EDUCATION: FUTURE FRONTIERS

Discussion Paper

Opportunities and challenges for education

INTRODUCTION

What knowledge, skills, values and experiences will young people need to thrive in a rapidly changing world? Does our current approach to school education sufficiently ensure our students have the skills and confidence they will need to successfully navigate this more complex world? How do we strike the right balance of prioritising strong literacy and numeracy skills, developing deep subject knowledge and fostering the right set of general capabilities and a growth mindset? And can education better leverage developing AI technologies to assist teachers and improve student learning?

In response to these questions, there are many within and outside the education sector who are challenging schools and school systems to reframe education to better meet the future needs of students given predicted economic, societal and workplace change. At the same time, amid calls for a greater focus on '21st century skills', use of technologies and personalised learning, there is rightly a view from many educators that these are not new features of schooling but, rather, have long been a valuable part of quality education.

Our research suggests that there is much that is not new in these debates. However, the significant implications of AI disruption combined with broader economic trends, demand that we consider now what might need to evolve across school systems to ensure that all students are able to make the most of the opportunities and successfully navigate the challenges of an AI world.

> "In an era of acceleration and increasing uncertainty, we cannot be in the business of predicting what employers want in 2030, much less in 2050. But we can describe the kind of citizen we want to emerge from our schools – students who are critical and reflective, open to a lifetime of learning and relearning, who are comfortable with change, have empathy and a global outlook. This demands that we all take a broader perspective about what we judge a good education to be because students with these skills and attributes will likely be best placed to flourish in a world of intelligent machines."
>
> **Mark Scott, speech to the Trans Tasman Business Circle, June 2017**

Sharpening our focus

Predictions about the effects of AI and automation on the workforce vary significantly. While debate continues about the number of jobs that might disappear as a result of these technological developments, there is little doubt that AI has the potential to radically change the types of work we will do and how we will do that work in the very near future. More than this, the implications of these developments extend well beyond employment, to society as a whole and to individual security and opportunity.

Australian education systems have a strong track record in providing quality schooling – a robust focus on literacy and numeracy, well established discipline content and standards, well-aligned formal and external assessment programs and progressions of learning that guide teacher instruction and assessment. But, at a system level, overall performance against international and national benchmarks is relatively stagnant. The achievement gap between high and low performers persists and, worryingly, has increased on some measures. This suggests we need to do things differently and do them better so that all students are well prepared for a more challenging and uncertain world.

The changing nature of employment and the complex public challenges arising from AI and other global trends will put increasing pressure on traditional models of schooling. Already there are emerging and innovative practices springing up across the education community seeking to motivate, engage and challenge more students, and to harness the potential of advanced technology to lift performance. Some of these practices have a stronger evidence base than others and it can be difficult within systems to distinguish which practices appear to be the most effective.

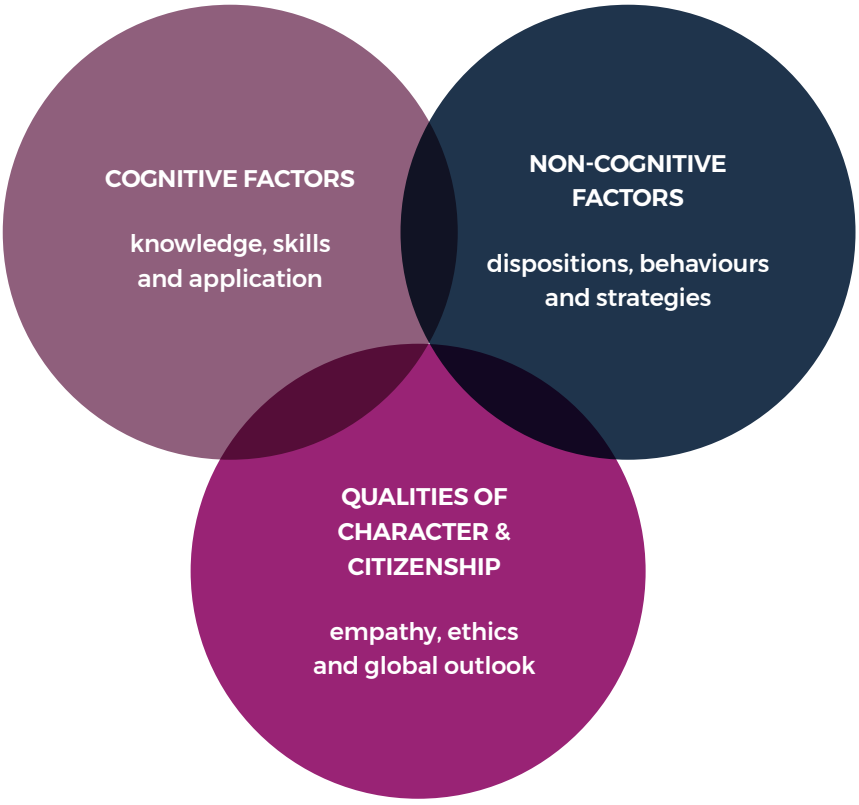
Against this backdrop, there is an emerging view that to best prepare students for the changes wrought by AI and other global trends, schools need to set students up for lifetime education, to be comfortable with change, empathetic, both outward-looking and self-aware, and to have the capacity to critically engage with new technologies.

