Education and the Fourth Industrial Revolution

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"The crisis consists precisely in the fact that the old is dying and the new cannot be born; in this interregnum a great variety of morbid symptoms appear." Antonio Gramsci, circa 1930[1]

Gramsci was one of the most important social and political theorists of the 20th century best known for his theory of cultural hegemony, describing how the state and ruling capitalist class use cultural institutions to maintain power in capitalist societies. He attempted to break from the economic determinism; a theory that economic forces define all political, social, cultural, intellectual, and technological aspects of society, of traditional Marxist thought.

Nearly 100 years later his words, describing how the old status quo is dying and how the new is yet to be born, seem to have renewed relevance as social, political and technological transformation is upon us once again.

The Future of Work

A report from the World Economic Forum (2016[2]) about the future of work informs us, "*by one popular estimate, 65% of children entering primary school today will ultimately end up working in completely new job types that don't yet exist.*"

WEF founder and chairman, Klaus Schwab[3] predicts an optimistic future where technological innovation – and our ability to harness it – becomes a powerhouse for social and economic growth. Schwab describes how our society is entering a "Fourth Industrial Revolution" (4IR). Characterised by a range of new technologies that are fusing the physical, digital and biological worlds, Schwab argues that 4IR developments are affecting all disciplines, economies, industries and governments, and even challenging ideas about what it means to be human.

Ubiquitous, mobile supercomputing. Intelligent robots. Self-driving cars. Neuro-technological brain enhancements. Genetic editing. Artificial intelligence. Schwab suggests that the evidence of dramatic change is all around us and it's happening at exponential speed.

Whilst technology is widely considered the main source of economic progress, it has also generated cultural anxiety throughout history. Stark technological shifts raise concerns about pressure on employment and wages, sparking a debate about the risk of greater job insecurity, growing inequality and even mass "technological" unemployment.

Viewed through the lens of economics, history suggests that major innovations such as the steam engine, electricity and the assembly line can be disruptive. They can result in substantial job losses in the short-term, even if this is more than offset in the long-term by the creation of more productive and rewarding jobs with substantial improvements in living standards. Just as cranes replaced dockworkers but created related jobs for engineers and financiers, the theory goes, new technology has created new jobs for software developers and data analysts.

But the lessons of the past may not always apply to the future.

Throughout history, people have held an ambivalent view of technological progress. Concerns tend to fall into three categories: replacing workers with machines to improve productivity and reduce cost, the moral implications of progress, and progress slowing down and resulting in stagnation. Mokyr, Vickers and Ziebarth, in a paper cited by OECD and published in the Journal of Economic Perspectives (2015[4]), explore these concerns. By providing a historical assessment of each of these categories they conclude that although short-term disruptions to certain labour classes could occur, in the longer term, technological progress benefits humanity.

During the Industrial Revolution, the worry was about the dehumanising effects of work, today, perhaps the greater fear is a world where the elimination of work itself is the source of dehumanisation as a result of income insecurity and declining social agency.

On the other hand there's a concern that the epoch of major technological progress is behind us. The U.S. macroeconomist Robert Gordon in his book, "The Rise and Fall of American Growth: The US Standard of Living since the Civil War" (Princeton University Press 2016[5]), contends that the productivity growth of western economies will be held back by the headwinds of rising inequality, stagnating education, an ageing population, and the rising debt of college students and government.

OCED's policy brief on the future of work points out that artificial intelligence (AI), automation and digitalisation challenge high-routine jobs. Automation has led to the substitution of machines for a substantial part of routine jobs, irrespective of the skill level (OECD, 2013[6]). Rapid progress in AI raises the prospect that a much broader range of tasks than previously thought could be carried out by machines.

In January 2017, a McKinsey & Company study[7] found that about 30% of tasks in 60% of occupations could be computerised and in 2016, the Bank of England's chief economist said that 80m US and 15m UK jobs might be taken over by robots[8].

In 2013, a highly cited study by Oxford University academics called The Future of Employment[9] examined 702 common occupations and found that some jobs – telemarketers, tax preparers and sports referees – are at more risk than others including recreational psychologists, dentists and physicians.

However, against this landscape of automation and artificial intelligence U.S. economists, Daron Acemoglu of M.I.T. and Pascual Restrepo of Boston University, published a paper[10] showing that increased automation would likely create new, better jobs, so employment and wages would eventually return to their previous levels.

