Horizon Scanning Series

The Effective and Ethical Development of Artificial Intelligence: An Opportunity to Improve Our Wellbeing

Education and Training

This input paper was prepared by Rosemary Luckin

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Education, skills and training (early childhood through to tertiary)

The below questions outline our current thinking in this space and we welcome your expertise on whether these are the right questions to be asking or indeed if there is a better direction to take.

3.2.1 Agile and transferable skills

- **How do we create agile and transferrable skills that can be applied to AI/How do we train individuals to be able to adapt to future jobs?**
- **Fostering creativity for AI, fostering the qualities we want for AI**

What skills are necessary for a future society which is integrated with AI? What may be some of the broad-based transferable skills required for this society?

How many people do we need to train with specific AI skills or is it more important to raise awareness, enable retraining and ensure lifelong learning is the norm? Is Australia already doing well in this space?

What may be some of the diverse skills and knowledge required for those developing AI technology, such as ethical frameworks, awareness of societal impacts, creativity?

3.2.2 How will AI affect the future classroom?

Will (or how will) AI affect how students and courses will be taught; how students are motivated; how course content might be tailored?

What elements of the traditional classroom might still be critical to education, and how can these elements be continually developed alongside the integration of AI?

How should education adapt to enable a future that provides appropriate skills to individuals to work with AI tools and live in an AI society?

3.2.3. How the education system need to change to prepare students to be work ready?

- **Industry involvement**
- **Microcredentials**

What actions can industries (small to large) take alongside or together with the education system to ensure creation of a workforce which is able to effectively use AI in the workplace and meet industry needs?

Is there scope for strengthening of CPD in response to changes resulting from AI?

What is the role for microcredentials to increase agility and flexibility in the face of change and will they be the dominant mode, not an add on?

How can industry and tertiary institutions ensure diversity in the development, training and application of AI? (e.g. inclusion of women, Indigenous, individuals with disability, LGBTIQ, minority and vulnerable populations).

Education, skills and training

Rosemary Luckin, July, 2018

1. The future of work and society: what are the skills and knowledge we need to foster?

In the summer of 2017 the Australian Broadcasting Commission (ABC), aired a programme called *The AI Race* (ABC, 2017). The show presented data from a study into the risks to Australian jobs from AI powered automation (AlphaBeta, 2017). The ABC presenter explored various jobs from truck driving to the legal profession, for example. What became quickly apparent to the viewer was the fact that few people felt well-prepared for AI's onslaught on their workplace. And yet, we must prepare everyone, young and old to be able to live and work effectively with and alongside AI if societies are to reap its considerable potential benefits. One of the big challenges for those of us involved in education and training is to identify exactly what this means in terms of skills, abilities, competencies, behaviours and knowledge.

A little later in 2017, Pearson, Nesta and the Oxford Martin School at the University of Oxford published a collaborative report called The Future of Skills: Employment in 2030.[1] This publication reports a detailed analysis to map out how future employment is likely to change and identify the implications of these changes for skills. The analysis focusses on the US and the UK, but nevertheless there are insights of value to countries across the globe. For example, those working in Education, healthcare, and the wider public sector are likely to see their roles and jobs grow in number and importance. However, some low-skilled jobs, such as those in construction and agriculture, are likely to suffer. The report identifies the skills that are likely to be in greater demand in the future, including: interpersonal skills; higher-order cognitive skills, such as Originality; Learning Strategies: the ability to set goals, ask appropriate questions, and take feedback into account as knowledge is applied meaningfully in a variety of contexts. The results reported in this publication confirm the future importance of what are often referred to as 21st century skills including, and in some cases especially, interpersonal competencies, a finding that is consistent with other writers, see for example (Tett, 2017).[2]

There are many versions of the so-called 21st century skills that we need to instil in people. Most versions have some things in common and a few differences. For example, in 2015 the World Economic Forum published a report called, *New Visions of Education: Unlocking the potential of technology (http://www3.weforum.org/docs/WEFUSA_NewVisionforEducation_Report2015.pdf)* . This report divided 21st-century skills into three categories:

- *Foundational literacies* would equip students to apply their core skills to everyday tasks. These literacies included: literacy, numeracy, scientific literacy, ICT literacy, financial literacy, and cultural and civic literacy.
- *Competencies* would help students approach complex challenges. Four competencies were identified: critical thinking and problem-solving, creativity, communication, and collaboration.