To do this, 21st century students need:

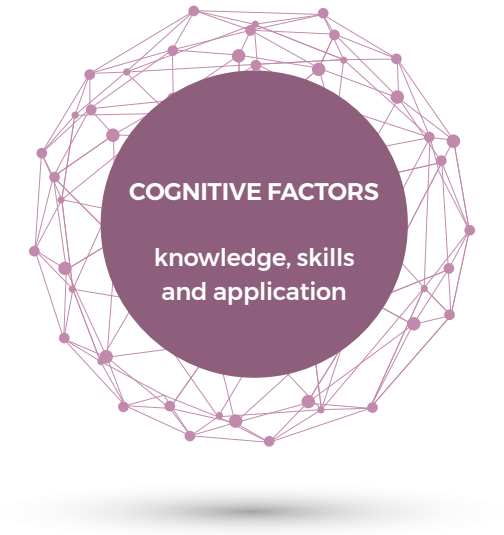
- high levels of functional literacy and numeracy
- a deeper understanding of the core concepts in the disciplines, including higher levels of digital literacy
- the opportunity to apply knowledge in meaningful ways to develop mastery in both content and capabilities, and find areas of interest
- the mindsets and strategies to be adaptable and resilient learners, to reach their goals and continue to learn
- to be well rounded, informed and culturally aware citizens, to successfully engage in an increasingly interconnected world.

This paper explores these themesusing a model of three overlapping dimensions (illustrated below). Of course,while separated here for simplicity,recognition of the interconnectedness ofthese elements is critical to supportingquality education in a knowledge age. Learning to think critically, for example, 'the chrome and steel of effective cognition', also helps students to develop intellectual, emotional and social resilience, to have empathy and engage with different points of view (Ellerton 2017).

As the technological revolution unfolds at pace, the challenge for education is to determine how best to give full weight to the needs of the 21st century student, and how to innovate to make this happen while maintaining and supporting the good work being done today.



THE COGNITIVE DIMENSION



> "Our world is becoming increasingly complex, and so higher and higher levels of educational achievement will be needed to be in control of one's own life, to understand one's culture, to participate meaningfully in democracy, and to find fulfilling work."

D. Wiliam 2016

The changing nature of our economy and society is increasingly demanding that students leave school with a more complex blend of knowledge and skills – a deeper understanding of facts and figures, and a stronger capacity to grasp and apply knowledge to new contexts.

Deep and rigorous learning to develop good thinkers

In response to economic shifts and predictions of intelligent machines with independent learning capacity being able to automate increasingly complex jobs, there are increasing calls on education systems across the world to focus on '21st century skills'. This set of skills is not universally defined and the terminologies used to classify its elements are often problematic. The cognitive factors included in the '21st century skillset' generally combine strong academic instruction with a greater focus on creative and critical thinking and problem solving, along with the 'soft skills' of collaboration and communication. Many believe that these 21st century skills are the least likely to be automated in the medium term and are what young people will need in order to lead rewarding and purposeful lives in an AI-rich world.

There is little doubt that these concepts are not new and have long featured in quality curricula, including the Australian Curriculum. Significant debate has occurred, however, about how these skills are best acquired in education. This has sometimes resulted in unhelpful discussions about whether 'content' or 'skills' matter most, and whether these 21st century skills are more effectively

learned through studying disciplines or by practising their application in non-discipline specific contexts. As US education expert Linda Darling-Hammond dryly observes:

"[Content people] fear that the 'skills people' will lose sight of valuable content. They envision that the skills people will put an undisciplined emphasis on collaboration, teamwork and project-based learning. They see students working with clay and toothpicks without actually mastering challenging intellectual content. On the other side, skills people are worried that the 'content people' will try to reduce what is to be known and demonstrated to a list of dry, disconnected facts tested by multiple-choice items without attention to meaning and application." (Darling-Hammond 2010)

This dichotomy is unhelpful because, as leading school educators acknowledge, skills such as problem-solving and critical thinking are developed within the context of building a deeper understanding of subject-related content where students can learn 'about' as well as learn 'how'. This can be achieved within core subjects as well as through interdisciplinary approaches that help students make meaningful connections across and within learning areas.

Achieving a deeper understanding of core content requires a combination of abstract learning, explicit instruction, learning in context, from example and by application (see also Zhang 2016, Anderson et al 2000). As Darling-Hammond notes, "All teachers need the ability to engage in high quality instruction that adequately represents both the content and the cognitive skills that enhance all students' deep understanding of content." Clearly, this is no simple feat and teachers need a sophisticated pedagogical tool-kit to enrich and deepen students' learning in this way.

Furthermore, while these 21st century skills are acknowledged as general capabilities in the Australian Curriculum, there is as yet no clear consensus on how to best combine rigorous content standards with well-disciplined ways to develop important skills. It is not clear that all schools are giving sufficient explicit attention to how these skills are developed within the subject disciplines nor does the curriculum give much guidance on this. Questions also remain about how best to assess these skills so that students and teachers can reflect on progress in developing both deep content knowledge and capabilities.