Less than a year later, Acemoglu and Restrepo, followed this upbeat appraisal with a sober reflection published by the National Bureau of Economic Research[11] that the New York times reported as "Evidence That Robots Are Winning the Race for American Jobs". It turned out that their earlier paper was a conceptual exercise whereas the NBER report used real-world data and suggested a more pessimistic future. The researchers said they were surprised to see very little employment increase in other occupations to offset the job losses in manufacturing. That increase could still happen, they said, but for now there are large numbers of people out of work, with no clear path forward, especially blue-collar men without college degrees.

Acemoglu said to the NY Times, "*The conclusion is that even if overall employment and wages recover, there will be losers in the process, and it's going to take a very long time for these communities to recover*."

Erik Brynjolfsson, a professor at the MIT Sloan School of Management and Andrew McAfee, in their book "The Second Machine Age: Work, Progress, and Prosperity in a Time of Brilliant Technologies" concede that at the heart of capitalism is the concept of creative destruction. And this phenomenon is turbocharged by technological progress. Innovations from the cotton gin to electricity to the computer have created dramatic changes in the way that we work and the jobs that are available.

Such advances in robotics and other digital technologies are stirring up anxiety among workers and in the media. There is a great deal of fear, for example, that robots will not only destroy existing jobs, but also be better at most or all of the tasks required in the future. But at best this is only a half-truth. While it is true that robots are getting very good at a whole gamut of jobs and tasks, there are still many categories in which humans perform better.

While it is easy to point to jobs that are threatened by technological change, what economists, futurists and others have been very bad at is pointing to the jobs that will emerge, whether people will be appropriately equipped to do those jobs and whether they will produce adequate incomes.

Brynjolfson and McAfee point out that the word "Computer," after all, used to be an actual job title of a person who sat and added long rows of numbers. Now it is an actual computer. On the other hand, jobs such as data scientist didn't used to exist, but because computers have made enormous data sets analysable, we now have new jobs for people to interpret these huge pools of information. In the tumult of our economy, even as old tasks get automated away, along with demand for their corresponding skills, the economy continues to create new jobs and industries.

Essentially tasks that can be measured or are based on rigid rules can and will be automated and as a result the secure jobs of the future will be the ones that machines can't do. There are three areas where humans have a distinct advantage over machines. These are areas that are key to job creation; creative endeavours, social interactions, and jobs that require physical dexterity and mobility.

From an economic perspective: what should workers and governments do?

Workers, for their part and supported by government, have to be strategic and aim for the jobs least likely to be overtaken by robots or other machines. They have to commit to a lifetime of practicing and updating their skills by, for example, taking extra courses online and in classrooms. Lifelong learning, agility and continued training and retraining are key.

Governments, for their part, need to create a climate where entrepreneurs can flourish, because new ventures create new jobs. The answer to the new and growing workforce of robots is not to slow the pace of technological progress, but to speed up our institutions so that entrepreneurs, managers and workers alike can thrive.

In face of this technological progress U.S. tech to sports billionaire Mark Cuban shared a bold prediction about the future of jobs: that within the next decade, as automation becomes the norm, free thinkers who excel in liberal arts will be in high-demand[12].

Cuban believes that the amount of change we'll see for jobs in the next five or 10 years will dwarf what we've observed in the past 30 years, and that as artificial intelligence and machine learning takes centre stage, there will be a greater need for expertise in subjects such as English, philosophy and foreign languages. According to his forecast, some of today's most in-demand skills, such as writing software, will eventually be taken over by automation and skills like communication and critical thinking will become more important.

Inequality and Agency in the Fourth Industrial Revolution

The British economist John Maynard Keynes (1930) offers a word of advice: "*Meanwhile there will be no harm in making mild preparations for our destiny, in encouraging, and experimenting in, the arts of life as well as the activities of purpose.*"

Keynes may well have been prescient in his thinking here. Irrespective of whether we experience mass technological unemployment something we do know is that technology is enabling a greater concentration of wealth to an ever smaller number of individuals and global corporations. A report published by Oxfam (January 2017[13]) showed that 8 men owned the same combined wealth of the 3.6 billion people who make up the poorest half of humanity, i.e. half the planet, 5 of these men run technology businesses.

