



The paradigm shift Redefining education

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A l'école en l'an 2000

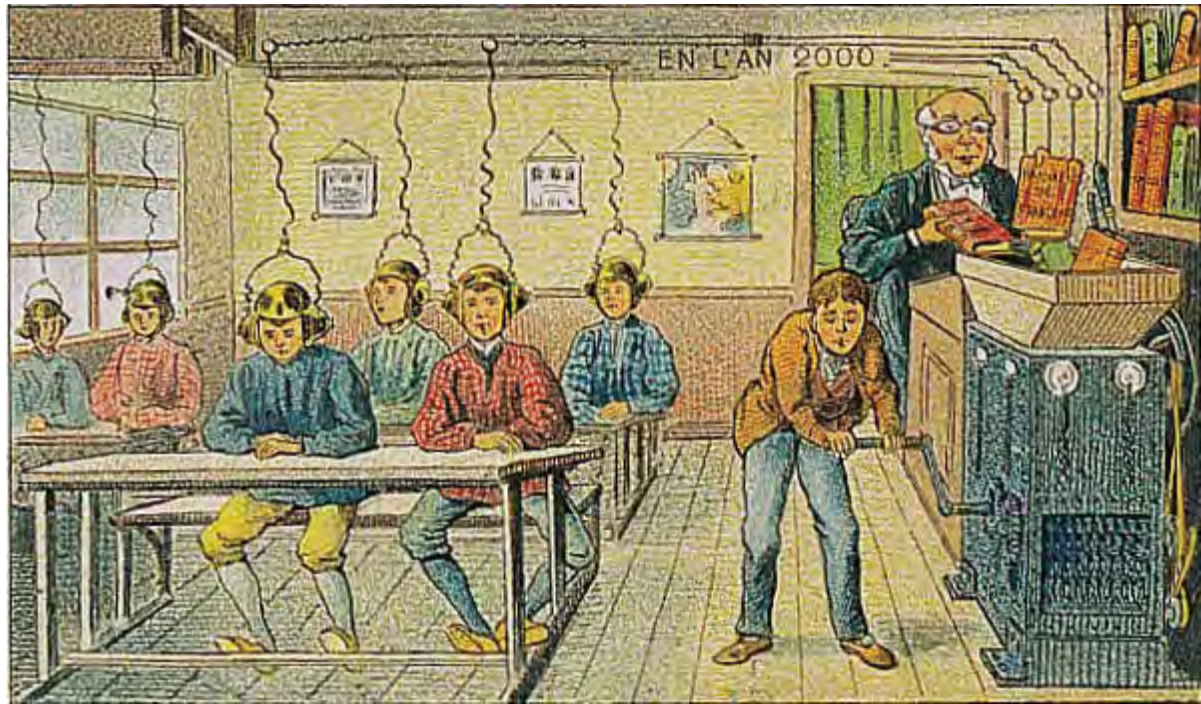


Image 1: A l'école en l'an 2000, Villemard, 1910, chromolithographie, Paris, BNF, Estampes.

If we had lived in the late 1800s, we might have imagined schools in the year 2000 as a place where students are educated by transmitting knowledge directly into their consciousness via something akin to the electric telegraph, an invention of the early 1800s. We wouldn't, however, have considered a future where the student decides which direction their education should take instead of relying on the teacher to direct them to what is (and what isn't) relevant.

Executive summary

Digital technology has changed how society relates to knowledge. The value accorded to what people know ('knowledge stocks') is progressively being replaced by an emphasis on the ability to find and share new knowledge ('knowledge flows'). At the same time, the relentless rise of digital technology means that traditional ways of acquiring an education are being disrupted. What once required a trip to the library and extensive research is now no further away than your smartphone. Ideas that previously took years to share with colleagues now flash around the world in seconds. Understanding the techniques that made Alfred Hitchcock's films so compelling previously involved a significant investment in researching film criticism and hunting down screenings. These same tasks can now be accomplished from the comfort of your lounge over a weekend. It might be said that 'it's not what you know, it's what you can google that matters'.

The Centre for the Edge has spent the last nine months investigating how this change in our relationship with knowledge might affect the education sector. We have identified two emerging trends that have led us to believe that the sector is about to go through a change in paradigm.

First is the shift from a traditional, formal education, to work-integrated learning. Historically learning has been concentrated in the years of our formal education, before our career proper began. More recently, learning has become something that we undertake periodically at the start of each new phase of our career, a career of serial specialisation driven by the rapid, and inevitable, ageing of our knowledge stocks. The emerging trend is for learning to be continuous and embedded within our professional environment; this work-integrated learning is necessary for us to adapt and thrive in an uncertain and ever-changing world. This is an environment where individuals are constantly on the lookout for interesting and useful knowledge, knowledge that they will 'pull in' and learn to fill a gap in their current knowledge, a gap that is preventing them from completing a project or reaching their goals.

Second is the emerging trend for employers to move away from using formal credentials as the gold standard against which all candidate employees are measured. The suitability of a candidate is increasingly being judged in terms of their observable attitude and behaviours, their broad experience and track record of integrating new knowledge and skills into their work. For example, Google (a leading indicator in business practices) has shifted its hiring practices from trying to find the most highly credentialed specialists possible, to focus on identifying what they call 'smart creatives' – smart and capable generalists who demonstrate the attitudes and behaviours that will enable them to be effective learners and team players, with formal credentials (should the candidate hold them) playing only a minor role.

Taken together, these trends suggest a future where being educated has a much broader definition than it has commonly had in the past. Historically, being educated meant possessing the knowledge and skills that allowed a person to participate in the traditional professions. In the rapidly changing world of the 21st century, the focus for many workers is shifting from the analysis and evaluation required to optimise a firm's operations, to quickly creating new products and services in response to a rapidly changing market. Today, being educated increasingly also means having the attitudes and behaviours that enable one to adapt quickly to changed circumstances.

The Centre for the Edge's research leads us to suggest that the questions confronting the education sector are not just those of pedagogy or technology, but of purpose and role. There seems to be a fundamental shift occurring in how we use and think about knowledge and skills. Knowledge is becoming something that we now pull in as required, rather than being pushed out by an institution via instruction in anticipation of a future need. If this fundamental shift turns out to be real, then it will usher in a new paradigm and transform the education sector. The shift will redefine the role of educators and how they relate to students and employers.

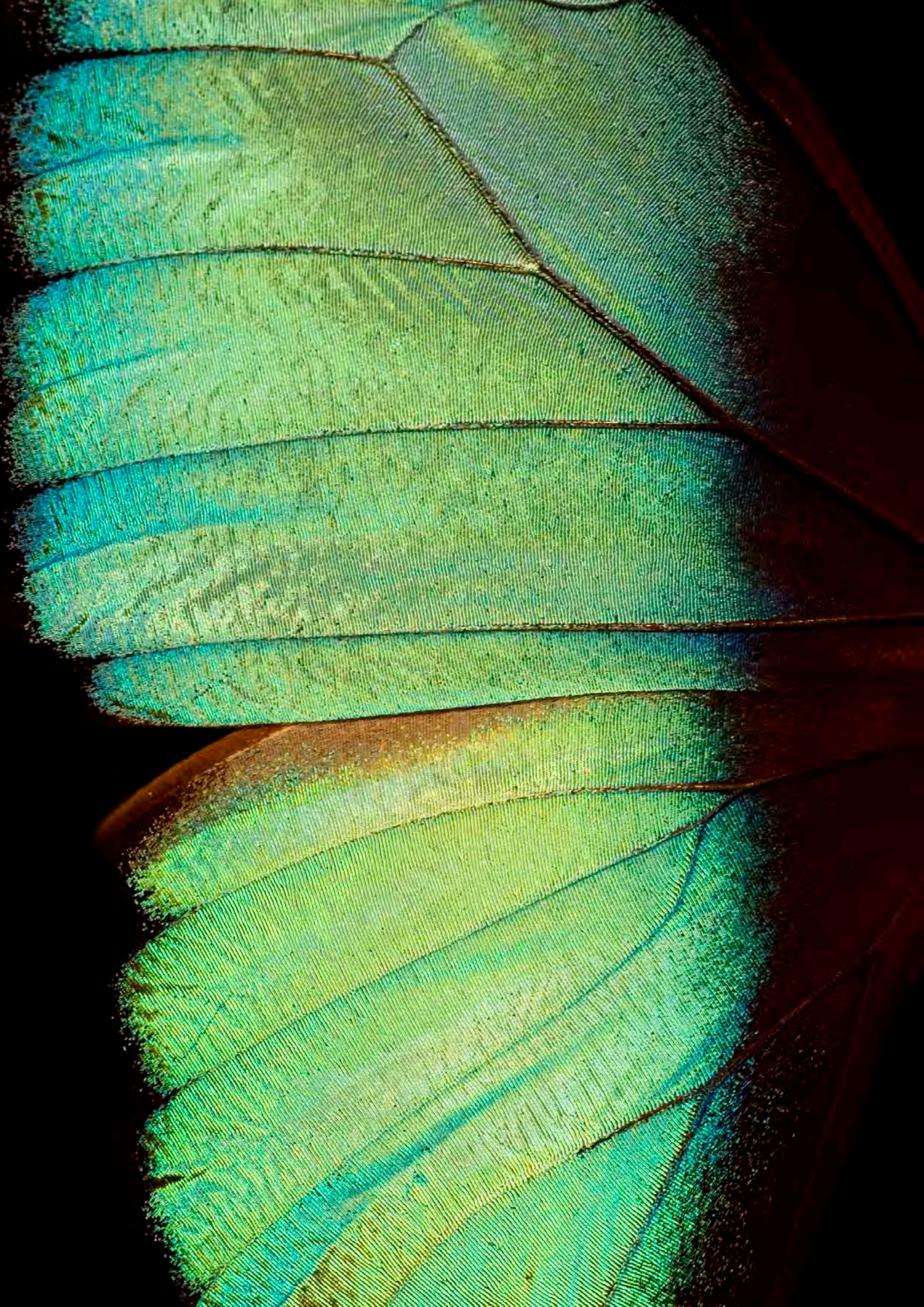
While knowledge stocks might be giving way to knowledge flows, individuals still need to know enough to be conversant with, and productive in, their chosen fields; they will also have to be sensitive to the need to continually update their knowledge stocks. This raises a number of important questions. What are the skills that students need to develop to help them know what they need to learn in later life when solving problems? How does an educator impart the attitudes and behaviours of the new paradigm students require to succeed? And how can an educator create an environment where students can explore the intersection between their skills and interests, enabling them to find the domain of inquiry that they will pursue for the length of their career?