The compulsory years of schooling expose students to a broad range of learning areas so that they can build strong foundations in general knowledge and skills and also have the opportunity to discover areas in which they might specialise. At a system level, this involves a delicate balance so that students are able to engage more deeply with subjects and learning areas that interest them, which can foster a love of learning and an appreciation of the joy of mastering something, while at the same time ensuring that all students have a well-rounded education that will best support them in reaching their potential beyond the school gates.

Finding the appropriate balance between breadth and depth of students' learning is also a daily challenge for teachers. Achieving this may require systems and schools to give teachers more room to manoeuvre in terms of curricula, faculty divisions and timetabling.

> Real learning rarely takes place unless it is used to solve interesting, real problems.

M. Tucker 2017

Applying knowledge and skills in meaningful ways

Education systems that embed real world learning opportunities can help students to deepen their understanding of core concepts and develop both cognitive skills and soft skills. By applying knowledge and skills to solve real problems and engaging in meaningful experiences both in the classroom and beyond, students are able to demonstrate mastery in new ways, translate their learning to real life contexts, and can be motivated to increase their levels of learning.

A study by the American Institutes for Research found that students attending a network of schools focused on deeper understanding of academic content and applying that understanding to novel problems and situations (known as 'Deeper Learning') had better outcomes in PISA, were more likely to graduate from high school on time and enrol in higher education (Bitter et al 2015).

There is a range of strategies which are being used by educators to implement applied learning within schools as well as evidence about what is effective pedagogy. These strategies include integrating real life problems into existing subjects, internship opportunities, project-based learning and longer-term assessments such as work portfolios. Different technologies are also increasingly being used to support applied learning opportunities such as simulation based learning, virtual laboratories, using online research data, working remotely with specialised equipment and cognitively guided web courses (see for example Lombardi 2007).

Project work, for example, has been implemented explicitly in all schools in Singapore over the last decade as a means of improving student knowledge and skills such as problem solving. Project work in the Singapore context is defined as learning experiences which aim to provide students with the opportunity to synthesise knowledge from various areas of learning and critically and creatively apply it to real-life situations (Tan and Low 2016). The process of undertaking this project work supports the development of curiosity, creativity, resourcefulness and teamwork, embeds a focus on independent learning and helps to prepare students for lifetime education.

The challenge of course is the need for teachers to expertly judge when, where and how this is effective for the wide range of students they teach and the range of knowledge and skills that they are teaching. There is merit too in exploring the potential longer-term and sustainable impacts that real world applications can have to deepen learning.

BY APPLYING KNOWLEDGE AND SKILLS TO SOLVE REAL PROBLEMS AND ENGAGING IN MEANINGFUL EXPERIENCES BOTH IN THE CLASSROOM AND BEYOND, STUDENTS ARE ABLE TO DEMONSTRATE MASTERY IN NEW WAYS.

> “Digital literacy can be defined as a survival skill in the digital era.”
>
> **Y. Eshet 2004**

Reassessing core knowledge in an AI world

The capacity to use and adapt to changing technology is becoming especially important in the workplace given the predicted expansion of jobs that will be fundamentally affected by technological change. Employees will need to be willing and able to learn how to use newly developed technology effectively and productively in the workplace. While this has always been a highly-valued characteristic, it is likely to become more of a requirement across the workforce.

It is not enough that today's students are 'digital natives'. All students today need a higher level of understanding of computational concepts, methods and tools, the ability to understand and evaluate information delivered in multiple formats and to adapt to new technologies and platforms.

As AI and associated technologies such as machine learning start to become increasingly embedded in life and work, the importance of understanding the building blocks of computation and to critically engage with the technology and its implications will become more important than ever.

More than simply understanding the basics of computer programming or coding, students will need to have the skills to critically evaluate information, to understand how machines make decisions, the choices embedded in computer code and the privacy implications arising with every technological development. This is critical in today's world of 'fake news' and 'push' algorithms, where, for example, AI-based systems deployed in the US to help determine sentencing conditions have been found to discriminate against African Americans, and it will only become more so as such technologies spread.

As with critical thinking, Information and Communication Technology (ICT) capability is one of the general capabilities in the Australian Curriculum, but there is more to be done to understand how well students are obtaining the breadth and depth of skills that digital literacy should encompass, and whether schools and teachers are well equipped to support students to do so.

Connected to the need for more explicit attention to digital literacy in all its dimensions – both the computational thinking and the critical analysis – is the need to consider whether greater attention should also be given to ethics and philosophy in today's classrooms, to ensure all students have the tools they will need to negotiate a world of intelligent machines. The focus on preparing our students for a more complex world needs to have a complementary focus on teaching students to understand the moral and ethical impacts that artificial intelligence (and other global challenges) will have on society, including the use of big data in real world decision making.