[1] https://www.nesta.org.uk/report/the-future-of-skills-employment-in-2030/

[2] Tett, G., 2017. An anthropologist in the boardroom. Financial Times

- *Character qualities* would help students know how to approach their changing environments. There were six character qualities: curiosity, initiative, persistence, adaptability, leadership, and social and cultural awareness.

By contrast, Bernie Trilling and Charles Fadel, in a much cited-book entitled *21st Century Skills: Learning for Life in our Times* (Trilling *et al*., 2009), suggested a slightly different set of 21st-century skills. Like the World Economic Forum, Trilling and colleagues categorised 21st century skills into three groups:

- *Learning and Innovation skills*. Learning to create together. This category included The Knowledge and Skills rainbow, Learning to Learn and Innovate, Critical Thinking and Problem Solving, Communication and Collaboration, Creativity and Innovation.
- *Digital literacy skills*. This category included: information literacy, media literacy and ICT literacy.
- *Career and Life skills* included Flexibility and Adaptability, Initiative and Self-direction, Social and Cross-cultural interaction, Productivity and Accountability, and Leadership and Responsibility.

These two examples illustrate the lack of consensus amongst those who are identifying these skills. All of the skills sound like a good idea, but they do not provide a good basis for designing education and training systems. In Luckin (2018) I suggest that a more future proof and appropriate approach to education and training is to focus upon Intelligence and the notion of an interwoven intelligence as the basis of an intelligence-based curriculum. The Interwoven Intelligence consists of seven elements as illustrated in Table 1.

Table 1 Interwoven Intelligence: Academic, Social and Meta Intelligence

	Element Name	1. Element Description
1	**Academic Intelligence**	**Knowledge about the world knowledge and understanding that is multi and interdisciplinary. Knowledge is not the same as information, but we frequently muddle them up. We need to stop doing this.**
2	**Social Intelligence**	**Social interaction capabilities** social interaction is the basis of individual thought and of communal intelligence. AI cannot achieve human level social interaction. There is also a meta aspect to social intelligence through which we can develop an awareness of and the ability to regulate our own social interactions.
–	**Meta-Intelligence**	
3	**Meta-Knowing Intelligence**	– Knowing about knowledge. Epistemic intelligence or our personal epistemology. We must develop an understanding of what knowledge is, what it means to know something, what good evidence is and how to make judgements based on that evidence and our context.
4	**Meta-cognitive Intelligence**	Includes regulation skills. We need to learn and develop the ability to interpret our own ongoing mental activity and these interpretations need to be grounded in good evidence about our contextualized interactions in the world.
5	**Meta-subjective Intelligence**	Metasubjective knowledge, and skilled metasubjective regulation. The term *metasubjective* encompasses both our emotional and our motivational knowledge and regulatory skills. We need to develop our ability to recognize our emotions and the emotions of others; to regulate our emotions and behaviours with respect to other people and with respect to taking part in a particular activity (our motivation).
6	**Meta-contextual Intelligence**	Metacontextual knowledge and skills are essential for understanding the way in which our physical embodiment interacts with our environment, its resources and with other people. Metacontextual intelligence includes physical intelligence, through which we use our bodies to

		interact and learn about the world. Metacontextual intelligence is our intellectual bridge to our instinctive mental processes so that we can recognize when they are demanding attention and evaluate if that attention is warranted. Metacontextual intelligence will also help us to recognize when we are biased and when we are succumbing to post-hoc rationalization;
7	**Perceived self-efficacy**	This intelligence element requires an accurate evidence based judgement about our knowledge and understanding, our emotions and motivations and our personal context. We need to know our ability to succeed in a specific situation and to accomplish tasks both alone and with others. This is the most important element of human intelligence and it is highly connected to the other 6.

The 'perfect storm' that brings together 3 factors: data, computing power and storage, have been combined with sophisticated AI systems that can use the computing power to learn from the data. Machines can learn thanks to AI, and they can learn faster and they can recall what they have learnt more accurately, than humans. However, this learning is currently only within the sphere of element 1 of the interwoven model of intelligence: knowledge about the world. Machines can mimic some of the features of other elements from the interwoven intelligence model, such as emotions, but they feel no emotions, and have no awareness of the subjective experience of any emotions.