At the same time, the shift to knowledge flows has the potential to expand the foundation of an educator's perceived value from their 'expertise' – their ability to develop knowledge stocks – to include their effectiveness in contributing to the topics in which they are interested – knowledge flows – interacting with communities built around common interests, sharing their experiences, insights and problems and pulling in a diverse range of participants (students, academics and industry practitioners).

For educational institutions, the implications are huge. While formal credentials will remain critical in fields such as medicine, law and engineering, a host of other sectors such as information technology will experience a greater concentration of informal and work-integrated learning. The danger is that by not considering the possibility of a change in paradigm they – with all their embedded value – will be replaced by the institutions of the new paradigm. The old education system, the one that has sufficed for centuries, may no longer be seen as sufficient in this changed environment.

It is possible that, sometime in the not too distant future, rather than having one education sector, we'll have two: an old, industrial-era sector that is increasingly marginalised and irrelevant for the majority of the population, and a new social-era sector dominated by social media and 'global tribes' with which a majority of people engage.





A sector under the microscope

Australia's education sector is under pressure.

An increasingly competitive job market is forcing individuals to look for an edge to stand out from the crowd. They're well aware that individuals with better skills and qualifications have historically enjoyed lower unemployment rates¹ and higher earnings.² Tertiary educational attainment in Australia (the percentage of adults aged 25-65 who obtain a tertiary degree) has steadily climbed over the past three decades and currently stands at 41 per cent, ahead of the OECD average of 33 per cent and the EU21 average of 29 per cent.³ The Commission on Inclusive Prosperity recently found that the inclusive nature of Australia's (and Canada's) education sector was a significant factor in maintaining middle class incomes and long-term economic growth in a world where technological change is increasing productivity and mechanizing jobs simultaneously in so many sectors, and where middle-income growth has halted in many other developed nations.⁴

Graduates are lacking workforce skills

While demand for a quality education (beyond secondary school in particular) continues to rise, both employers and students are dissatisfied with the nature of the education that institutions are providing. Employers complain that educators aren't providing students with the skills they need to succeed in the workplace.

Students, on the other hand, struggle with the disconnect between educators' calls for engaged citizens and independent thinkers and the credential-based admittance criteria tertiary institutions actually use to select students. The creative and collaborative pedagogy practised during the majority of K-12 education goes by the wayside in the later years as secondary schools focus on helping students obtain the test scores needed for admission to tertiary institutions.

Technology causes societal shift

In early 2014, the Centre for the Edge attempted to gauge the level of this disconnect as part of the first release of the Australian Shift Index.⁵ The Shift Index uses three indices to measure the change in Australia's economy (see Figure 1). This change is founded on the penetration of cost-effective computer and

communications technology into Australian society, together with improvements in economic freedom, as illustrated by the Foundation Index (the leading indicator in the Shift Index)

Citizens and businesses are empowered by the new technology, using it to shop, research and work in new ways, creating complex new knowledge flows as a result. The Flow Index gauges the magnitude of this increase in terms of changing information and capital flows.

Finally, the Impact Index (the lagging indicator) measures how the developments mapped in the previous two indices have affected the Australian market, and the citizens and businesses within it.

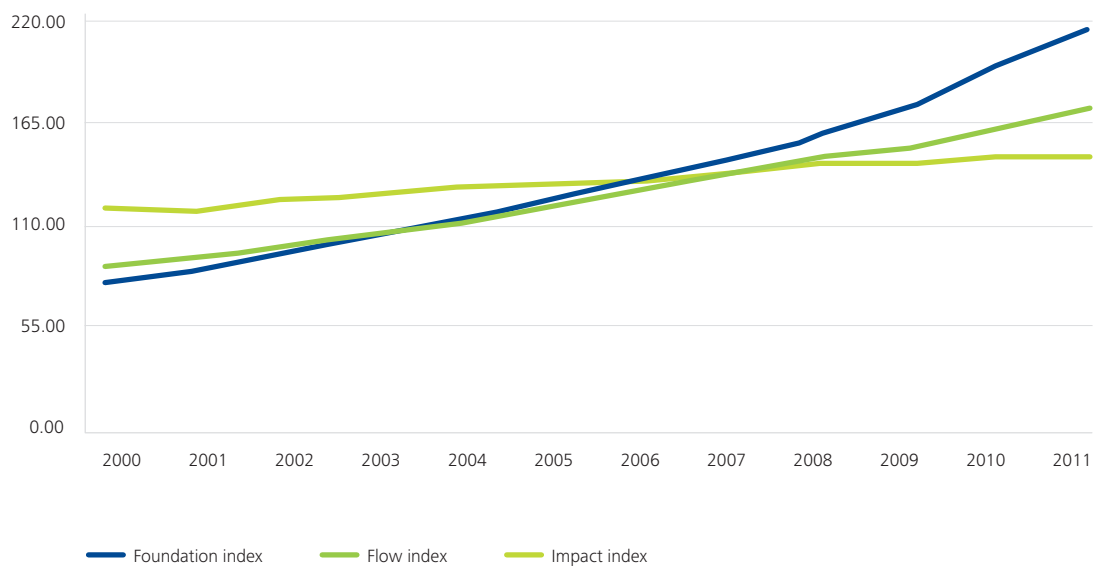


Figure 1: The Shift Index shows that Australians are voracious adopters of technology (the Foundation Index) and that we are successfully using this technology to create new information flows (the Flow Index), but we are not realising the full potential of these information flows (the Impact Index).

The relative difference in gradients between the Foundation and Flow indices – and between the Flow and Impact indices – provides a measure of Australia’s ability to leverage the opportunities presented by digital technologies.

If the Foundation – Flow gap is smaller than the Flow – Impact gap, we have been more successful at creating knowledge flows than realising their value. If the Flow – Impact gap is smaller than that Foundation – Flow gap, the opposite is true: we are more successful at leveraging knowledge flows than creating them.

Ideally, we want a balanced result, one where we are creating new knowledge flows and successfully tapping into the value they contain. If there is an imbalance – if the Foundation – Flow and Flow – Impact gaps are not roughly equivalent – we can assume that there is untapped value, or waste.

The Australian Shift Index shows that while Australia is a technologically voracious society, we are not seeing the full benefit of digital technologies. Individuals and groups are increasingly adopting these technologies and using them in their daily lives. Institutions are lagging, however, and the impact of these technologies on the economy as a whole is lower than it could be.

The conclusion therefore is that we are not leveraging the knowledge and knowledge flows as effectively as we should be. We are leaving money on the table and the education sector would appear to be one of our most effective tools to improve our ability to capture this value.

The rise of digital technology – particularly mobile technology and social media – is driving what might be called the social revolution. Digital technology slashes the cost of communication, and data collection and processing, resulting in a dramatic (often exponential) increase in the flow of information through society.⁶ Most of the friction has been removed from communicating and collaborating. What once required a trip to the library and extensive research is now no further away than your smartphone. Ideas that previously took years to find their way around the globe now flash around in seconds. Modern smartphones and social media have shifted the balance of power from firms to consumers, fragmenting the consumer landscape.

Products are being transformed into value-added services – a process called ‘servitisation’ – erasing the distinction between sectors and industries in the process. Monolithic, integrated firms are giving way to business ecosystems, or business value networks, where firms do for themselves only what they can’t have done more effectively externally.⁷ Additionally, new manufacturing techniques and technologies are slashing the cost of production, enabling more and smaller firms to bring new products and services to market and distribute them globally.

Today's employees are increasingly focused externally, intent on creating new opportunities rather than optimising internal operations. Employers are asking them to design new products, collaborate with networks of partners and customers to find new solutions to old problems, as well as find new problems to solve. These design thinking practitioners (the computer engineers, designers and architects) who create these new products and services, are supplanting the administrative professionals from the information revolution.