As a result of widening divisions of inequality we are seeing the emergence of what Guy Standing, Professor at SOAS, University of London, calls the "precariat". In Standing's 2011 book he describes how the western globalisation movement promoted market-led competition above job security. Real wages across the west had stalled for decades and "flexible" work was becoming the norm, leaving many millions around the world without income security (an anchor of stability) or social agency (purpose and meaning). Standing warns that the growth of the precariat produces instabilities in society where some are susceptible to the dangers of political extremism. Standing argues for a progressive strategy of wealth redistribution and income security.

One such strategy, with an intellectual pedigree going back more than 500 years countenanced by Thomas More in Utopia (1516) as an antidote to crime, is Universal Basic Income.

The idea is simple: a regular state payment to every adult regardless of working status. Advocates say it would provide a vital safety net for all citizens and remove inefficient benefit systems currently in place; critics say it is unaffordable and would serve as a disincentive to work.

Automation along with the other affordances of the fourth industrial revolution have the potential to disrupt the status quo of the live to work society opening up new possibilities for what people can do with their time. If machines performed the bulk of humanity's work citizens could spend more time on volunteering, entrepreneurship, family, civic engagement, and creative endeavours.

Just after the financial crisis in 2008 across southern Europe rates of unemployment amongst young adults was in the region of 50%-60%, essentially half of an entire generation without purpose or social agency and participation in society. This is a tragedy and yet is there really no work? Are there no children in overcrowded classrooms, no sick people, no buildings to renovate, no communities to create infrastructure for?

These are entirely rhetorical questions because there is no lack of these in society or opportunities for people to be involved in society. There is simply a deficient economic structure. We're encouraged to think that the future is about technology, artificial intelligence, automation and so forth yet the opportunity for the many to participate meaningfully in society is potentially a thing of the past.

The real efficacy of UBI is that even if we're not headed into a future without work, we're destined for a future where work will be based on short-term contracts. For a lot of people, even if there is plenty of that sort of work, there are going to be periods where they've got nothing. A society based on that insecurity and lack of social agency has the potential to be a bad society.

This argument is being heard in a number of countries; U.S., Finland, India, Italy, Uganda and Canada and others, where pilot schemes testing basic income are taking in place. In most pilots indicators[14] have shown improvements in recipients basic living conditions, food sufficiency, nutrition, educational and economic activities with a decrease in illness and debt.

Under the Canadian scheme[15] some 4,000 people in Ontario are given circa C$17,000 a year, with no conditions or restrictions attached. At the launch of the pilot Ontario Premier Kathleen Wynne said the scheme was needed to address "new challenges" presented by the modern world. Wynne was quoted as saying, "*From technology to Trump, it is a time of greater uncertainty and change,*"

Beyond the challenges we face as a result of technological progress predicted by the fourth industrial revolution our global society faces formidable challenges in the form of climate change, population growth, ageing populations, antibiotic resistance and rising inequality, to name a few.

Whilst the actions of some nations would suggest that they believe they can sequester themselves from these challenges the reality is that these "big" global issues, if left unchecked, will affect every living soul.

The learning of STEM (Science, Technology, Engineering, Maths) subjects, often with the addition of the arts (STEAM), has been widely touted as an urgent requirement to future-proof current and future generations. Yet on closer inspection this demand and the "STEM crisis" or shortage of STEM graduates has been expressed in terms of national GDP rather than planet-saving endeavours. Our greatest minds are working for Google to sell advertising space, or Uber to maximise profits, or the NSA to read your email[16].

Ben Williamson, Lecturer in Education, Stirling University is concerned about the corporatisation of school computing curriculums[17]. He posits that a properly purposeful and meaningful computing education would engage with the social and political power of code to engineer, in part, how we live and think. Whilst understanding how computers work is useful, Williamson suggests, also is knowing about privacy and data protection, how news circulates, understanding cyberattacks, bots and hacking, how algorithms and automation are changing the future of work, and that there are programmers, business plans, political agendas and interest groups behind this, is worth including in a meaningful computing education too.

As identified by MediaSmarts, Canada's Centre for Digital and Media Literacy, digital literacy is that next step which gives students the adaptive abilities they need to participate fully in the global

digital society[18]. It guarantees they will benefit from the digital economy and derive new opportunities for employment, innovation, creative expression, and social inclusion[19].

Education and lifelong learning will be of vital importance to equip present and future generations to not only be a productive part of this new world but also to meet the societal challenges presented by the 4IR, and the existential challenges presented by climate change and population growth.