Our human ability to learn is the key to 'moving' our intelligence so that we better value and more effectively develop and use all 7 elements of intelligence, and in particular our accurate perceived self-efficacy. Societies must fulfil their responsibility to their members by designing and implementing education systems that effectively develop people's interwoven intelligence.

2. AI and the future classroom

It is tempting to address the impact of artificial intelligence in the work place and within education from the perspective of computer science. This is somewhat techno-centric perspective is understandable, because it is after all computer science that has built the AI systems we use today and therefore it is understandable that we would look to disciplines such as computer science to help us as we deal with an increasing number of such systems. It is certainly true that we need to engage a more diverse population in acquiring the skills to design and develop our future of artificial intelligences. However, whilst this is important it is only applicable to a minority of the population, whereas understanding enough about AI to use it effectively and to make sound decisions about whether or not to allow it into our lives is something that everyone needs to understand. I therefore urge that we adopt a more human centred approach to education
I have previously identified two key dimensions that need to be addressed (Luckin, 2017b):

1. How can AI improve education and help us to address some of the big challenges we face?
2. How do we educate people about AI, so that they can benefit from it?

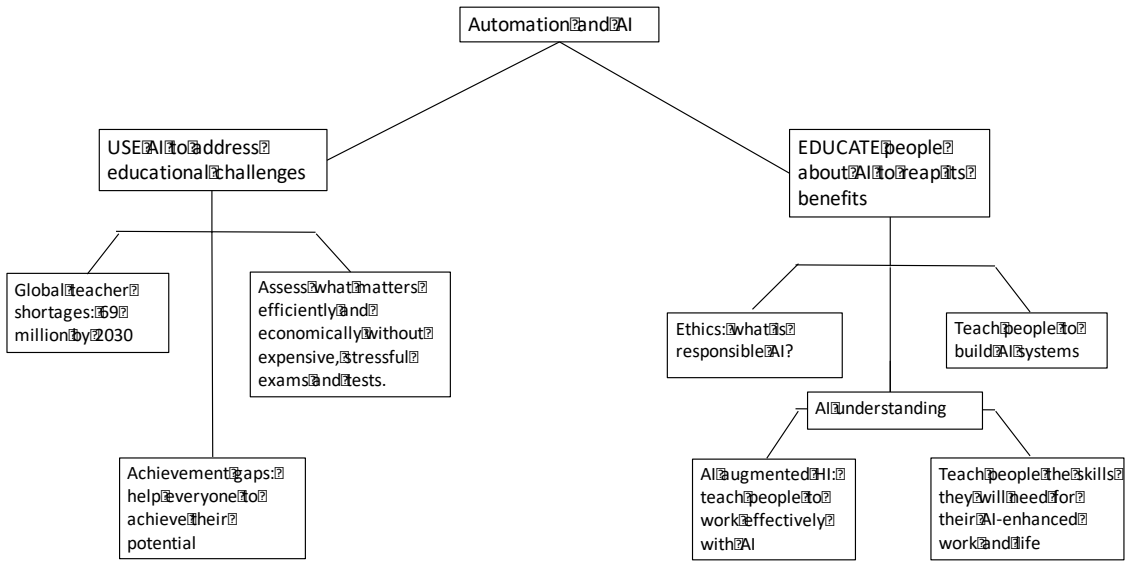

Figure 1: The AI and Education Knowledge Tree (taken from Luckin, 2017b, page 111)

Dimension 1 requires the thoughtful design of AI approaches to educational challenges. This enterprise must start with a thorough exploration and specification of the educational problem to be tackled, not with the technology. Only when a well-designed solution to a well understood educational challenge exists, can we start to consider what role AI can best play in that solution and what type of AI technology or technique is best suited to achieving a solution.

It is relatively straightforward to develop AI systems that can teach well-defined subject areas, such as those that are routinely part of the STEM curriculum. These systems can help learners to build an understanding of the facts that continue to be a part of the STEM subject curricular and they can help with deeper study of these subjects too, thus linking to other intelligences and helping to build stepping stones to develop learner's personal epistemology. Some of these AI systems are modelled on research from AI scientists such as, Anderson, Simon and Sweller, research that is also used as the basis for the what and how of teaching proposed by Christodoulou.