These individuals are the 'smart creatives' at the heart of firms such as Google⁸ and Facebook. They are the passionate explorers with a drive to learn and improve that goes above and beyond, and who actively seek out others to help find solutions to challenges.⁹

This gradual shift from internal optimisation to external discovery has resulted in a steady rise in the proportion of creative professions and professionals in the Australian economy (see Figure 2).

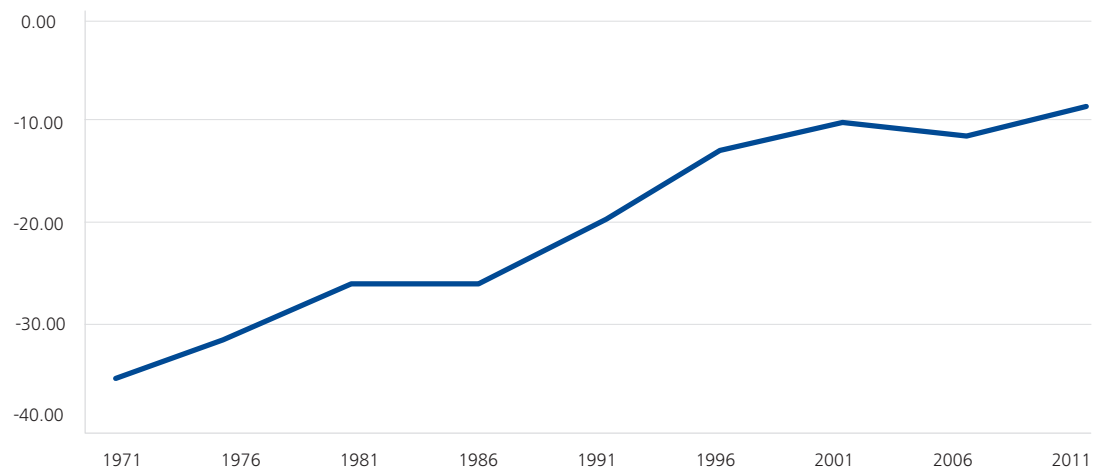


Figure 2: Australia has seen a steady rise in the proportion of its workforce jobs that are described as 'core creative class'¹⁰. The net-bohemian score, developed for the Australian Shift Index, captures this trend by calculating the percentage of the population in a geographic area that has a 'core creative' occupation versus the percentage in the same area with an 'industrial' occupation.

The changing nature of trust

The thread that binds firms and individuals together is trust. The changing nature of knowledge work – the shift from analysis and evaluation, to creation – is changing the nature of this relationship.

Traditionally trust between a firm and an individual was based on the individual's skills and knowledge. The firm trusted the individual to have the knowledge and skills required to fulfil a specific role. The individual would, in turn, trust the firm to support them and develop their skills, hopefully rewarding them with promotion in the process.

The challenge was finding a way to establish this trust relationship when neither the firm nor the individual knew each other. The individual was forced to rely on the implicit social contract between industry and society, historically known as jobs for life, and the expectation that the firm would support the individual for the length of their career.

The firm, on the other hand, needed a way to determine that the individual possessed the skills they claimed to have, that it could trust the individual to be able to apply a known body of knowledge and skills to a known problem in a known way for a reliable outcome. The formal credential – issued by an established educational institution with a well-known brand – enabled the firm to leverage their trust in the institution to determine if they should trust the individual.

Today, trust is being turned on its head.

Congruent with the rapid depreciation of an individual's knowledge stocks is the rapid depreciation of a firm's knowledge stocks, the best practice used to develop products and optimise the firm's operations. Best practice looks backward, providing advice that worked in the past, while next practice focuses on what to do in the future.¹⁷ Next practice is, by definition, future-oriented. No single institution or company is an exemplar of the next practice that a firm should adopt; next practice is focused on amplifying weak signals, experimentation and discovery. A firm now needs individuals who can, together as a team, develop the next practice that will carry the firm into the future. While firms know that they have problems to be solved and develop next practice, they are unsure of the precise nature of these problems or what is required to solve them.

It is not possible to find a person with applicable certified skills and knowledge as it is not possible to identify from the outset the skills and knowledge that will be required. New roles and professions are being created, and existing ones redefined, as firms blend domains and disciplines as they explore and synthesize new solutions. Marketing departments, for example, are hiring Data Scientists, Service Designers and creating Chief Marketing Technologists to support marketing campaigns that blend analytics, social media, internet and mobile applications, temporary supply chains, and popup retail stores. Human resources are using analytics, big data and social media to find new candidates. The growth of servitisation is forcing firms to create blended teams that roam across product categories, industries and sectors in pursuit of a compelling value proposition and a competitive edge.



Individuals, in turn, are looking for opportunities to pursue their interests and develop their skills rather than a career-long commitment. This is partly due to the steady erosion of the jobs-for-life social contract over the past few decades. Careers are being transformed from a story of increasing specialisation (or even serial specialisation) in a single firm, to the prosecution of a domain of inquiry, with the individual pursuing their interests via tours of duty in a range of firms.¹²

In this environment, trust is based on future expectations, and not just past performance. Firms are looking for individuals who can develop next practice, individuals they can trust to find new ways to solve new problems, individuals who have a track record of learning and integrating new ideas into their work to create novel products and solutions. Individuals, on the other hand, want firms they can trust to provide them with the freedom they need to do their job and opportunities to grow professionally and publicly demonstrate their value.

In this new environment, traditional certifications do not have the value they did in the past. Knowledge and skills, while still important, have become table stakes. As mentioned earlier, firms are focusing on hiring 'smart and curious people [rather] than people who are deep, deep experts in one area or another.'¹³ Identifying these people increasingly means using alternatives to a formal credential; alternatives that enable a firm to determine which candidate has the right attitude to apply their expertise and the ability to work within the organisation's team and grow professionally.

One such alternative is the Building Leadership Simulation Centre (BLSC) in Melbourne, which uses simulated work environments to help construction firms determine where recently hired graduates' abilities lie. The outcome of these simulation sessions can have a significant effect on an individual's career, as it will highlight their skills (or lack of skills) across a range of areas such as negotiation, time management, conflict resolution and leadership. This will determine where in the firm their career lies and how far they can be expected to go.

Trust, in these circumstances, means finding an individual who:

- Has a demonstrable interest in prosecuting the problem at hand
- Has a track record of having solved similar types of problems successfully in the past
- Has broad experience and a track record of integrating new knowledge and skills into their work
- Is connected to a broad range of communities that enable them to tap into a diverse range of new ideas, skills and techniques
- Exhibits behaviours that let them work effectively as part of a larger team.

It is for this reason that Google puts its trust in (potentially uncredentialed) 'capable generalists' rather than 'experts', as Laszlo Bock, Google's Vice-President of People Operations, pointed out in an interview with *The Economist*.¹⁴ Google finds that a 'smart' person will find the same solution as an expert 90 per cent of the time, and the other 10 per cent of the time they will find a new solution that is actually better.¹⁵

New tools and techniques

Neither the commonly perceived problems with traditional education, nor the resulting prescriptions, get to the heart of the matter. The recent emergence of new learning tools and techniques has driven the development of pedagogy, however the challenge facing credentials is different. The problem with credentials is not one of size, longevity or subject selection – which could be fixed by unbundling degrees – but one of relevance.

As knowledge and best practice depreciate at an increasing rate, the skills employers are looking for – the skills that are the most valued – have broadened from analysis and evaluation to include synthesis and creation, from the development of best practice to the creation of next practice.

The current educational paradigm is built on building stocks of knowledge, transferring those stocks to individuals, then certifying that the knowledge has been successfully transferred. Society has, however, moved on. The focus is now on behaviours, as skills and knowledge can be obtained on demand as required. The next generation is increasingly defining itself in terms of their social graph – their interests, activities and relationships with other individuals – rather than institutional badges such as credentials or affiliations.¹⁶

The challenge for organisations is to find the individuals who excel at finding new problems to solve and new ways to solve them, rather than individuals with deep analysis and evaluation skills in a particular field.





The problem with predictions

The problem with many predictions is the unstated assumptions behind them. We like to imagine a future that is different, but not so different that established norms are upset. Details might change, but key roles (particularly our own) will remain intact. Our focus is on incremental change, with our predictions based on observable and (often) quantifiable trends.

We avoid the larger questions that suggest a future where our own role is significantly different, where the knowledge and skills we hold dear do not have the same value as they do today, or a future in which we might not have a role at all. Avoiding these questions, and focusing on incremental change, makes us blind to larger environmental shifts.

Progress is not solely incremental. We often find that long periods of incremental improvement are interrupted by short periods of rapid change.¹⁷

These abrupt changes are not due to the invention of new tools or techniques. They happen when we realise the old paradigm is holding us back and the only way forward is to find a new paradigm, changing the roles of stakeholders and the relationships between them in the process. Or, as Thomas Kuhn put it, 'When enough significant anomalies [inconsistencies] have accrued against a current paradigm, a state of crisis is created which allows new ideas to be tried, eventually leading to a new paradigm.'¹⁸

A model of the education sector

Before we can determine the shape of the new paradigm, we need to tease out the assumptions hidden behind the current one. To do this we need to develop a simple model of the current paradigm that captures the key stakeholders, their motivations and the relationships between them. We can then use this information to look beyond incremental change and consider what the future paradigm might look like.