CONNECTED TO THE NEED FOR MORE EXPLICIT ATTENTION TO DIGITAL LITERACY IN ALL ITS DIMENSIONS IS THE NEED TO CONSIDER WHETHER GREATER ATTENTION SHOULD ALSO BE GIVEN TO ETHICS AND PHILOSOPHY IN TODAY'S CLASSROOMS.

In considering the need for a greater focus on digital literacy and streams such as ethics and philosophy, combined with the need for deeper content knowledge, the question needs to be one of how to balance breadth and depth of core student learning. In this context, perhaps further consideration needs to be given to what is defined as core knowledge and skills.

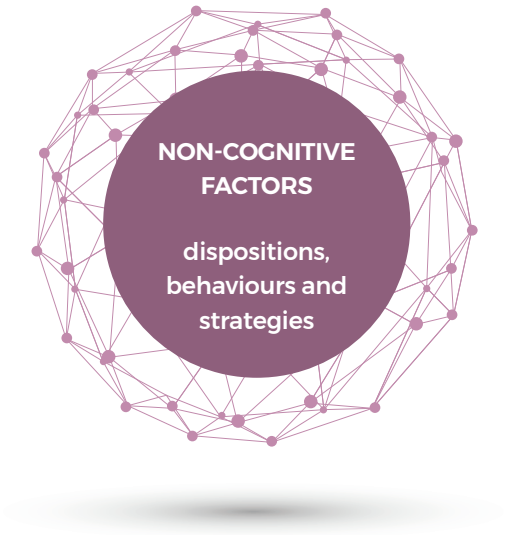
For example, education systems may need to look afresh at the mathematical skills students will need to successfully engage in an AI world. While concerns have been raised about the proportion of students undertaking advanced maths in the senior secondary years, recent changes to entry prerequisites by some universities may go some way to drawing more students into these subjects. But in a world of big data, just as significant is the extent to which sufficient attention is being provided to developing students' skills in, for example, statistics, and whether changes to mathematics curricula over the last few years will be enough to ensure all students develop a deeper understanding of core mathematical concepts.

Diminishing levels of engagement in maths also suggests the need to examine more deeply the way the subject is taught and how much it is valued. Too much content to cover can lead to superficial engagement and a focus on the content of exams rather than real world context and understanding (Maltas and Prescott 2014). This can also make it difficult for collaborative problem solving, investigation and student reflection to take place. Teachers must ensure students experience success and a sense of achievement if they are to develop a positive attitude towards maths (Attard 2015).

THE COGNITIVE DIMENSION: QUESTIONS TO CONSIDER

- *How should the broader set of cognitive skills be more clearly articulated and more robustly implemented, and what support needs to be provided to assist teachers to do this?*
- *How best to provide space in the delivery of schooling to enable students to delve deeply into core concepts and apply their understanding to real problems?*
- *Is there sufficient evidence of the strategies that are most effective in supporting students to apply knowledge and skills to deepen learning, and how can educators be supported to embed such strategies in their schools?*
- *How can non-school partners and new technologies support applied learning within school and beyond?*
- *How can schools provide more meaningful foundations in digital literacy, and broaden opportunities to advance, with a focus on rigour, greater sophistication and complexity?*
- *How do we give greater attention to teaching ethical reasoning as machines become increasingly capable of making decisions?*
- *How do we increase students' engagement in maths, and their understanding of its value, throughout schooling?*
- *In addressing concerns about low take up of advanced maths in the senior secondary years, is there also a need to reconsider the core maths skills students will need to engage in an AI world?*

THE NON-COGNITIVE DIMENSION



> "Knowing that non-cognitive factors matter is not the same as knowing how to develop them in students."
>
> **C. Farrington et al 2012**

A growing body of evidence is showing important links between 'non-cognitive' factors – particular dispositions and behaviours such as self-efficacy, self-regulation, perseverance and growth mindset – and academic performance. While they may be difficult to define and measure, research is suggesting that these factors may matter a great deal, including as potentially significant contributors to achievement gaps for socio-economically disadvantaged students (Reeves et al 2014).

Developing learning dispositions and behaviours

The evidence is developing around the extent to which non-cognitive factors or socio-emotional dispositions, which have not traditionally had an explicit focus within schools, are malleable and responsive to teaching strategies. As a consequence, there is growing pressure for school systems to pay greater heed to non-cognitive factors and focus on strategies to improve them. Many believe that focusing on these factors could have multiple life-long benefits in addition to improving students' academic performance, such as developing more engaged learners and better supporting students' holistic development and longer-term wellbeing.

A growth mindset

A growth mindset allows students to see failure and setbacks as opportunities to learn; with effort and effective strategies they can use these setbacks to improve. However, a fixed mindset means that the learner believes that their ability is fixed. Mindset may be important during significant transitions. Learners can have a

mix of growth and fixed mindsets at any one time, depending on the task at hand (Dweck 2012).

Studies have shown that a growth mindset is teachable. Instructing students with a fixed mindset that they can improve and giving them effective strategies to do so can develop a growth mindset (Dweck 2012). While intervention programs have been tested, the context and execution is important, indeed praising effort in the face of continuing failure without giving students strategies to improve can be detrimental.

