The MIT Press.

Ling, R. (2012): Taken for Grantedness: The Embedding of Mobile Communication into Society. The MIT Press.

Malone, T. W. (2004): The Future of Work: How the New Order of Business Will Shape Your Organization, Your Management Style, and Your Life. Harvard Business School Press.

Manning, P. (2013): Electronic and computer music. Oxford University Press. 0199912599.

Mazmanian, M. A., W. J. Orlikowski, & J. Yates (2013): The Autonomy Paradox: The Implications of Mobile Email Devices for Knowledge Professionals. Organization science, vol. 24, no. 5, pp. 1337-1357.

Mick, D. G. & S. Fournier (1998): Paradoxes of Technology: Consumer Cognizance, Emotions, and Coping Strategies. Journal of Consumer Research, vol. 25, pp. 123-143.

Morris, R. (2015): The Mexican immigrant who set up a global drone firm, http://www.bbc.co.uk/news/business-31356080.

Navarro, A. (2015): Google's D-Wave 2X Quantum Computer 100 Million Times Faster Than Regular Computer Chip, http://www.techtimes.com/articles/114614/20151209/googles-d-wave-2x-quantum-computer-100-million-times-faster-than-regular-computer-chip.htm.

OECD (2015): Students, Computers and Learning. Making the Connection. OECD Publishing.

Palfrey, J. & U. Gasser (2008): Born Digital: Understanding the First Generation of Digital Natives. New York: Basic Books.

Prensky, M. (2001): Digital natives, digital immigrants. On the Horizon, vol. 9, no. 5, pp. 1-6.

Rice, K. (2013): How Long Does it Take to Build a Mobile App?, http://www.kinvey.com/blog/2086/how-long-does-it-take-to-build-a-mobile-app.

Richtel, M. (2011): A Silicon Valley School That Doesn't Compute, http://www.nytimes.com/2011/10/23/technology/at-waldorf-school-in-silicon-valley-technology-can-wait.html?_r=0.

Scarbrough, H. (1995): Blackboxes, Hostages and Prisoners. Organization Studies, vol. 16, no. 6, pp. 991-1019.

Schlender, B. & R. Tetzeli (2015): Becoming Steve Jobs. Marabout.

Schmidt, E. & J. Cohen (2013): The New Digital Age: Reshaping the Future of People, Nations and Business.

Shapiro, C. & H. R. Varian (1998): Information Rules: A Strategic Guide to the Network Economy. Boston: Harvard Business School Press.

Shirky, C. (2010): Cognitive Surplus: Creativity and Generosity in a Connected Age. London: Allen Lane.

Sørensen, C. (2011): Enterprise Mobility: Tiny Technology with Global Impact on Work. Palgrave. http://enterprisemobilitybook.com

Sørensen, C., D. Elton, & R. Gear (2010a): Innovation with Information Technology: Listen, Engage, Be! LSE - PA Consulting Group Report. http://mobility.lse.ac.uk/whitepapers.html

Sørensen, C., R. Gear, & D. Elton (2010b): Listen! Engage! Be! Open for Innovation with Information Technology. LSE - PA Consulting Group Report. http://mobility.lse.ac.uk/whitepapers.html

Statista (2015): Statistics and Facts about Container Shipping, http://www.statista.com/topics/1367/container-shipping/.

Susskind, R. E. & D. Susskind (2015): The Future of the Professions: How Technology Will Transform the Work of Human Experts. Oxford: Oxford University Press. 019966806X.

Tapscott, D. (2009): Grown Up Digital: How the Net Generation is Changing Your World. New York: McGraw-Hill.

Tilson, D., K. Lyytinen, & C. Sørensen (2010): Digital Infrastructures: The Missing IS Research Agenda. Information Systems Research, vol. 21, no. 5, pp. 748–759.

Vargo, S. L. & R. F. Lusch (2004): Evolving to a New Dominant Logic for Marketing. Journal of Marketing, vol. 68, no. 1, pp. 1-17.

Vodanovich, S., D. Sundaram, & M. Myers (2010): Digital Natives and Ubiquitous Information Systems. Information Systems Research, vol. 21, no. 4, pp. 711-723.

Watters, A. (2015): The Invented History of 'The Factory Model of Education', http://hackeducation.com/2015/04/25/factory-model/.

Weilenmann, A. (2003): Doing Mobility. PhD Dissertation, Gothenburg University.

Wikipedia (2015a): Google self-driving car, https://en.wikipedia.org/wiki/Google_self-driving_car - Road_testing.

Wikipedia (2015b): Wheat and chessboard problem, https://en.wikipedia.org/wiki/Wheat_and_chessboard_problem.

Yoo, Y. (2010): Computing in Everyday Life: A Call for Research on Experiential Computing MIS Quarterly, vol. 34, no. 2, pp. 213-231.