Figure 3 examines the major roles in the education sector, the relationships between these roles and the motivations of each stakeholder. This model is intended to capture the legacy of the education sector since the dramatic changes of the Industrial Revolution when the sector turned its attentions to providing an industrialised society with the bureaucrats it needed to function. It is a model of how education has functioned, but is not necessarily an accurate model of how the sector functions today – we are caught somewhere between this older sector model and a new model that is forming.

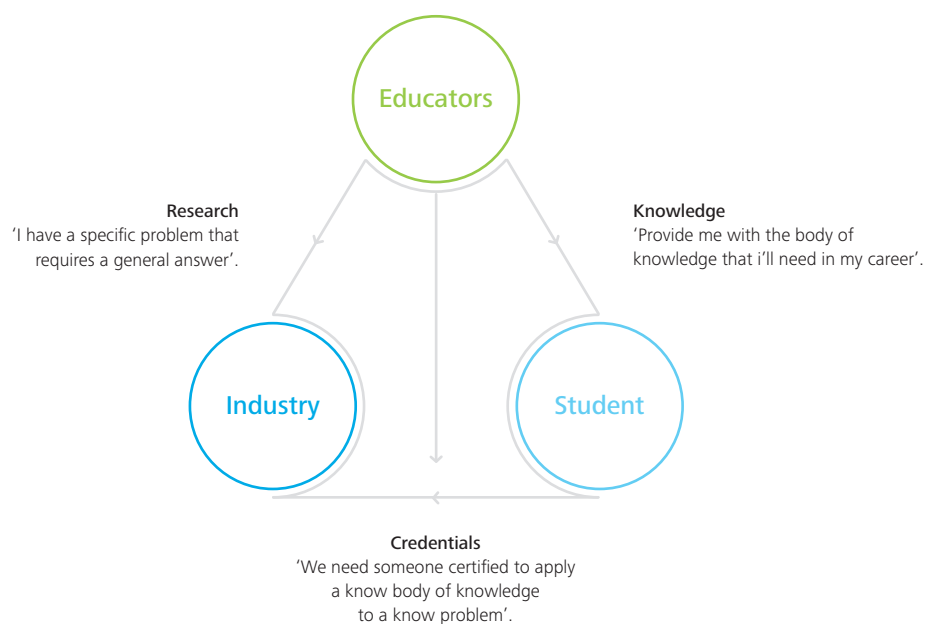


Figure 3: The current education sector is found on creating and maintaining stocks of knowledge (as knowledge has been equated with power), and then pushing these stocks of knowledge to other stakeholders.

To ground our model in the past, we can look to a time before the digital technology that is transforming society emerged on the world stage.

Our model contains three roles: industry, educator and student (or graduate). We have defined the roles in this order as industry has typically set the terms for educators by specifying the skills and knowledge it requires from its employees. Educators have, in turn, defined the terms for students (and graduates), as it was the educators that developed the knowledge stocks and set the performance standards for students.

At this earlier time, industry was focused on scale and efficiency. Management primarily concerned itself with finding enough staff with the analytical and evaluation skills required to populate the vast bureaucracies needed to manage its operations. Knowledge was scarce and educators, as the developers and keepers of knowledge stocks, also acted as trusted advisors to business, providing answers to challenging questions.

Students relied on educators to give them the skills and knowledge which was needed by industry and which formed the basis of their careers. Educators created industrialised letters of recommendation which were granted to students so industry, in the absence of other information, could gauge a graduate's worth.

Educators also focused on building their knowledge stocks. This knowledge would be packaged into curricula – designed to address specific needs in industry or specific educational goals. Initially these needs were not particularly specific, and a general, liberal arts education was seen as the best foundation for students (as well as providing the educated classes with a similar set of experiences that helped bond them together). As business became more complex, these curricula became more specific and more prescriptive, resulting in the various flavours of technical and commercial qualifications. Educators would also engage industry in research and development to develop new tools and techniques.

The value of an educator could then be seen as resting on two pillars:

- The quality of the educator's knowledge stocks which they give to their students. Before the commoditisation and democratisation of these stocks, the best gauge for their value was in the research profile of the educator
- The trustworthiness of the credentials granted by the educator that industry uses in lieu of other information about a graduate. The quality of a credential was determined by a combination of the profile of the educator (such as an 'elite' or 'tier 1' institution) and the certification of the credentialing processes by other professional institutions and the government.

Before we modify our model to estimate the shape of the future paradigm, we need to understand the purpose of education in both the old and new models, as this will determine how the education sector sits in society. Doing this first requires us to be clear on the distinction between research and innovation, and learning and education.

Research versus innovation

Industry is obsessed with innovation, the fuel that powers progress. Unfortunately it is easier to identify innovation in hindsight. For example, many analysts were not impressed by Apple's iPhone when it was first launched as it lacked many features that were seen as standard, essential even, for any smartphone. Time proved them wrong.

The challenge with innovation comes from it being a social process, rather than technocratic or research-driven. The steam engine, for example, was invented by an ironmonger¹⁹ and made practical by a mechanical engineer,²⁰ before thermodynamics (which was, at its origin, the study and theory of engines) successfully explained the operation of what the practitioners had cobbled together.

Research is question focused.²¹ The sign of a good researcher could be said to be the ability to find the interesting questions that need answers. Industry, on the other hand, is problem focused. The challenge is to find new solutions to old problems, or (as in the case of the iPhone) to find new problems that can now be solved with current tools and techniques.

The vast majority of individuals and firms do not need the absolute latest research or access to the best experts. As Henry Ford showed us, managers employ experts in fields (and push buttons to call them in) rather than try to know everything.²² Firms need only knowledge good enough to get the job done, and they need it quickly. The focus is on short-term change. Research is a longer game, as it involves building models that help us understand the world and, through this understanding, improve or change the world in some way. This is not to say that research cannot provide us with innovation. Research into building a computer network that would withstand a nuclear war gave us the modern internet, while research into teasing the information from the noise in radio astronomy resulted in the creation of Wi-Fi.²³ Research and the development of society's knowledge stocks, while essential to progress, are games played on a much longer timescale than the timescale on which industry and innovation operate.

Learning versus education

What does it mean to be 'educated'?²⁴ Historically this implied possession of the knowledge and skills required for success in the professions. These included the ability to organise one's thoughts to communicate them clearly to others, to break a complex problem into its components, apply general principles to specific cases, discern cause and effect, and negotiate trade-offs between competing values. Education was implicitly defined in terms of knowledge and our skill in applying this knowledge.

Learning represents the acquisition of new skills and knowledge by an individual. Ideally, in today's turbulent world, learning occurs when and where an individual realises there is something they need to learn. The widespread penetration of digital technology – from the internet and social media through mobile communications – means learning can, and should, happen anywhere. Knowledge and skills can be pulled into the individual's current context where they can be internalised and then applied to the problem at hand.

Education, on the other hand, is an intervention.²⁵ External forces, mediated by the teacher, are brought to bear on the student, changing the student in a positive way. This is not a passive process, as the intent of the institution is to change the student, to reshape them, their knowledge and their personality. The educator deliberately introduces the student to new ideas and experiences in ways that are outside the student's control. The student is roused from their default behaviour and forced to respond, to accommodate the lessons and make a place for them.

While it is attractive to think of education institutions – from K-12 through tertiary to post-graduate studies – as places for learning, they are, fundamentally, places of teaching, where we might think of teaching as being 'any process [or intervention] that produces good learning.'²⁶ This confusion between teaching and learning is reflected in the term 'lifelong learning'. As it is commonly used, the term would be better thought of as 'lifelong instruction' since the focus is firmly on regularly returning to the educator for formal instruction, even if this instruction is via a massive open online course (MOOC)²⁷ and involves very little human oversight.

There has been a revolution in pedagogy over the past few decades that has resulted in a shift from students 'being taught by' to 'learning from' teachers (some might even say that this represents a shift from the instruction paradigm to the learning paradigm).²⁸ However, while students may, in many cases, learn from their teachers, what they are being taught is

equally important. As schools (and teachers) have reframed learning, shifting the focus from rote content to problem-solving skills, teaching has broadened its focus to include instilling students with the attitudes and behaviours required for them to be productive members of a rapidly changing society. For example, students are encouraged to treat assignments as an opportunity to learn and improve, as well as a way of demonstrating their skills and mastery of a topic.²⁹ Similarly the Centre for the Edge saw during the research of this report an emerging trend for secondary institutions to create wellness programmes and centres which explicitly focus on ensuring that the students are physically and emotionally prepared for both learning, and for the subsequent application of what was learnt.

If a student can improve their ability to perform a task a few per cent every year by finding and absorbing new strategies or techniques, then they will dramatically improve their performance over the longer term. If constantly learning new strategies and techniques is an ingrained behaviour, then they are more likely to adapt to new situations when they are graduates, as the world evolves around them.

If we are to form a view of the purpose of education in the new paradigm, we need to understand the interventions that educators will make, and what they hope to achieve through these interventions.

Knowledge flows versus stocks

The focus of education has moved away from the challenge of transmitting hard-won and tightly held knowledge from teacher to student, or institution to firm. The days when educational institutions were seen as the guardians of society's knowledge are passing.