Perseverance

Perseverance is related to drive and grit, and is linked to resilience and to the personality trait conscientiousness. Duckworth's concept of grit has received a lot of attention in recent times; less so her focus on the role of long-term perseverance and passion. Duckworth's studies have linked grit to the ability to succeed in a number of realms.

While some analyses suggest that academic perseverance – grit, tenacity, self-discipline and self-control – can lead to academic behaviours which then improve results, a focus on grit alone is unlikely to lift performance. Studies have shown that where students feel that they belong, have a positive mindset and effective learning strategies they are also more likely to persevere. That is, mechanisms that focus on mindset and development of students' metacognition and self-regulation skills will also likely improve perseverance (Farrington et al 2012).

Self-efficacy and self-regulation

Self-efficacy is related to self-confidence, belief in oneself, self-esteem and self-regulation. Studies have related it to increased effort, participation and persistence as well as to academic performance and deeper learning. Bandura (1994) describes self-efficacy as being developed through mastery (mastering a task), vicarious experience (seeing someone similar to yourself doing the task), verbal persuasion from someone trusted (however failure after encouragement can cause a decrease in self-efficacy) and, finally, the emotional state a person is in.

Self-regulation involves managing the causes of impulses that are inhibited by self-control. It is seen by some as a sub-category of self-efficacy. The ability to self-regulate comes from both internal factors such as temperament, as well as external factors such as rules and modelling from adults. Self-regulated learning helps students to obtain their goals by understanding the steps required to achieve them. Learners use metacognitive strategies, which can be taught, to set personal goals, monitor their own learning and adapt the way they work (Zimmerman and Schunk 2011; Dweck et al 2014).

ALTHOUGH NON-COGNITIVE FACTORS HAVE BEEN ASSOCIATED WITH INCREASED ACADEMIC OUTCOMES UNDER CERTAIN CONDITIONS, INVESTIGATIONS ARE ONGOING ABOUT THE EXTENT TO WHICH ALL THESE FACTORS ARE MALLEABLE AND WHICH ARE TRANSFERABLE BETWEEN DOMAINS.

Limits of the research

A great deal of research effort – from psychology, education, economics and other fields – has been expended on investigating the role of non-cognitive factors in academic performance. The field of neuroscience has shown the brain is adaptive but there's a complex interaction with genetics and environment (Le et al 2014).

While there is a lack of agreement on definitions, non-cognitive factors are considered by some researchers to be interrelated – for example, a growth mindset has been shown to help students persevere, and this can also help to develop self-efficacy – and also deeply connected to the development of cognitive skills. Connected to this is the importance of a sense of belonging to a school community in the willingness of students to persist and excel.

Although non-cognitive factors have been associated with increased academic outcomes under certain conditions, investigations are ongoing about the extent to which all these factors are malleable and which are transferable between domains. The focus for schools needs to be on the factors which are learned capabilities rather than simple categorisations of learners. It is also not yet clear that interventions are effective beyond single schools or particular cohorts, or that studies in the laboratory under controlled conditions translate to the classroom. A further challenge for schools is that there is also little agreement on how students' capacity to develop such factors might change over time. Nor is there agreement on how much is the responsibility of schooling to 'teach' these non-cognitive factors.

THE NON-COGNITIVE DIMENSION: QUESTIONS TO CONSIDER

- *How do we determine which factors can and should be focused on within schools, and at what point?*
- *Are there effective and concrete teaching and learning strategies to support their intentional development?*
- *To what extent are interventions context specific and can they be built into the subject domains?*

THE THIRD DIMENSION: QUALITIES OF CHARACTER AND CITIZENSHIP

> "It is entirely possible that the most important function of education in the years ahead will be to prepare our future citizens for citizenship in a world only barely imaginable today."
>
> **M. Tucker 2017**

In focusing on the cognitive and non-cognitive dimensions that drive student performance and improve educational outcomes, we cannot lose sight of the broader goals of schooling in supporting the development of the whole student. Nor should we lose sight of the role of activities outside the classroom – in school and beyond – in developing qualities such as confidence, empathy, resilience, creativity and tolerance. This includes, for example, the role of team sport, debating, bands, drama, community activities and peer mentoring.

Broadening what we value in education

Many schools and communities are making genuine attempts to broaden the criteria for what makes a "good" education and are examining the types of experiences that will shape the kind of adults their students will become. A pertinent question though, is how many schools are doing it intentionally, in a planned, organised and reflective manner?

This is a question facing educators the world over. There is evidence across the globe of successful school systems

placing more explicit emphasis on qualities of character, citizenship and whole student development. In places as diverse as South Korea, Singapore and Ontario greater focus is being given to this dimension partly in response to community and workforce demands.

In South Korea, for example, the introduction of an exam-free semester in middle school enables students to focus on developing what are described as personal growth competencies. Students spend about two-thirds of their time studying the core curriculum without the pressure of exams, and spend the remaining third undertaking their own activities, which need to be approved by the Principal or teachers (Min-ho 2014). Students might participate in debates and experiments, learn how to manage projects, learn a new musical instrument, participate in art education and student clubs, as well as undertake career development activities. The initiative was trialled in 2013 and rolled out more widely in 2016 due to the positive response of students, teachers and parents (OECD 2016).