These systems, such as those by Carnegie Learning (https://www.carnegielearning.com) provide individualised tutoring, by continually assessing each student's progress. The assessment process is underpinned by an AI-enabled computer model of the mental processes that produce successful and near-successful student performance. The growing body of AI educators is increasingly breaking beyond the constrained areas of STEM subjects, to language learning for example. With companies such as Alelo (https://www.alelo.com/), for example developing culture and language learning products that specialise in experiential digital learning driven by virtual role play simulations powered by AI. Machine Learning techniques are also being used to enable companies such as UK-based Century Tech (www.century.tech/), to develop a learning platform with input from neuroscientists that tracks students' interactions, from every mouse movement and each keystroke. Century's AI looks for patterns and correlations in the data from the student, their year group, and their school to offer a personalised learning journey for the student. It also provides teachers with a dashboard, giving them a real-time snapshot of the learning status of every child in their class. There is now every chance that an AI educator can be developed for almost all areas of the current school and college curriculum in most countries. *Therefore, if we reduce the job of teaching to one of helping students remember facts and rules and using only these to construct key knowledge across school or college subject areas, we are damning teachers to be replaced by AI.*

We must be far more ambitious for our learners then merely helping them to acquire knowledgeable understanding and skills from the standard academic curriculum. All educators know that this has never been sufficient. But, because we can now increasingly leave the job of doing this Element 1 development to AI, we must develop education systems that encourage our human educators to use their expertise to focus on the other elements of our human intelligence.

There are three key parts to Dimension 2 of the AI and Education tree in Figure 1, each of which needs to be introduced into the curriculum at different education stages from early years to adult education to prepare people to reap the greatest benefits from AI. One of the key parts to Dimension 2 is concerned with technical knowledge and ensuring that we have enough people from a diverse population who can build the AI systems of the future. We need to bear in mind however that much of this will be about clever design and comparatively less Will be about writing computer code. To some extent at least our future AI systems will be able to code parts of themselves.

The two much larger parts of Dimension 2 are concerned with what many more people will need to understand. Firstly, everyone, including those who are currently out of work and outside of any educational or training System, will need to understand enough about what AI is to use it effectively. This means that we all need to understand the principles of what AI means, what it can and cannot achieve, what we can and should expect from our AI and what AI is not capable of achieving. It is important that we do not succumb to the notion that this understanding of the basic principles of AI is beyond the capability of society at large. We need to find ways to explain it to people to ensure that they are able to make informed decisions about how they use AI in their lives.

Secondly, we need to ensure that enough people understand the subtler and more nuanced implications of what AI can and cannot achieve, both directly and indirectly in order to ensure that the appropriate ethical and regulatory mechanisms are in place. History is strewn with examples that demonstrate that left your own devices we do not always universally see to act in a manner that benefits societies as a whole rather than specific populations. The three parts of Dimension 2 cannot be dealt with it discreetly, they are interconnected and must inform each other. Four example the minority of people who develop the AI systems of the future need to communicate with those who develop the regulatory frameworks to ensure that the implications of our AI systems are fully understood and encompassed. In turn those who work with the ethical regulatory requirements the society must ensure that the manner in which members of society are educated and engaged in understanding their AI systems are sufficient and fit for purpose. Above all we must prioritise the education and training of our educators and trainers. The vast majority of whom currently have little or no understanding of AI, its implications and how they must now change their practice to both encompass its use and to build within their students an appropriate understanding of AI as well as a sophisticated level of intelligence across all the seven elements I have described in this book. Any failure to recognise and address the urgent and critical educator training requirements implicit in societies' adoption of AI is likely to result in increased disadvantage, poor productivity and increased vulnerability.

Imagination and Creativity

Einstein is believed to have equated intelligence with imagination. Creativity and imagination can be found within proposals about 21st-century skills and innovation, such as those already outlined. Creativity and imagination enable us to express our thoughts, feelings and desires and they underpin scientific and technological development too. Creativity and imagination are not a separate sort of intelligence, rather they are the result of the development of all seven elements of our human intelligence.