Our relationship today is with knowledge flows, rather than knowledge stocks. Knowledge, however, does not flow. It is a construct, the value of which is defined socially, diffusing between individuals and throughout society.

We can divide knowledge into two distinct types depending on how much it can be structured and formalised. Explicit knowledge can be expressed formally, via words and symbols, allowing it to be stored in databases and transmitted to remote locations. Tacit knowledge is difficult to express in formal language as it comes from experience and depends on the context in which it was generated.

Knowledge can be thought of as an iceberg. Explicit knowledge is the visible top, easy to find and recognise and therefore easier to share. Beneath the surface, invisible and hard to express, is the body of the iceberg. We know more than we can express and this part of the knowledge resource can be more difficult to share. So while explicit knowledge has been commoditised, transmission of tacit knowledge still relies on diffusion via interactions with other people and through experience. Tacit knowledge cannot be taught, it can only be learnt.³⁰

When we talk of tapping into a knowledge flow we implicitly mean tapping into the tacit conversations surrounding a topic. We interact with a community built around common interests, sharing our experiences, insights and the problems that we are currently trying to solve in exchange for insights from others, and pointers to tools and techniques (explicit knowledge) that may be of help. These interactions might be virtual – via email and instant messaging, group discussions and newsgroups, or social media – or they may be physical – from having coffee with a few colleagues through to business travel to conferences.

Tapping into a knowledge flow means engaging with a community around a shared problem or pursuit.

A new way of educating

Our evolving relationship with knowledge – the shift from analysis and evaluation to creation, and the growing importance of creative knowledge work – is a sign that the trends in education are driving the creation of a new educational paradigm. They are redefining the roles and relationships in and around the education sector.

This is more complex than simply asking ‘How do we best support lifelong learning?’, ‘What is the best way to integrate new education technologies into the classroom?’ or even ‘Why remember what you can Google?’. Nor is the question one of pedagogy, research methodology or (educational) technology. It is a question of purpose and value. What is the purpose of education and, by extension, educators? And what value do they provide?

The growing number of alternative education institutions is not diluting the value of formal credentials. Nor is their value being affected by degrees taking too long to obtain (however long that might be). Formal credentials remain important – it is a rare individual who would be happy with an uncredentialed surgeon performing their heart bypass – however we don’t need to rely on credentials in the same way as we have in the past.

Our toolkit has expanded to provide us with more tools with which to gauge the quality of potential employees (or the surgeon for that matter), such as profiles built by publicly available data from (open source) projects and social media. These profiles show an employer what a candidate is interested in and what they have achieved rather than what they know. Indeed, Google has trawled through its extensive employee performance database and established that there is no correlation between holding a credential and having a successful career at Google.³¹



Similarly, no direct link has been found between commercial innovation and formal research and development (R&D) activity,³² with technology commercialisation programmes providing a poor rate of return.³³ Research used to be the preserve of the idle and curious rich. More recently, firms became involved, using R&D to develop new technologies and products, or create barriers to competition. Today, thanks to trends such as open source software³⁴ and the maker movement,³⁵ small organisations and even individuals are developing new technologies and products.³⁶

Some firms and individuals are finding that their needs have changed and, as Google discovered, that credentials provided by education institutions are not as relevant as they once were. While credentials and formal R&D will remain essential in a range of situations, the need for them appears to be in decline. The relationship between firm and individual has also changed as the economy has evolved under the influence of digital technology. However, the relationship between firm and educator, and between educator and student, has not.

The implications of this paradigm shift for educators and educational institutions, for firms and for students, will be profound. Educators who continue to define themselves in terms of the quality of their knowledge stocks and the credentials they provide may find themselves increasingly marginalised as individuals and firms find other ways to tap into the knowledge they need. Educational league tables will become meaningless and investments in publication profiles will be for naught.

Firms will need to find new ways to screen and qualify candidates if formal credentials (whether they are granted by a member of the Group of Eight or a MOOC) are not a predictor of an individual's capability or future potential. They will also need to look to the crowd (the loose-knit communities of makers, developers and innovators) rather than only to research institutions, to access the knowledge flows they need to develop new products.

Students will need to rethink what it means to be educated if a formal education is not the only path – or, potentially, not even the most effective path – to launching a successful career. How will they define themselves in a world that is focused on creativity and problem solving, rather than on credentials and institutions?

Preparing for change

Unfortunately, we cannot use the old paradigm as a tool to understand the new as the trends shaping the old paradigm may have little influence on the new. Nor can we extrapolate these same trends to predict when a paradigm shift might occur, as the drivers are sociological rather than technological.

Our only option is to look for the early signs of the new paradigm and use this to outline the shape we expect to take hold. We can build a hypothesis, a model of the new paradigm that captures the new relationships between the stakeholders, and then use this model as a tool to develop our understanding of the enablers for a change in paradigm, the drivers behind the change, and the barriers.

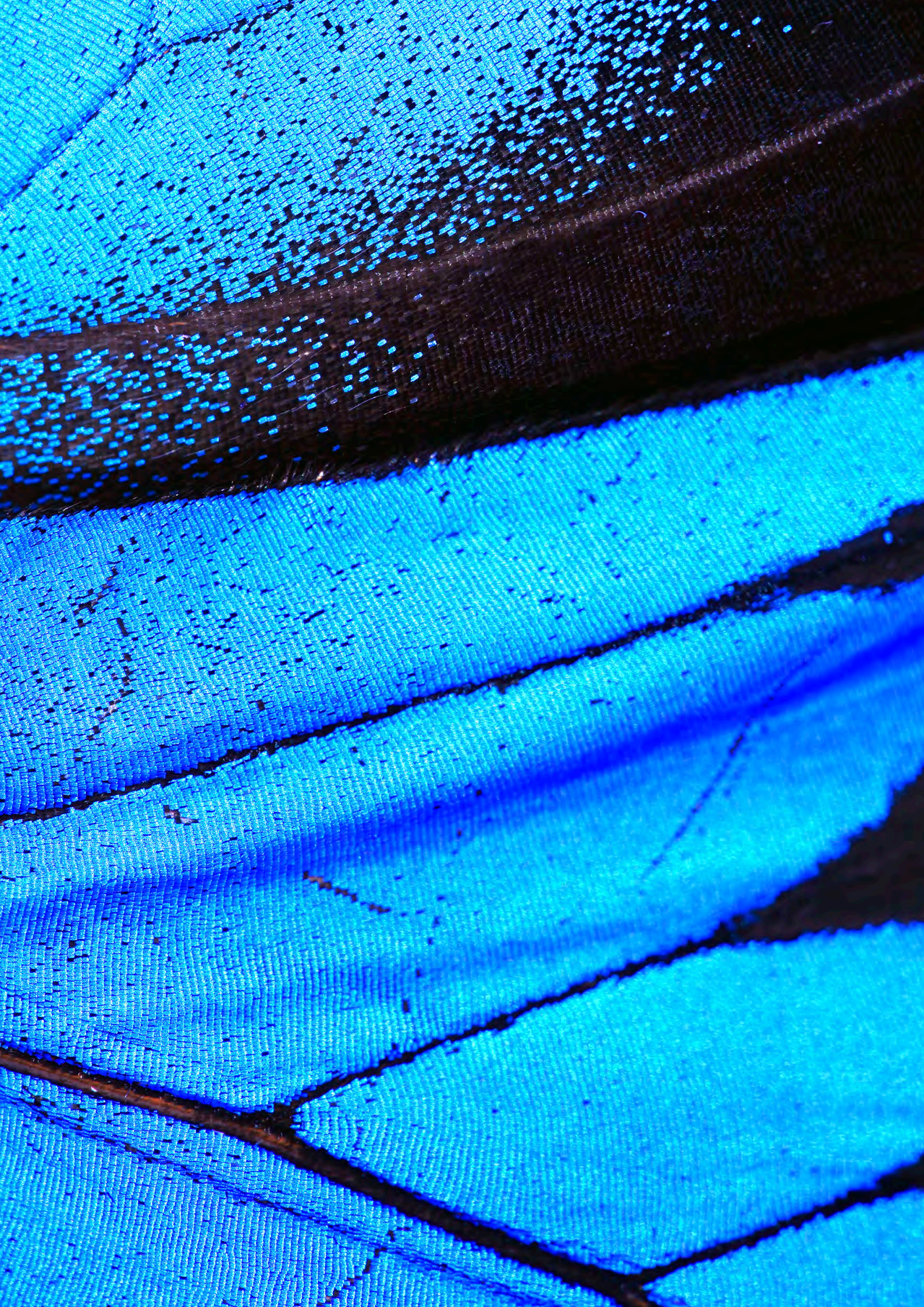
A model of the new paradigm enables us to look beyond short-term incremental change and develop our understanding of the bigger shift. It is a framework that enables us to discover the interesting questions and experiments that will enable us to understand how the roles and relationships across and within the education sector will change.

It will be challenging to collect the mass of evidence required to prove that what we are seeing is the leading edge of a paradigm shift; the vast majority of that evidence will exist only after the new paradigm has fully taken hold. However, the Centre for the Edge hopes that proposing a model for a new education paradigm will help focus our investigations and foster discussion.