Under Ontario's Citizenship Framework clear direction is given to teachers across all subject areas about the attributes and structures through which students learn how and why to demonstrate self-respect, and respect and empathy for others through topics such as inclusiveness, fairness, justice and social cohesion.

Recent education reforms in Singapore have focused on providing a holistic education, with refinements to the curriculum and assessment to provide more explicit focus on what they describe as 21st century competencies and values. Among other changes, this includes the formal introduction of character and citizenship education lessons. At the same time, Singapore has removed school rankings which were deemed to promote academic competitiveness among schools and an obsession with test scores among parents (Tan and Low 2016).

Along with the deliberate refocusing on what makes for a 'well rounded' student, is the increasing relevance and importance of global citizenry for young people. This too has been a strong focus in school systems globally, including in Singapore which has recognised the importance of their students developing a sense of global awareness and a broader worldview. The opening of the Yale-NUS College in 2011, Singapore's first liberal arts college and one of the few in Asia, also marks an important shift in the demand for global-minded university graduates who are adaptable and can deal with uncertainty.

The Australian Curriculum's general capabilities include ethical understanding and intercultural understanding, and embedded into many syllabus documents are ways to teach students to think critically and

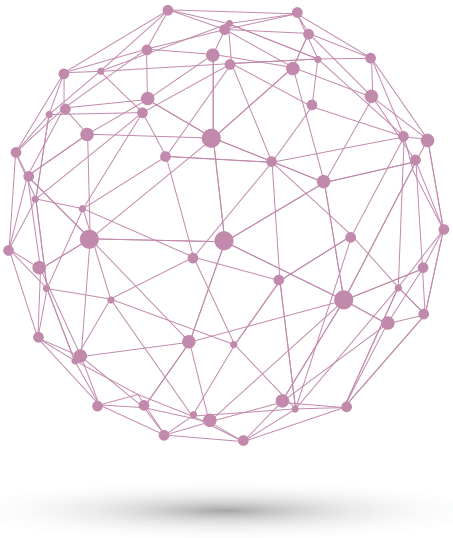
ALONG WITH THE DELIBERATE REFOCUSING ON WHAT MAKES FOR A 'WELL ROUNDED' STUDENT, IS THE INCREASING RELEVANCE AND IMPORTANCE OF GLOBAL CITIZENRY FOR YOUNG PEOPLE.

analyse global issues, challenges and opportunities. The question is how much prominence this aspect of education should have, given our increasingly interconnected world and the geopolitical and economic challenges we face.

The concepts of character and citizenship are more than a subject and extend well beyond school – it's in the culture of families, classrooms, institutions. That said, in thinking about the kind of citizen we want to graduate from our schools – those who will flourish in a world of intelligent machines – the themes that emerge are deeply connected to these concepts: students who are critical and reflective, open to a lifetime of learning, who are comfortable with change, have empathy and a global outlook.

QUALITIES OF CHARACTER AND CITIZENSHIP: QUESTIONS TO CONSIDER

- *Should schools be supported to provide an intentional focus on the qualities of character and citizenship for all students? How?*
- *Are there opportunities to deepen this focus by better leveraging relevant aspects in existing curricula?*
- *How can we better recognise the role of non-classroom and extra-curricular activities in supporting whole student development?*
- *How can schools better ensure all students benefit from such opportunities, and should they more explicitly track and plan for them?*



SYSTEM ENABLERS

> "I would like to conclude by summarising a compelling case showing that the major uses of tests for student and school accountability over the past 50 years have improved education and student learning in dramatic ways. Unfortunately, that is not my conclusion."
>
> **R. Linn 2000**

The challenge of assessment

Assessment is an essential part of teaching and learning systems, but it can also be its Achilles' heel, particularly when it comes to high-stakes testing. What to assess, how to assess and when to assess are all critical considerations in education contexts – and the answer to each of them depends very much on the purpose for which the assessment data is being sought.

Assessments help teachers – and ideally students themselves – gauge where students are in their learning at a given point in time. Teachers can use learner data to inform their pedagogic approach for individuals and groups of students (often called 'formative assessment'). Assessment is also used to measure to what extent students have successfully learned an expected outcome ('summative assessment'), which is usually interpreted relative to a benchmark or standard (Wiliam 2014).

There is evidence that some assessment approaches are less effective than others in improving student outcomes and system quality. Some research evidence suggests that formative and school-based assessment approaches, for example, are more likely to improve the quality of education and learning outcomes in the longer term compared to more traditional standardised test approaches (Sahlberg and Hasak 2016). More questions are being asked about the high-stakes use of data, particularly in the US, and whether there is any connection with long-term system improvements or with addressing inequalities in education systems.

Measuring what matters, matters

Students and schools for obvious reasons gravitate toward focusing their effort on the outcomes that systems value the most or on what is definable, teachable and assessable. Because systems have historically focused on narrow – though foundational – measures of cognitive ability, these are what have become the most valued.