Alvin Toffler, an influential American writer and futurist, is quoted as saying:

"*The illiterate of the 21st century will not be those who cannot read and write, but those who cannot learn, unlearn, and relearn.*"

The quote originates his 1970 book, Future Shock, where he wrote "*By instructing students how to learn, unlearn and relearn, a powerful new dimension can be added to education. Tomorrow's illiterate will not be the man who can't read; he will be the man who has not learned how to learn.*"

This begs the question about the role our formal education systems are performing today. For example, are students learning how to learn or are they learning how to pass tests?

Given national and international preoccupation with academic league tables and measurement one could be forgiven for believing that the purpose of education is the latter. Yet this would seem at odds with the challenges that present generations will face within their lifetime during this century.

So how did we get here?

The American psychologist R.Keith Sawyer in his paper "Optimising Learning: Implications of Learning Sciences Research" published by OECD, 2008[20] made the following observations about schooling.

> The schools we have today were designed around commonsense assumptions that had never been tested scientifically:
>
> Knowledge is a collection of facts and procedures for how to solve problems.
>
> The purpose of school is to get those facts and procedures into students heads. People are considered educated when they possess a large collection of facts and procedures.
>
> Teachers know these facts and procedures and their job is to transmit them to students.
>
> Simpler facts and procedures should be learned first, followed by progressively more complex facts and procedures. Definitions of "simplicity" and "complexity" and the sequencing of material were determined either by teachers, textbook authors, or expert adults but not by studying how children actually learn.
>
> Success of schooling is determined by testing students to see how many of these facts and procedures they have remembered.

This transmission and acquisition model of schooling is referred to by learning scientists as "instructionism" because it assumes that the core activity of the classroom is instruction by the teacher. It is also often referred to as the "standard model" for education.

Standard model schools effectively prepared students for the industrialised economy of the early 20th century; transmitting a standard body of facts and procedures to students. The goals of standard model schools were to ensure standardisation where all students memorised and master the same core curriculum. Schools were structured and regimented in a manner explicitly analogous with the industrial-age factory (R. Callahan, Education and the Cult of Efficiency, 1962), and this structural alignment facilitated the ease of transition from school student to factory worker.

When we consider the challenges of the 21st century and the knowledge and skills that may be required to live well in the world we think of creativity, innovation, ingenuity, higher order and critical thinking to solve complex and abstract problems as well as how to get along with one another and become civically engaged.

Valerie Hannon in her book Thrive (Innovation Unit Press, 2017) argues that the traditional pillars of education; that it is about prosperity and growth measured by GDP, and that it is good for individuals in that it will provide them with competitive access to better jobs, are no longer true. Hannon says that the purpose of education is about learning how to thrive in a transforming world.

The key finding of the Harvard Study of Adult Development[21], one of the world's longest studies of adult life, is that our relationships and how happy we are in them has a powerful influence on our health. Robert Waldinger, the study director, noted that "*taking care of your body is important, but tending to your relationships is a form of self-care too. That, I think, is the revelation.*"

Evidence presented by Wilkinson and Pickett in their book "The Spirit Level: Why Equality is Better for Everyone", (Penguin, 2010) demonstrates how nearly everything from life expectancy to depression levels, violence to illiteracy is affected not by how wealthy a society is, but how equal it is. Inequality, they point out, causes shorter, unhealthier and unhappier lives; it increases the rate of teenage pregnancy, violence, obesity, imprisonment and addiction; it destroys relationships between individuals born in the same society but into different classes; and its function as a driver of consumption depletes the planet's resources.

Yet nothing in our formal education systems today are designed to meet these human challenges of the 21st century.

One might have anticipated that the technological affordances of the fourth industrial revolution would both demand and deliver a reimagining of our global education systems. And yet what we are witnessing, despite enormous investments being made in commercial educational technology companies, is the exact opposite.

The tension lies between the competing forces of personalisation and standardisation where personalisation is designing for an individual's; changing needs, unique talents and interests, while standardisation is the engine for rapid growth, lower costs and greater profits.

Teaching and learning, the relationship between a teacher and learner, is uniquely personal and responsive to the many different ways students can become their best selves. We want high

standards for our students. But standardisation is not the same as high standards. Having high standards doesn't mean that we all reach them in the same way. However, when a process is standardised, it can be repeated at a lower cost. Industrial manufacturing was built on these principles to reduce cost and standardise output.