The model will provide us with a new vantage point to view the changes in education and a framework that might bring together existing efforts in pedagogy focused on specific pieces of the shift and make them whole. It will be a tool to start asking the hard questions, which the education community can then use to harness the paradigm shift and make it a constructive (rather than destructive) force for change across the sector. The production of a model is not the end of the journey, it is only the beginning.

The danger for established educational institutions is that, by not considering the possibility of a change in paradigm, they, with all their embedded value, will simply be replaced by the institutions of the new paradigm. The challenge is to look beyond short-term pressures to understand the bigger changes. If a shift takes place, it may happen sooner than we think and sooner than we are ready for.





Redefining education

Assuming there is a paradigm change in the not-too-distant future, what might the education sector look like on the other side? How do we change our model to capture the emerging roles and relationships? As Bill Gates pointed out, 'We always overestimate the change that will occur in the next two years and underestimate the change that will occur in the next 10. Don't let yourself be lulled into inaction.'³⁷

The new knowledge worker

The challenge for creative knowledge workers – such as those in engineering, design, science, education and computer programming – is to find new problems, and new solutions to these problems.

This challenge is even finding its way down into what have traditionally been more stable professions. Lean manufacturing (a management philosophy derived mostly from the Toyota Production System),³⁸ for example, devolves power for identifying and solving production problems from experts to the team on the shop floor.

John Seddon, an occupational psychologist specialising in the service industry, has used the ideas behind Lean to improve the productivity of knowledge workers in call centres and support organisations.³⁹ Seddon advocates a model of knowledge work where the team at the front line is trained to solve the most common problems, recognise when a problem exceeds their current skills, and 'pull' in additional skills as required to solve a problem.⁴⁰ The problem can then be solved at the first point of contact as well as providing the individual with the opportunity to learn new skills.

Creative knowledge work relies on analysis followed by synthesis. Military strategist John Boyd would demonstrate this process⁴¹ by asking an audience to consider the following separate items: a pair of snow skis, an outboard motor, motor-bike handlebars and the rubber treads from a tank. He would challenge the audience to identify what is created when you pull these items together: a snowmobile.

Boyd uses this scheme of pulling things apart (analysis) and putting them back together (synthesis) in new combinations to find how apparently unrelated ideas and actions can be related to one another, creating new solutions to new problems. We have, in effect, moved up one layer in Bloom's Revised Taxonomy of (cognitive) learning objectives (shown in Figure 4). Today, value is created by generating new ideas or products (creation) rather than breaking problems into parts to explore understandings and relationships (analysing), or justifying a decision or course of action (evaluating).⁴²

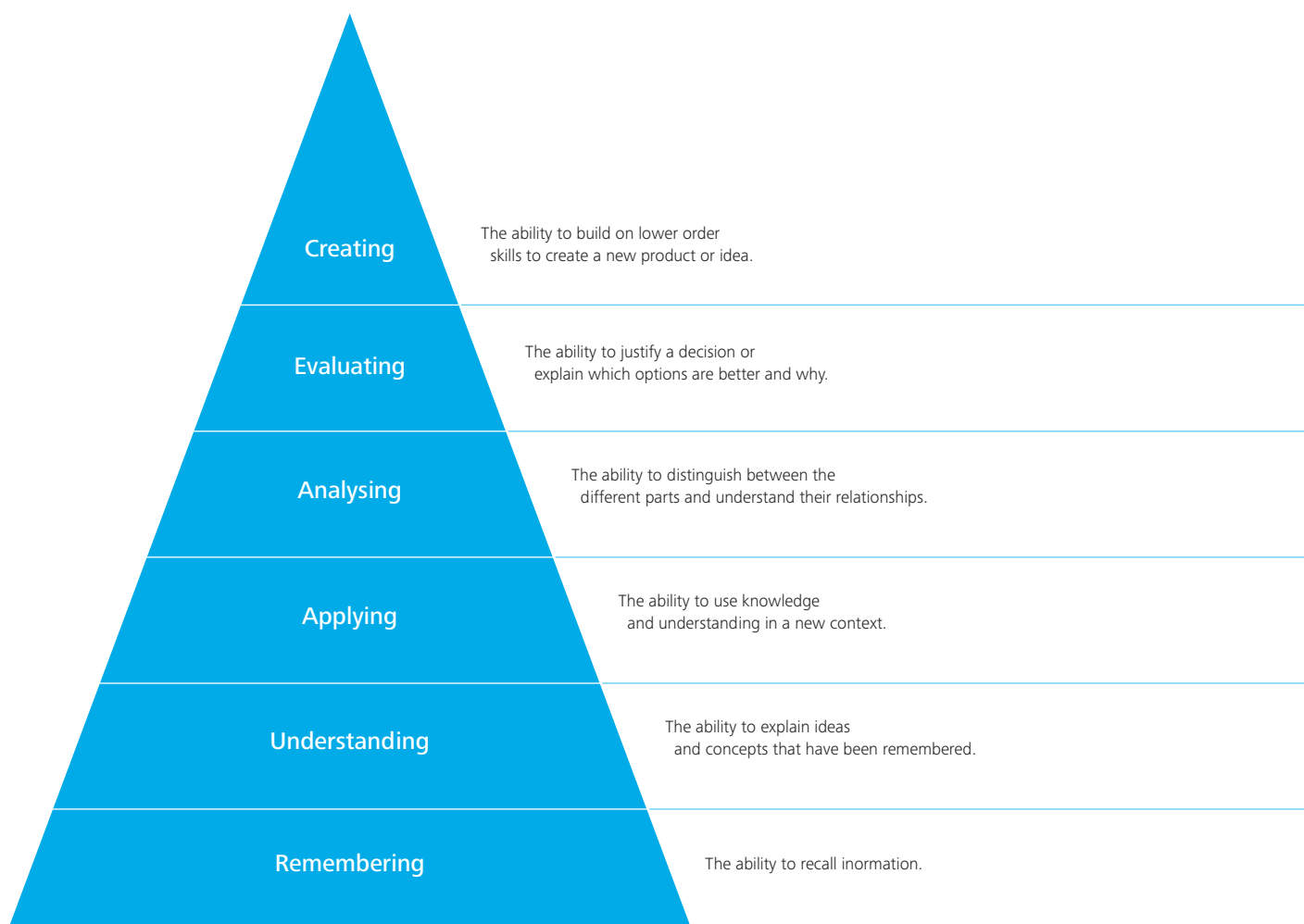


Figure 4: Bloom’s taxonomy was developed in the 1950s and is still used today to categorise ways of learning and thinking in a hierarchical structure, where skills in the upper layers build on the skills in the lower layers. A revised model (the Bloom-Anderson taxonomy, shown above) was developed in the 1990s to better-fit educational practices of the 21st century.

If we integrate the ideas from Seddon and Boyd, we can outline a model for creative knowledge work that is built on three pillars.

First is the body of knowledge a worker requires to identify, discuss and solve the domain of problems they are interested in. Without this knowledge they will be unable to understand the problem they are trying to solve.

Second, the worker needs exposure to a diverse range of experiences to provide them with a broad pallet of ideas and tools to draw on (the analysis) when they come to create a new solution to a new problem (the synthesis). As Donald Rumsfeld might say, they need to minimise the unknown unknowns.

It is only possible to imagine the creation of a snowmobile if we know of and understand the purpose of snow skis, outboard motors, motor-bike handlebars and rubber tank treads. Workers investing their own time in 'surfing' knowledge flows helps them to build awareness of the other viewpoints, tools and expertise that they might integrate into their own toolkit in the future.

Third, the worker needs to be able to draw on knowledge flows to solve the problem at hand, enabling them to reach out and pull in the tools and expertise that they don't have, but which are required to realise the solution. Each time the worker reaches out for expertise is an opportunity for them to learn, to build their own tacit knowledge by applying a new technique or idea to a problem in which they are already invested.

Integrating learning into an employee's work – rather than treating it as a separate 'educational' activity – enables them to increase the rate at which they learn, helping them move up the collaboration curve.⁴³

Current prescriptions and incremental change

The debate on the future of the education sector is focused on fixing problems with the existing structure and pedagogy. The focus on market trends – global mobility, digitisation, democratisation of knowledge, tighter ties with industry and the increasing contestability of education markets – leads us to incremental solutions to incremental problems.

The sudden emergence of alternative knowledge sources and education providers, such as MOOCs, is disrupting established pedagogy and forcing established educational institutions to respond. This digitisation of knowledge and education has resulted in a massive expansion in the availability of knowledge, changing student preferences for content consumption and challenging the role of educational institutions as originators and keepers of knowledge.

Initially, many institutions feared that the low-cost online models used by MOOCs (and other alternative education providers) would cannibalise their established curricula, changing the dynamics of the education sector by making the content available to all for free and only charging for the credential at the end of the course. Many institutions rushed to move their curricula online rather than be left behind. However, these fears appear to be misplaced. While these platforms enable students to cobble together an elite education for free and only pay for the credential if they deem it necessary (and under-served students are doing just that)⁴⁴ the low completion rate for MOOCs⁴⁵ shows there is something more to education than ingesting content and passing tests.