Some education systems are currently exploring how broader capabilities such as critical thinking and problem solving are currently assessed, and whether, how and when to assess additional concepts such as non-cognitive skills.

There is a growing body of research observing a correlation between many of the non-cognitive and 'character' skills, which are not easily tested by traditional assessment approaches, with a range of success measures including higher academic outcomes (Farrington et al 2012). Despite the complexities of their definition, some education systems are exploring how to include them in the list of things that matter, which would include considerations of assessment regimes.

Many 21st century skills are not necessarily assessed well using existing instruments and approaches. The Australian Curriculum's general capabilities, such as creative and critical thinking are addressed through the content of the learning areas, and

teachers are expected to teach and assess these capabilities within learning area content. There are a range of ways that this is occurring, and some jurisdictions are more advanced than others in supporting schools to assess such capabilities.

Some systems are also investigating how to assess non-cognitive and character skills across school systems. In the US, the California Office to Reform Education (CORE), a collaboration of nine districts, is trialling incorporating social-emotional or non-cognitive skills into their curricula and classroom activities, as well as a low-weighted dimension in school accountability reporting. There are many critics of including these measures to evaluate school performance, including Duckworth, a pioneering researcher in this field and advocate of schools focusing on these dimensions. It is too early to know if the CORE approach is having any positive effect or whether the high-stakes use of these data is resulting in negative and perverse outcomes. Many systems across the US and internationally are, however, observing this experiment with great interest.

Part of the concern around assessing non-cognitive factors is that there is a tendency to rely on self-assessment tools, which are considered to be more vulnerable to intentional and unintentional manipulation of results. Students can provide quite different answers depending on the context or use of the assessment, for example whether their teachers or parents will see the results, and the social context and culture of the school environment. Significant skill is necessary therefore to interpret the results of such assessments.

Of significance in this debate is that education systems will need to consider how the results of assessments of non-cognitive skills are contextualised to students. In addition to providing teachers with the tools to benchmark results and demonstrate to students what improved scores could involve, the use of negative labels or deficit models when measuring these concepts could result in psychological distress and long-term harm. Additional sensitivity will be required in terms of assessing and scaling non-cognitive factors given their potential for a more intrinsic relationship with character and self-identification. This is especially important given that the research base for effective interventions that teachers could employ to positively influence non-cognitive factors is still in its infancy compared with remedial programs for cognitive abilities.

More small data is needed

As Pasi Sahlberg has noted, what is needed to drive improvement in education systems is more 'small' data, not 'big data' (2016). Assessment works best to improve student outcomes if it is designed for and by teachers to gauge students' learning strengths and weaknesses, so that teaching or the curriculum can be adjusted accordingly. Students need to be given effective feedback so that they can adjust their

> WHAT IS NEEDED TO DRIVE IMPROVEMENT IN EDUCATION SYSTEMS IS MORE 'SMALL' DATA, NOT 'BIG DATA'.
>
> **Sahlberg 2016**

behaviours to improve their outcomes. Systems also need to encourage approaches to assessment that enable students to learn from failure.

There is growing recognition of the benefits of shifting the focus from single point in time measurement to a more dynamic form of assessment that gives teachers regular and objective insights into the progress of each student.

As noted below, there is an opportunity for AI and other technological developments to significantly change the way students' learning is measured and data collected. New tools could help to reward the effort students invest in deeper learning beyond the prescribed curriculum, while also checking that other learning outcomes have been achieved, rather than asking all students in a cohort the exact same set of questions. Individualised assessment approaches could provide teachers and students with richer information across all learning areas and capabilities to support every student to progress.

CHALLENGE OF ASSESSMENT: QUESTIONS TO CONSIDER

- *How can systems better support schools to use formative assessments to measure the full set of cognitive skills to assist in deepening student knowledge and skill development?*
- *What tools are needed to enable teachers to better assess individual student progress across all areas of learning and skill acquisition?*
- *Other than measuring in high-stakes ways, how else can we be sure that all students within a system are developing important non-cognitive skills and have opportunities to demonstrate them?*
- *Should systems measure social-emotional skills while at the same time ensuring that there is sufficient instructional guidance for teachers on how to improve them? If so, how?*

THERE IS AN OPPORTUNITY FOR AI AND OTHER TECHNOLOGICAL DEVELOPMENTS TO RADICALLY CHANGE THE WAY STUDENTS' LEARNING IS MEASURED AND DATA COLLECTED.

> "Don't get seduced by the technology, start with learning."
>
> **R. Luckin 2016**

AI in teaching and learning

With AI affecting almost every field of endeavour, many experts in AI are asking the education community to consider the potential offered by these technologies: to see a future where AI supports the unique role of the teacher by automating routine tasks, supporting personalised learning and student mentoring, and enabling teachers to better assess individual student progress, including by shining a light on how each student learns and is influenced by non-cognitive factors.

Studies suggest that the susceptibility of the education sector to automation is relatively low, with the teaching profession predicted to be among the least likely to be automated (McKinsey 2017; Frey & Osborne 2013). Education operates in a context deeply dependent on human relationships and interactions with other people; where the best outcomes are achieved with people at the centre.