In Canada, the Canadian Teachers' Federation and Alberta Teachers' Association have been active in stimulating a global dialogue about the issues of personalisation and standardisation that are leading to the privatisation and datafication of public education. In May 2017 they released a set of resources to the creative commons under the banner of "We The Educators"[22].

The Conference Board of Canada in its report, Learning in the Digital Age[23], also noted that as evolved from a specialised niche to a mass-produced service, the standard model has come under strain as post-secondary education (PSE). It suggested that digital learning may, in fact, be more engaging, less passive, and more customised to different learning styles than traditional lecture-based learning (transmission).

Circa 2008 the promise of disruption of the PSE sector by digital learning in the form of the Massive Open Online Course (MOOC) seemed to answer the challenge of access to higher education for the masses at a significantly reduced cost. Another Conference Board briefing noted that MOOCs did not result in the radical reforms to higher education some expected[24].

After healthcare, the market for global education is the largest in the world valued, according to a report from Global Silicon Valley, at US$6.3 trillion by 2020. With the global population continuing to grow this is a sustainable industry with new students arriving every day[25].

The biggest costs within this market are for the training and provision of qualified teachers and the infrastructure for them to practice.

The standard model for education, characterised by standardised knowledge distribution and testing together with the profits that they generate for multinational corporations, is at the heart of what Finnish author and Harvard Professor, Pasi Sahlberg, calls the Global Education Reform Movement (GERM)[26]. The GERM assumes that market mechanisms are the best vehicles for whole system improvements.

The ongoing privatisation of public education implicit within the GERM therefore relies on standardisation and a model of education that rewards students who memorise and master the same core curriculum. Such a system reflects a 20th century industrial economy characterised by factories rather than an economy powered by human creativity. It is a system that is training humans to compete with machines and at odds with what the anticipated challenges of the 21st century tell us we need.

These reforms are being advocated by; the World Bank, OECD, some governments, and private corporations where education is viewed as an opportunity to maximise human capital, abandoning education's role of creating cultural good and social cohesion. By taking education out of the hands of those who create it and own it (teachers, students, and the public) education becomes a commodity open to trade and investors where profit is prioritised over people and the needs of society. The result is that commercial interests are driving the development of educational technology and digital learning systems hastening the privatisation of public education.

Rather than transforming education, teaching and learning to meet the challenges of the 21st century we are witnessing a digitisation of 19th and 20th century practice to be delivered by 21st century platforms.

In some ways this is analogous to what we are seeing with the transformation of the transportation sector with new entrants such as Uber. In the final pre-automation days before self-driving vehicles a human operator is sent instructions from a centrally controlled computer program or app. The same approach is being widely used to deliver education on the African continent by corporations such as Bridge International Academies where qualified teachers are replaced with human operators receiving instructions from a low cost tablet computer[27].

In both the Uber and Bridge scenario the goal is automation that; replaces costly human operators, reduces cost of infrastructure, and improves profit. Whereas the self-driving car will almost certainly be a reality we should question the efficacy of a self-driving classroom and whether this is what we need as a society. A report by WIRED magazine describes how Pearson, the company behind Common Core, the global testing-industrial complex and a major investor in Bridge, plans to conquer the world with its standardised model for education[28]. Standardisation is vital to the success of these operations as without standardisation it becomes impossible to scale and generate the profits necessary to sustain private interests.

There are alternatives, both physical and technological, to the standard model of education advocated by the GERM and corporations such as Pearson. One alternative to the instructionism implicit in the standard model is constructivism. Whereas instructionism regards education as the transmission of knowledge, constructivism believes that education is a reconstruction of knowledge where learning is experiential and situated within a professional and social context. Learning by doing, in other words.

The teaching methods, physical or digital, of the standard model assume that conceptual knowledge is independent of the situations in which it is learned and used. On the other hand, situated learning (cognition) is a theory which emphasises that people's knowledge is constructed within and linked to the activity, context, and culture in which it was learned[29]. Thus learning is social and not isolated, as people learn while interacting with each other through shared activities and through language, as they discuss, share knowledge, and problem-solve during these tasks.

For example, while language learners can study a dictionary to increase their vocabulary, this often solitary work only teaches basic parts of learning a language; when language learners talk with someone who is a native speaker of the language, they will learn important aspects of how these words are used in the native speaker's home culture and how the words are used in everyday social interactions.