Yoo, Y. (2013): Global Industries based on DIgitised Data. Personal communication and power point slide. 2013.

Yoo, Y., R. J. Boland, K. Lyytinen, & A. Majchrzak (2012): Organizing for Innovation in the Digitized World. Organization science, vol. 23, no. 5, pp. 1398-1408.

Zuboff, S. & J. Maxmin (2002): The Support Economy: Why Corporations are Failing Individuals and the Next Episode of Capitalism. London: Penguin.

Conclusion

For many centuries mass schooling as it was originally designed, served the rich, but the changing political, economic and social conditions have opened up education to the public. The purpose of schooling also evolved reflecting the needs and priorities of the societies they served. 20th century's industrial revolution needed a workforce suitable for factory mode of working, with the education systems including schools and universities adapting to equip learners with skills to participate in the economy -routine non cognitive and manual skills. 21st century with its 'knowledge economy' requires learners to be equipped with non-routine analytical and interactive skills. Members of the modern workforce will need to be versatile, capable of abstraction and other higher order thinking. The demands of the 21st century will force us to re-imagine and rearrange what is taught in schools and how.

While the 21st century schools will still carry the legacy of early school systems, the changing nature of certain factors will turn the wheels of change in the way future schools, teach and operate. The need for organizing the learning environment, equitable distribution of resources across socio-economically disadvantaged schools and better accountability through assessments are some of the essential drivers for future schools. Advances in scientific knowledge will help enable better understanding of learners' needs and provide ways to improve learning. With increased pressure on building teacher capacity to meet the needs of increasing population, government and schools will increasingly look towards the use of technology in the School of the Future. This requires the instructors to be constantly updated, equipped with skills and confident with technology to efficiently utilize the insights from advances and adapt it to learner's context.

To effectively participate in the 21st century's 'knowledge economy', nations need to increase and improve educational attainment of their citizens. Improvements in schooling and increases in the percentage of the population who attend school will lead to a more knowledgeable population who will have increased expectations of what schools ought to provide. This leads to a demand for more personalised learning experience. Learners will need specific subject knowledge as well as application and synthesis of said knowledge in flexible ways as well key competencies such as communication skills, critical thinking, and resilience. Schools will need to look beyond their current teaching force for the resources they need, to provide high quality education. The School of the Future will need to utilize resources available within their local communities and develop partnerships with individuals and organisations that can provide the expertise required. Further, constraints like physical space and increasing diversity due to globalization would present challenges and opportunities to which the School of the future needs to respond by changing the paradigm of learning.

In order to ensure the School of the Future is prepared to meet the needs of the learners in the 21st century, it needs to focus on three foundational pillars which need to work in tandem with one another, while being guided by the learning themes-reflecting the important issues facing the global future economy.

The practice in the School of the Future consists of curriculum which addresses the needs of the 21st century society. The curriculum consists of skills, competencies and character qualities to make learners ready for the challenges and needs of the 21st century. In order to help learners learn, the core pedagogical techniques could include, keeping the learner and his needs pivotal for the school's strategy, and providing an environment which facilitates collaboration and makes learning a social journey rather than an isolated experience. Further, the learning need to be personalised based on learners' own passion, needs and abilities while ensuring appropriate means to identify progress and provide feedback for achieving their full potential. In addition to the core skills of literacy-language, science and numeracy, the School of the future must impart soft skills like entrepreneurship, financial and ICT literacies. These soft skills are neither new nor specific to the 21st century. However, in the 'knowledge economy,' they have become basic expectations for knowledge workers. The School of the future places emphasis on character development and social emotional learning for its learners as they play a very crucial role in development of attitudes, behaviours and eventually scholastic achievement. Teachers in the 21st century have an expanded role in the classroom. Apart from being knowledgeable, the teacher needs to be creative and innovative, constant learner, a role model, an attentive counsellor and a trained professional. The teachers also need effective systematic support for scaling up innovative and effective practices. By implementing a networked improvement program that build local knowledge in tandem with research knowledge, School of the Future can have quality teachers teaching at scale.

The School of the Future leverages the partnerships with a wide variety of stakeholders in order to create an ideal learning environment (learning ecosystem) for the learner. The learning ecosystem utilizes the expansive, diverse and rich learning opportunities available to the learners from their respective contexts in communities, relationships and experiences. This ecosystem provides support to learners to personalize their learning, to impart skills to not only tackle the current problems but also ones that are unseen in the future. It also uncouples the learning from the school, by allowing them to learn anywhere and anytime. With the help of the learning ecosystem of peers, community and mentors, it provides a chance for learner to be involved in solving real world problems while providing authentic and continuous feedback for improving their skills and competencies. Further, their voice in matters of school's operations and vision, makes them empowered decision makers and brings in true accountability by making the schools' respond to needs of the learners. This helps them develop a sense of ownership over their learning and as they become independent learners; the absolute owners of their own learning. The 21st century educator will have a distinct role in the School of the Future. Their proximity to the learner help provide context to the school's vision. In addition they will be responsible for ensuring equitable access as learning becomes networked. As a departure from traditional generalist roles, they would be specialists and their roles reimagined to support the learner centered ecosystem. They would also play a proactive role in their own learning and professional development as means to support the learning ecosystem better.