That said, digital technologies have already had a significant impact on education, some more successfully than others. AI in education builds on new developments in machine learning, computer modelling and probability statistics – developments that are being implemented in a range of sectors, such as health – with the aim of supporting teachers to adapt and assess learning of individual students (Luckin 2016).

But in order to make the most of the educational opportunities afforded by AI, the education sector needs to own and shape the challenges and opportunities that AI is deployed to address – it cannot start with the technology. As Luckin puts it "to be effective, AI in education must involve teachers and students in its design, and must be grounded in the science of how we learn, as well as educational practice."

Teachers and school leaders must play a central role in defining a clear purpose and the educational problem. Further, this must be in a context where the whole education community, including students and parents, has engaged in decisions about the use of these technologies and the ethical frameworks that should accompany them.

The potential of AI to personalise learning can have direct and immediate application in helping to address access and equity challenges faced by many students and can support learning beyond the classroom. Adaptive learning techniques can personalise learning to a student's existing knowledge and progress, and empower students to take control of their pace of learning, challenging the traditional rigid conceptions of learning and instruction. Equally promising is the potential for AI to augment teaching practices by helping to monitor student engagement and teaching impact and suggest adjustments to content.

IN ORDER TO MAKE THE MOST OF THE EDUCATIONAL OPPORTUNITIES AFFORDED BY AI, THE EDUCATION SECTOR NEEDS TO OWN AND SHAPE THE CHALLENGES AND OPPORTUNITIES THAT AI IS DEPLOYED TO ADDRESS.

In short, the aim should be for such technologies to sit comfortably with teachers and students as a dynamic tool. When we consider the potential of AI to analyse large amounts of data collected in the background, can we imagine the capability of producing a more effective assessment regime that evaluates students over a longer period of time and that cannot be reduced to cramming and memorisation or gamed by expensive tutoring but one which is rich in evidence of real and deep learning? Already we are seeing work on intelligent tutoring systems that can use student responses to personalise how they navigate through material and assessments, targeting the skills they need to develop (Buckingham Shum 2017). And with progress in AI in education, might we imagine teachers freed up to focus on human interaction, communication, scaffolding and support while AI streamlines administrative and routine tasks?

While the potential benefits may be great, we need to approach AI in education cognisant of the risks and implications of these technologies, not least the very real and important issue of the use and ownership of student data. Systems need to be on the front foot to not only define and shape the purpose of these technologies in schools but also demand that appropriate checks and safeguards are in place.

AI IN TEACHING AND LEARNING: QUESTIONS TO CONSIDER

- *How can technological advances be best harnessed to enhance learning and to what extent can such developments support teachers to devote more time to deepen learning and capabilities?*
- *What do systems need to do to ensure effective implementation of these technologies, that the ethical, privacy and regulatory challenges are addressed and necessary safeguards are in place?*
- *How can we lift teacher capability to exploit the benefits of such technologies to improve student outcomes?*

SO WHAT'S ALL THE FUSS? WHAT'S DIFFERENT ANYWAY?

> "There are increasing demands on schools to prepare students for more rapid economic and social change, for jobs that have not yet been created, for technologies that have not yet been invented, and to solve social problems that have not been anticipated in the past."

OECD: Future of Education and Skills: Education 2030

To return to a theme highlighted in the introduction of this paper – many of the ideas explored here have been debated and dissected over many years and have been part of robust examinations of education reform before. However, we have heard the message that business as usual will not solve the challenges of tomorrow and while there is significant uncertainty about the nature of the changes ahead, the expectations on our students will be high.

One of the most defining imperatives which has emerged in response to these new challenges, is that 21st century learners will need 21st century teachers. The challenge is how to ensure every teacher can expertly, deliberately and systematically lead and drive the reform agenda demanded by the 21st century. How do we ensure that teachers are front and centre in research, evidence building and practice, are of the highest quality and are fully equipped with the knowledge and skills to expertly lead their students to reach their full potential? With the approach of an AI-world, the role of teachers and their ongoing personal and professional development needs to continue to be education's deep and enduring centrepiece.

Secondly, what is becoming increasingly evident is that education needs to be a key player in the innovation agenda.

To deal with the complex, high impact and urgent challenge of educating students for a rapidly changing world, education will require innovation to successfully exploit new ideas, to create sustainable benefits and no longer rely on an ad hoc approach that allows for risky experiments, untested solutions and fragmented deployment.

Education needs to be bold enough to identify and scale successful, innovative practice and schooling arrangements, including quality pedagogy, and ensure the rules of engagement put students and learning first. The system needs to be agile enough to respond strategically to innovation (whether generated bottom up or top down), have the discipline to lead where the evidence indicates success and then to systemically scale practice across the system.

In short, we need to ask ourselves, how do we ensure that the success of some becomes the outcome for many and that greater equity is realised through a culture that allows for experimentation combined with a robust evidence base? If education is to be the transformative vehicle that equips young people to thrive in an AI world, our response to challenges ahead cannot be fragmented, but must flow through to each of the cornerstones of school education – quality teaching, school leadership, curriculum and assessment.

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