Constructivism not a new idea given that contributors include educational theorists from the early 20th century such as Piaget, Vygotsky and Dewey.

Such approaches to education elevate the practice and craft of teaching as well as the art of learning by stimulating problem solving, higher order thinking, creativity, collaboration and critical thinking. By encouraging students to use active techniques (experiments, real-world problem solving) to create more knowledge and then to reflect on and talk about what they are doing and how their

understanding is changing, students ideally become "expert learners". The teacher makes sure she understands the students' preexisting conceptions, and guides the activity to address them and then build on them with the objective that the students learn “how to learn”.

The lack of standardisation, dependency on craft, and novelty inherent in constructivist approaches to education have lead to less financial investment from the private sector, particularly from those with a vested interest in selling content, and have thus relied on public sector stimulus. However a rapidly growing movement that has bucked this trend is in the field of project-based learning, making and constructionism[30], a variant of constructivism where the learner is consciously engaged in constructing a public entity. In this context the emphasis is on exhibition rather than competition.

LEGO is a successful multinational corporation using constructivist learning approaches within its education programmes and many new start-ups, many of which are technology based, have entered this space.

In the argument between instructionism vs constructivism it’s worth noting, as Dr Ken Rowe suggests in the book Standards in Education (2007), that, *“The relative utility of direct instruction and constructivist approaches to teaching and learning are neither mutually exclusive nor independent.”*[31]

Project-Based Learning, Playful Learning, Learning by Making

Teaching and learning approaches using constructivist principles can be found in many formats and a skilled practitioner will use and adapt the most relevant to suit the needs and learning objectives of their students. From this position we see what Larry Rosenstock, the founding principal and CEO of High Tech High - a US charter school network in San Diego, calls the “teacher as designer of curriculum"[32].

Mitchel Resnick, Professor of Learning Research at MIT MediaLab uses real world examples in his essay about playful learning to demonstrate how many of people’s best learning experiences come when they are engaged in activities that they enjoy and care about. Rather than sugar coating education as if it were a bitter pill, Resnick describes how youth who have short attention spans in traditional school classrooms often display great concentration when engaged in projects that they are truly interested in. Learners don’t mind activities that are hard as long as the activities connect deeply with their interests and passions.[33]

A literature review published by The National Academies of Sciences, Engineering, and Medicine (Vossoughi and Bevan, 2014[34]) explored 3 themes. First, how making can be designed to position young people in science learning activities that support new intellectual dispositions, identities, and future trajectories of practice. Second, how making programs can be structured and implemented in ways that support young people’s learning and development by placing STEM concepts in context via meaningful activities that connect to multiple disciplinary practices (STEAM). Third, how orchestrating programs to help young people build interest, skills, and shared goals can be achieved by encouraging collaboration, sharing amongst young people, and fluid roles between more expert and novice group members.

The authors conclude that there remains a gap between the ideals of the “maker movement” and the existing research on equity and learning. They note that much of the movement associates with

“work, ideas, and images of middle-class white men”. The authors point to the important role educators play in framing processes of making and who is considered a skilled maker. Educators are integral to creating collaborative learning (rather than overly individualistic or competitive) learning environments.

Canada as a Global Education Superpower

The OECD’s Education at a Glance[35] report provides comparable national statistics measuring the state of education worldwide. The report analyses the education systems of the 35 OECD member countries, as well as Argentina, Brazil, China, Colombia, Costa Rica, India, Indonesia, Lithuania, the Russian Federation, Saudi Arabia and South Africa.

The latest 2016 report shows that inequalities still persist in education, with serious consequences for labour markets and economies. In 2015, only 60% of adults without an upper secondary education were in work, compared to over 80% of tertiary-educated adults. In general, employment rates and earnings increase as an adult's level of education and skills increases; but the labour market still regards a diploma or degree as the primary indication of a worker's skills.

Inequalities in education also affect earnings. Adults without an upper secondary education earn on average 19% less for full-time employment than adults with an upper secondary education, while those with a tertiary degree have an earning advantage (55% more) over adults with an upper secondary education.

Despite gender gaps in educational attainment, women are still under-represented in certain fields of education, such as STEM.

Governments are facing challenges in financing education since the economic crisis of 2008. Between 2010 and 2013, as GDP began to rise again, public spending on educational institutions fell in more than one in three OECD countries, including Australia, Denmark, Hungary, Ireland, Italy, Portugal, Slovenia, Spain and the United States.