Creativity and imagination can be nurtured by education, although systems that focus primarily on knowledge acquisition where there is an emphasis on testing and examinations can hamper learners' capacity to be imaginative and creative. Some of the key aspects of behaviour that have been identified as being associated with creativity include being curious and questioning, being willing to explore and challenge one assumptions. Persistence is also important, as is being confident enough to be different and capable of coping with a degree of uncertainty as well as having the ability to focus and direct one's attention.

Creativity and Imagination are also sought by AI system designers, but with limited success.. Margaret Boden (1990, 1998) believes that there is still much for us to learn about human creativity and that AI can help us to understand more about our own creativity. Boden draws a useful distinction between exploratory and transformational creativity, the former can be thought of as finding something new from within an existing space of possibilities and accounts for the vast majority of what human creativity produces, whereas the latter requires a paradigm shift to a new conceptual space. Machine learning using neural network systems can be used to identify a novel item, a random combination of musical notes, for example, or a mix of colours and shapes. This will fall within the exploratory form of creativity.

3. The Future of Education

AI is taking over a great deal of what has previously been viewed as the human domain. As a result, the evidence that we need to change the way we view intelligence and the way we design our education systems is increasingly compelling. We need to act on this evidence and use our human ingenuity to re-imagine our education systems to enable us to remain the smartest intelligence on the planet.

To achieve this, education systems need progression models that constantly promote growth across and between all seven intelligence elements. Embracing the AI augmented world is not simple however, and whilst educators are unlikely to be amongst the early white-collar victims of AI replacement, but their lives must and will change forever. They will need to teach different material, as well as some of the material they already teach, and they will need to teach differently.

A sophisticated personal epistemology helps people develop sophisticated knowledgeable understanding and skills from their academic Studies. And it is beyond AI. To extend the initially simple personal epistemologies of our students, we need to explicitly teach them about the potential sources of knowledge and the ways in which they can justify that knowledge is justified. We need to help people design and ask good questions that probe the information they are presented with in an appropriate and useful manner. We and they must recognise the contextual nature of their knowledge and its inconsistency.

The final and most important most important element of human intelligence is perceived self-efficacy. It pulls together all the other intelligence elements and is way beyond the powers of AI. Self-efficacy is important for teachers as well as learners. We can help learners to develop a greater understanding of their own self-efficacy through developing the other six intelligence elements. It also needs to be the focus of specific and explicit teaching. It should be the intelligence that we strive for throughout our lives, within and beyond our formal education and training.

Moving to an intelligence based curriculum of the sort outlined here will require a transformational change, for which we must plan now. And, as if this were not challenging enough, we also need to teach people about AI, including and as the highest priority, we need to teach the teachers and

trainers about AI. Education about AI must include: teaching people how to work effectively with AI systems; giving people a voice in what AI should and should not be designed to do; and helping some people to build the next generation of AI systems.

AI can help us build our future education systems based on the progression models that include all seven intelligence elements. It is technically straightforward to develop AI to teach academic, interdisciplinary knowledgeable understanding and skills including the provision of detailed continuous assessment about each individual's progress towards each goal. The use of such systems would free our human educators to focus on the holistic development of their students interwoven intelligence.

References

ABC (2018) The AI Race. The Australian Broadcasting Commission. Online. http://www.abc.net.au/tv/programs/ai-race/ (accessed 13 February 2018).

AlphaBeta (2017) The Automation Advantage: How Australia can seize a $2 trillion opportunity from automation and create millions of safer, more meaningful and more valuable jobs. AlphaBeta. Online. http://www.alphabeta.com/wp-content/uploads/2017/08/The-Automation-Advantage.pdf (accessed 13 February 2018)

Boden, M. 1990. The Creative Mind. Abacus.

Boden, M. 1998. Creativity and artificial intelligence. Journal of Artificial Intelligence.

Luckin, R. (2017) Towards artificial intelligence-based assessment systems. Nature Human Behaviour 1, Article number: 0028 DOIdoi:10.1038/s41562-016-0028

Luckin, R. 2018 Machine Learning and Human Intelligence: The Future of Education in the 21st Century

Tett, G., 2017. An anthropologist in the boardroom. Financial Times

Trilling, B., Fadel, C., & Partnership for 21st Century Skills. (2009) 21st century skills: Learning for life in our times. San Francisco: Jossey-Bass.