Institutions are integrating these alternative knowledge sources into their curriculum, shifting their focus from delivering content to fostering learning, using techniques such as the flipped classroom⁴⁶ where students ingest content – often online via video while at home – before the lecture to allow teachers to offer students more personalised guidance and interaction rather than devoting face-to-face time on traditional chalk-and-talk instruction.

More emphasis is being placed on student needs, with the shift to student-led learning in higher education mirroring the move to enquiry-based learning⁴⁷ established in many K-12 schools, where the emphasis is on instilling the behaviours and attitudes in students that will serve them for the length of their career. Institutions are relaxing guidelines on subject selection to make their curriculum more modular in order to enable students to more closely tailor a course to their interests and needs.⁴⁸

This transfers some of the responsibility to constructing a credential to the student in the process, as they pick-and-choose what is relevant to them,⁴⁹ while the educators shift to a role where they guide the student choices, rather than mandating the majority of what they must learn. Even MOOC providers are acknowledging that they need to support the social needs of their communities,⁵⁰ rather than just focus on the content and certification.

Traditional credentials are seen to be under threat; they are seen as taking too long to earn and not providing the students with knowledge and skills that they need in the workforce. For many individuals a credential is simply something required to finesse their resume through the initial screening process, rather than the source of knowledge and skills that they use in the pursuit of their career.⁵¹

The response by some established institutions has been to unbundle credentials, break them into smaller parts to enable students to focus on earning only the certifications they need to remain relevant in the workplace, or by exposing badges that students can earn to highlight achievements,⁵² thereby increasing the relevance of the certification while also decreasing the time taken to earn them. The intention is that individuals will earn a series of 'nano' or 'stackable' credentials⁵³ over the length of their career – lifelong education as just in time credentialing – rather than concentrating their education in a degree obtained at the beginning of their career.

This would blur the boundaries between the individual educational strata, and not just between education and career, as students engage with subjects when they discover that they need the knowledge and skills that the subject will provide, rather than at some predetermined point of time during their period of formal education.

A new education model

The problem educators need to solve, though, is not one of making credentials shorter and more digestible. The sense of the relationship between educator and student (or graduate) and educator and firm, has flipped. Knowledge is pulled in as required, rather than pushed out via instruction. Knowledge is delivered just in time as work-integrated learning, rather than being concentrated in periods of instruction. This is an environment where individuals are constantly on the lookout for interesting and useful knowledge, knowledge that they will 'pull in' and learn to fill a gap in their current knowledge, a gap that is preventing them from completing a project or reaching their goals. Nor does this knowledge necessarily come from an elite educational institution, as it may as likely come from a MOOCs or even a peer-production source such as Wikipedia. The educator's role in these relationships is to help the student (or firm) to optimise how they navigate and use knowledge – to help them find, tap into and draw from the knowledge flows that will be most beneficial to them.

We can use this understanding to reformulate our model of the education sector, changing the sense of the relationships between educator and student, and educator and firm. This will capture how the dynamics of these relationships have changed (shown in Figure 5) and outline the new paradigm.

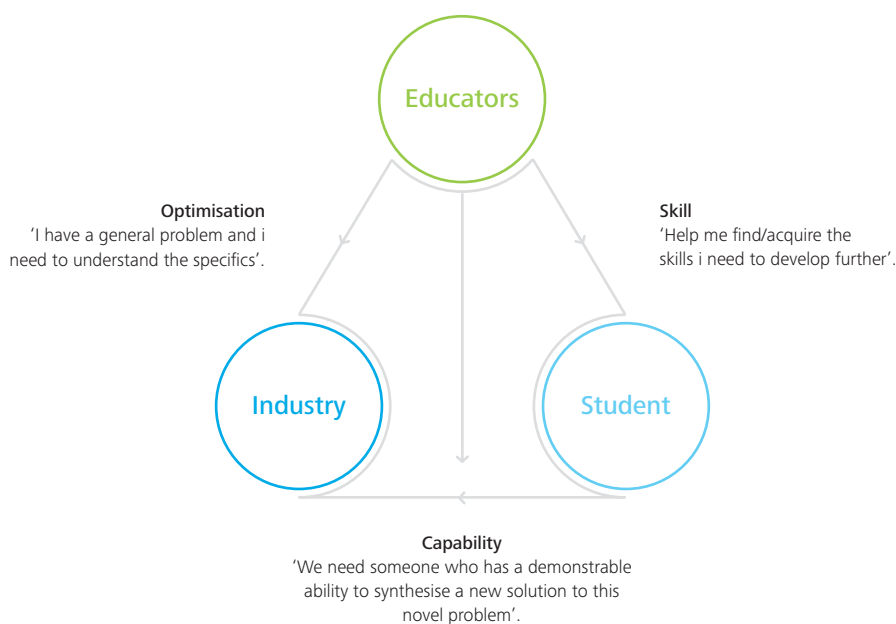


Figure 5: A new model for the education sector will be founded on knowledge flows, rather than stocks, and empowering organisations and individuals to pull in knowledge and skills when they realise the need, rather than attempting to provide them with the knowledge that we expect them to need.

This means the purpose of education is to learn skills and knowledge that benefit students, but which they might not naturally seek out otherwise. In the early years, this implies instructing them in basic literacy, numeracy and digital literacy skills, and habits of mind that they will need to become self-motivated learners. In the middle years, this expands to instructing them in the attitudes and behaviours they need to treat each challenge as an opportunity to learn and grow, and instilling an attitude of lifelong learning (as opposed to lifelong instruction).

During their tertiary years, the focus shifts to helping the student to branch out from childhood interests to discover their passions – the problems that represent the intersection between their abilities and interests. This will broaden their experience so that they have a diverse range of skills to bear on the problems to which they will devote themselves. Their journey through primary, secondary and tertiary study could be characterised as ‘help me find the knowledge, skills and insight that I need to develop my interests further’.

The practice, particularly in Australia, of academics seeking to engage industry around specific research questions, with three-year time horizons, clashes with a business environment where there are more problems than questions and timelines are measured in months, not years. Industry focuses on problems, not questions, and struggles to form a relationship based on questions that researchers might answer.

The new relationship should be built around optimisation. A firm shares with the researcher the problems it is trying to solve. The researcher determines interesting questions around the problem, and then proceeds to find answers. The firm uses the answers to optimise its solution to the problem.

This is an approach that one university and a large financial institution took with great success.⁵⁴ A team of researchers supported the firm's rollout of its information technology infrastructure library (ITIL) and IT service management framework over 30 counties by surveying research into change management, identifying the most suitable change models, and distilling the insights into the best practices and key business drivers and metrics. This provided the firm with a much better outcome and the research team with a rich trove of research material.

How much do we need to know?

While constructivist ideas might dominate the modern classroom, this should not be taken to imply that 'the guide on the side' has supplanted or should completely supplant 'the sage on the stage'. The role of education might be changing, but the role of the educator is still to intervene, to change the student in some way that they didn't expect; instruction will remain an important intervention.

Having a bedrock of facts in a child's long-term memory is fundamental to learning as our working memory is limited and we must rely on what we store in our long-term memory. Unless we have a sufficient stock of knowledge we are excluded from understanding the world around us, making us illiterate in a literate world. In the early years, this means providing children with the core literacy and numeracy skills they need to become self-sufficient learners. In the later years, the focus may move to being a 'guide on the side', but the student will still require instruction in (or direction to) the knowledge and skills they need to round out their own stocks of knowledge so that limitations in learning don't become life limitations.

The important question then is not, 'should we instruct a student, building their knowledge stocks', but 'how much knowledge does a student need before they are effective?' Too much and we're wasting the student's time by building stocks of knowledge that they will never use. Too little and they won't be able to make sense of the world.

An increasingly important part of education – and intervention – will be to instil in students the importance of continually updating and expanding their own knowledge stocks. Doing this is a skill in and of itself, a skill built on the attitudes and behaviours that a student develops during their formal education.

The maintenance of our knowledge stocks is an active process, one where new knowledge and skills are analysed, evaluated and then integrated with existing knowledge stocks (often with the student needing to unlearn something else in the process). Bruce Lee captured the attitude nicely when he wrote, 'Adapt what is useful, reject what is useless, and add what is specifically your own.'

Finally, a key outcome of a formal education should be the self-awareness in the student that enables them to realise when their knowledge is lacking and that this is holding them back in some way.

The new credential

As discussed earlier, credentials are not broken, nor is their value being diluted by lower cost, faster-to-obtain alternatives. The problem for many students and firms is that traditional credentials do not capture the information they need. Hiring is based on trust and the nature of trust has changed. Historically, firms have relied heavily on credentials to determine who to interview, but that was in large part because firms had little or no other information on which to base a decision. Now, with open source and social media, it is possible for students to build a portfolio of what they have done. Trust is built between firms and graduates based on them looking at each other and seeing track records they find mutually interesting.

The challenge is to create a new credential, one that firms can use to screen candidates, rather than developing their own in-house ability to build an application profile. The driver behind the old credential was a paucity of information – it was next to impossible for a firm to determine if an applicant was who they

claimed to be without a letter of introduction from a trusted third party. The driver behind the new credential will be time – the significant time and effort required to harvest and then validate the breadcrumbs of information that we all leave behind on the internet. While it is possible to scan an applicant’s various side projects, review their Facebook profile and Twitter timeline, and peruse their blog or Tumblr, the time taken will be prohibitive in many instances. It would be easier and more efficient to rely on the word of a credible third party.