Parents will play a crucial role in the learning ecosystem by providing environments at home which facilitate learning and development of social and emotional competencies. Their interests dictate the educational practice and resource allocation to the school and as part of the school and learning ecosystem, bring in accountability from the part of the school and the mentors. The School of the Future provides the parents with opportunities to become lifelong learners, by providing access to continuing education, reskilling and learning experience to help support their children at home. In return, the parents can play an important part in the learning ecosystem by contributing rich and diverse artisanal skills and cultures which can be preserved and propagated to future generations. Businesses and other organisations can play an important part in the eco system by providing opportunities for the learners to solve real world problems while at the same time provide inputs during the curriculum review process. They also can work closely with the School of the Future to develop meaningful and relevant solutions which can help improve the learning ecosystem.

Policymakers are likely to play a crucial role in ensuring that the School of the Future is able to achieve its vision. Decentralizing control of schools, and flow of resources based on needs and building capacity for creating a sustainable learning ecosystem are some areas where the governments can play an important role. Their main role in the future would be to ensure that learning ecosystems are supported, accountability is present at all levels, and learning is accessible and equitable to all the population.

The School of the Future should be designed considering the physical limitations and the learning needs of the 21st century curriculum. The design should be modular to allow flexibility. The design should take into consideration features like sustainability and safety. By using renewable sources of energy, materials and design, it should encourage sustainability as way of life. Also the school should allow collaboration and integration of technology to meet the learning needs. Beyond physical design, the School of the Future must adopt an Ethos, which defines the morals, beliefs and values of the school and its learning community. The ethos in School of the Future could be described by three words - considerate, convivial and capacious. Being considerate ensures that the reciprocity in feeling of importance between students and the school. It also ensures the school community is reflective of their actions. Conviviality ensures that the learning journey is fun, enjoyable and the learners and their educators develop strong social bonds and

Conclusion *continued*

networks with one another. Capaciousness ensures room for flexibility and diversity in what kinds of teacher or student one can be or what kinds of teaching is valued, rather than a narrow enforced consensus.

Technology will continue to play an important part in the School of the Future. In close step with the needs of the 21st century education, education technology can help in creating a personalised education through tailoring education according to the learner's needs. Enriching technologies ensure that the physical environment and the learning experience are convivial and supportive to the learner.

Collaboration and team work are some of the most crucial skills required in the 21st century. The globalised future economy requires individuals to communicate over great distances to collaborate and solve problems together. Social technologies enable leaners in the School of the Future to interact with the communities and build networks both within and outside of school. Finally, supporting technologies in the School of the Future will help provide better information discovery and collation by designing platforms for creating portfolios which can be freely and securely shared across the networks.

In order to enable new models of education technology, themes like Intelligent Adaptive Learning analytics, Consumerized technology, Internet of things and wearable computing will play a crucial role. These technologies will enable the learner acquire 21st century skills through practice based and project based learning. Intelligent Adaptive and Learning analytics themed technologies will provide the learners' with adaptive systems to support their personalised journeys. Consumerized technology and Internet of things and wearable technologies will provide new tools for collaboration and participation. These two themes in technology will help learners by blending physical and digital environments for exploration and provide them with opportunities to interact with information in novel ways. Further, such technologies are likely to help the learners combine personal devices with appropriately designed environments and highly flexible web tools to create and share their work. Also these technologies can allow learners to learn through enquiry and learning in and across settings.

In considering technologies for the school of the future we must avoid technological utopianism whereby it is perceived that learning technologies offer all the solutions to education's failings. Finally, it is worth reflecting that a technology's meaning is constructed not by the designer but by the user. Whether a technology is successfully adopted by students depends on complex interrelationships between the technology and the expectations of classmates.

As more information and services get digitized, it is crucial to improve the design of these digital services so that they provide the most optimal interaction experience to its users. The design needs to reflect the changing needs and preferences of its users. As more and more services in the future become digital, the importance of teaching design for the future become paramount. This requires the learners to learn innovation through recombination, understand the complex data relationships for improvement through measurement of user interactions and the concerns which arise from them. Complex problem solving, creativity and thinking critically will be extremely crucial for a thriving digital service economy. Beyond these skills, they also need to understand the balance of use of technology and the complications which might arise from overuse and/or abuse.

Through discussion of various aspects, this report has aimed to provide a broad framework on the School of the Future. We hope that further discussions and debates about the framework would help in planning and executing the strategy for ensuring the future educational vision of a nation is met.