The economic downturn also had a direct impact on primary and secondary teachers' salaries where there remains a considerable pay gap between teachers and other similarly educated workers.

Canada spends more per tertiary student than almost all of the OECD countries and has the largest share of tertiary educated adults but a lower than average share of 25-64 years olds with a masters, doctoral or equivalent degree.[36]

Full-time, full year workers with tertiary education earn 39% more than those with an upper secondary education compared the OECD country average of 55%. Although the gender gap narrows with increased educational attainment the gap between men and women’s salary in Canada is higher than average for OECD countries. Of those 25-44 year olds in Canada with tertiary education 42% have parents who are both foreign born (compared to an OECD average of 16%) indicating that education helps immigrants integrate into their communities.

Indeed, as reported in the Canadian press, universities in Canada are welcoming unprecedented numbers of international students this fall 2017, with some institutions seeing jumps of 25 per cent

or more in admissions of students from abroad. This is seen as evidence that Canada is increasingly seen as a tolerant, stable destination in a world beset by political uncertainty.[37]

Another Conference Board report on the economic impact of PSE in Canada showed that the real GDP of Canada's universities and colleges grew by over 17 per cent since 2007, and growth in full-time enrolments far outpaced growth in the Canadian population in the first decade of this century. The report identifies economic impacts alone are significant; over CA$40 billion in direct spending flows through Canada's colleges and universities each year, which generates up to CA$77 billion in indirect economic activity, after multiplier effects.[38]

Expenditure on public education below tertiary level increased by 11% from 2008-2012 in Canada compared to an OECD average of 5% during the same period. Canada spends USD $21,000 per tertiary student per year, the highest across OECD countries after Luxembourg, Sweden, Switzerland, United Kingdom and the United States.

Teachers salaries in Canada are amongst the highest across OECD countries after Germany, Luxembourg and the Netherlands. The results of this public investment are reflected in the 2015 PISA results.

The Programme for International Student Assessment (PISA) is a worldwide study by the OECD in member and non-member nations of 15-year-old school pupils' scholastic performance for maths, science and reading. In the most recent round of tests, Canada was one of a handful of countries to appear in the top 10.

The results show that Canada's teenagers as among the best educated in the world. They are far ahead of geographical neighbours such as the US and European countries with strong cultural ties like the UK and France.

Canada's success in these tests is also very unusual compared with other international trends. The top performers are often cohesive, compact societies and the current highest achiever, Singapore, has been seen as a model of systematic progress, with each part of the education system integrated into an overarching national strategy. Further, if Canadian provinces entered PISA tests as separate countries, three of them, Alberta, British Columbia and Quebec, would be in the top five places for science in the world, alongside Singapore and Japan and above the likes of Finland and Hong Kong.

Canada can be rightly proud of their achievement in PISA. The results demonstrate the value and importance in which the nation, along with other high performers such as Finland and Norway, place on public education. A characteristic shared by these nations is the high status in which the teaching profession is held and the public investment that has been made as a result[39]. Herein lies the contradiction within the OECD who on the one hand note the importance of the things we can not measure such as creativity, ingenuity and higher order thinking, whilst creating league tables from the things we can, i.e. memorising facts and procedures. The leading countries in the PISA league table recognise that teaching and education is more than that which the standard model implies.

Despite stellar results in PISA however there remains a challenge within Canada to support its francophone community. Minority francophones have, on average, lower levels of educational attainment than their majority anglophone counterparts[40]. The right to Francophone education falls

under Section 23 of the Canadian Charter of Rights and Freedoms. As a result members of the French or English minority in a Canadian province or territory thus possess the right to have their children receive their primary and secondary education in the language and facilities of the minority.

This extends beyond the learning of French alone, as the writer and linguist Benoît Cazabon points out, "*Underlying every linguistic enterprise lies a deeper cultural motivation. If such enterprises are not built upon a solid foundation rich with cultural experience that heightens the sense of belonging and identity, they risk collapsing much faster than they were erected.*"[41]

A report published by the Canadian Teachers' Federation in 2013 highlighted 3 key challenges for the government in regard to francophone education; early childhood, new technologies, and research support.[42]

Early childhood is a crucial period for the cognitive, social and emotional development of children. The early years of a child's life are also a critical period for language acquisition. A report from the Canadian Office of the Commissioner of Official Languages points to a growing body of research recognises that early childhood education and care bring a wide range of benefits, including better well-being for the child, better learning outcomes, reduced poverty, increased intergenerational social mobility, more female labour market participation and better social and economic development for the society at large.[43]

The CTF is concerned about how little attention is being paid to technology in measures to support official language communities. Pointing to survey results involving over 1,600 French-language school students on technology and building a francophone identity CTF recommends that government support efforts to increase French-language content on the Web and digital learning platforms. A survey conducted by Media Technology Monitor in 2013 showed that Canada's francophones slower to adopt new technology possibly because they're in a different language and they often get service later than others.[44]

Whilst recognising Canada's educational achievement in delivering a high-quality education with comparatively modest spending to people between the ages of 5 and 19, the Conference Board in its "How Canada Performs" audit (March 2013) points to a need to improve workplace skills training and lifelong education.[45] In the 1994 International Adult Literacy Survey (IALS), Canada's majority francophones (i.e., those in Quebec) achieved higher literacy scores than minority francophones (i.e. those living outside of Quebec). A similar trend can also be found in the Canadian results of the 2003 Adult Literacy and Life Skills Survey.[46]

Looking at employment and the economy, the Council of Ministers of Education Canada (CMEC) noted their PISA analysis that the skills and knowledge that individuals bring to their jobs, to further studies, and to society play an important role in determining economic success and overall quality of life. Today's knowledge-based economy is driven by advances in information and communication technologies, by reduced trade barriers, and by the globalisation of markets that have changed the type of knowledge and skills that the future economy requires.[47]

For nations who understand the challenges of the immediate future, a commitment to providing an education fit for this century is clearly more than achieving high scores in standardised tests and a place in the PISA top ten. Singapore outperforms the rest of the world in PISA scores and yet in

order to nurture a love for learning as well as nurturing a population that is more creative and capable of innovation the government announced a move away from grades and test scores. Schools Education Minster, Ng Chee Meng on announcement of changes to the state Primary School Leaving Examination in 2016 said *"Let's help our children make good use of their time to branch out to explore other interests and passions and to pursue what they want to do in life. Let's help them make good choices about their educational and career pathways based on their aptitudes and aspirations. Let's help them to be ready for the future."*[48]

In designing an education system that future-proofs present and future generations it may well be that measurements alone will not be enough. As the leading education countries in the world are now suggesting, the things that we value the most are the most difficult, if not impossible, to measure and as a result we need complementary if not alternative practices.

Conclusion

By examining imminent technological trends we are able to anticipate changes in the nature and future of work that will place significant challenges over many years on employment, income security and social agency for large populations across social and cultural groups. It is impossible to predict; the exact timing and impact of these transformations, the jobs that will be lost to machines, nor the new jobs that will emerge that we have not yet imagined.

Science tells us that during this century we will also face existential threats in the form of climate change, population growth, ageing populations, growing inequality, antibiotic resistance and ideology.

Interventions are required to catalyse a transformation within the education sector to build upon the impressive lead that Canada has established in the provision of quality education. Interventions that support inclusive teaching approaches and continual learning experiences relevant to the challenges that we can identify today and the ones that we can anticipate for tomorrow.

Lifelong inclusive and equitable quality education; formal and informal, physical and digital, will be vital in preparing our populations and society to thrive in this uncertain future. The 20th century model of education that inculcates standardised facts and procedures designed to output a workforce for jobs that no longer exist will be insufficient to meet the challenges ahead. The jobs of the future are the ones that machines can't do, they will rely on creative expression, social interaction, physical dexterity, empathy, ingenuity and collaboration. We will need scientists, mathematicians, engineers and artists to design and invent solutions to our most pressing problems and we will need to learn how to co-exist with our neighbours. We will need to equip our people with the skills and knowledge to reimagine society to meet the challenges that they face.

Canada's unique predicament is to address these challenges in a way that meets the bilingual demand of the national population where French is the mother tongue of 6.8 million Canadians which is 23% of the population[49]. This large Francophone community forms an integral component of the Canadian identity and contributes to its unique character whilst generating 20% of GDP (CA$230 billion)[50]. The vast majority of Francophones live in Quebec, the hub of Francophone culture in North America. However, close to a million Francophones form vibrant minority communities throughout Canada's other provinces and territories. Reaching these minority communities across a variety of platforms including broadcast and digital is both a constitutional and economic imperative.

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