These new credentials will be founded on the three pillars firms are using to qualify candidates in the new creative economy, by looking at their past to determine:

- What sort of problems the individual is interested in
- Their ability to integrate new ideas into their work and to continue learning and improving
- Their ability to work as a part of a cross-functional team.

The traditional credentials will remain an essential tool for a range of professions and circumstances, however firms at the edge are starting to set aside the credential to focus on finding those individuals who exhibit the behaviours and track record which show that they will be productive members of the firm.

Even firms that continue, in the shorter term, to rely on hiring individuals with the highest quality credential that the firm can afford, are turning to alternative means to gauge the ability of their new hires to apply their knowledge in a modern workplace. Individuals are also increasingly seeing credentials – and the formal education on which they rely – to be optional. They are either avoiding credentials entirely, or taking a more cynical approach and only obtaining the credential to help them past resume screens.

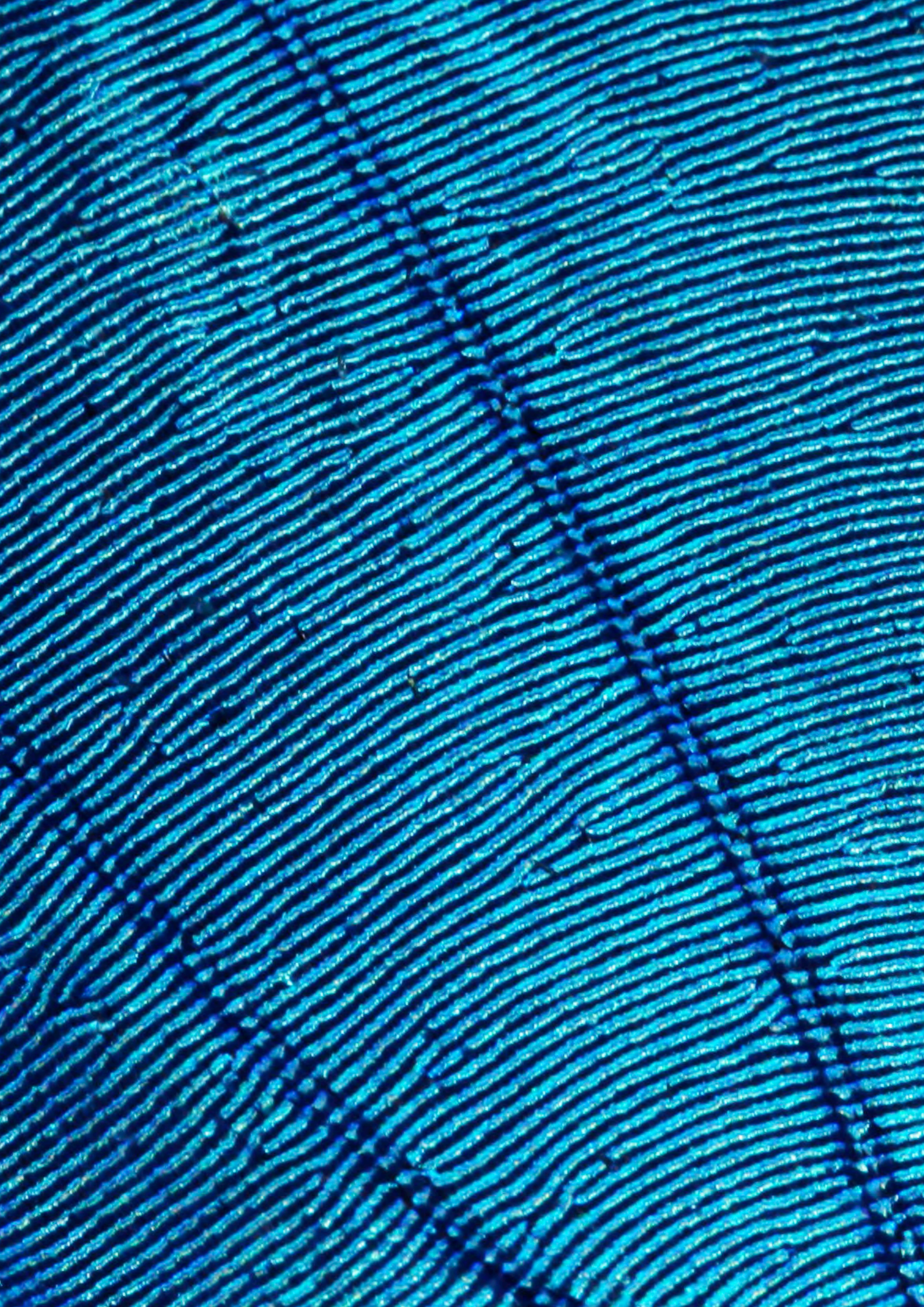
Education institutions of the future

Tertiary institutions have historically been measured in terms of the quality of their knowledge stocks and the perceived rigour of the credentials they grant, while primary and secondary schools have traditionally been measured by their ability to prepare students for the next stage in the journey (how successful the students are at meeting the entrance selection criteria). To be well educated was to be seen to have obtained the knowledge and skills expected by the established professions. But how will we gauge the value of educational institutions in the future?

The first obvious candidate is the perceived vibrancy of the community around an institution. Firms and individuals will look for institutions that are active and respected participants in the communities in which they have an interest. This is a question of contribution, rather than status or qualification, and the institution must be seen to be actively contributing to the community, rather than jealously guarding its stocks of knowledge. Research will remain important, and will be something in which a university continues to invest, but the purpose of research is to improve the value of the institution’s contributions to knowledge flows, not to build up a private stock of knowledge.

The second obvious candidate is the public achievements of alumni. Individuals want to see that an institution supports its alumni in their success (rather than treating a student’s invention as the institution’s own). The publication of student projects could provide a foundation for the creation of a new credential.

Traditional certification will remain, but it may become a niche product. Moving courses online can be a double-edged sword. While reducing delivery costs, it can also prevent the development of a community and reduce the value of the knowledge flows into which students and alumni can tap. When balancing long-term incremental change and a potential paradigm shift we often find that our reflex reaction to change is not always the wisest action. The challenge, then, is to understand how to get from here to there.



Conclusions

The nature of the education sector continues to evolve. Educators need to turn their attention to creating environments and platforms where students can learn what they need to learn when they need to, and instilling in them the habits of mind, attitudes and behaviours that will enable them to thrive in today's (and tomorrow's) knowledge-rich environment. The biggest challenge facing educators, however, is in forging a new relationship with students and industry, a relationship built around knowledge flows and one where the educator and student or firm work together to optimise how they navigate knowledge flows to identify and use knowledge. If we can find more effective means to realise the potential in the knowledge flows that are coursing through society then we may go some way to fixing the imbalance in the Shift Index and realise the potential of our society?

At this point it seems that a fundamental shift is occurring in how we use and think about knowledge and skills. If this fundamental shift turns out to be real then it will transform the education sector and usher in a new paradigm.

As with all paradigm shifts, this shift will be more obvious in hindsight than when crystal-ball gazing. It is hard to see past a discontinuity that we do not understand, and we never truly understand them until they are in our past. While our evidence is not as strong as we would like, by building a model we have created a framework to help seek out the evidence we need to either bolster, or disprove, the future that our model suggests. We also hope that we have provided some insight into how long-term trends affecting the education sector might play out, trends that will continue to defy a simple linear extrapolation.

So, our questions to educators and the education sector are:

1. Can we enhance the model, finding the evidence to develop/improve the model and thereby improve our understanding of the likelihood of a paradigm shift, its nature and timing, including evidence of the practical application of these ideas?
2. Can we develop some of the underlying ideas, such as the future creative knowledge work model and work-integrated learning, to provide us with a better understanding of the drivers for change?
3. Assuming our model is accurate, what are the implications for credentials, educators, research and the relationship with industry?
4. In the meantime, what can educators (and industry and students) do to hedge their bets across a wide range of factors, from credentials through curriculum to relationships with industry?
5. How do we fully realise the potential of the knowledge flows coursing through society?

None of these are a question of pedagogy or technology, but of purpose and role. Each is of relevance and value in a society that has evolved to have a new relationship with knowledge. Nor can individual educators, students or firms answer these questions on their own; we need to tackle them together, as these questions are concerned with the relationships between stakeholders within and without the education sector.

The danger for established educational institutions is that, by not considering the possibility of a change in paradigm, they will simply be replaced by new institutions. The challenge is to look beyond short-term pressures to understand the bigger changes.

The goal of a formal education should be to prepare students for life after their formal education. In a world dominated by change it would be wise to define 'being educated' as having the ability 'to adapt to whatever life might bring'. An increasingly important part of education – and intervention – will therefore be to instil in students the importance of continually updating and expanding their own knowledge stocks, as well as fostering within them the sensitivity to know when they need to do this. Doing this is a skill in and of itself. It is a skill built on habits of mind, the attitudes and behaviours that a student develops during their formal education.

Maintenance of knowledge stocks is an active process. New knowledge and skills are analysed, evaluated and integrated with existing stocks, often with the student needing to unlearn something in the process.

We cannot determine from the outset how much knowledge or what knowledge a student will need during their career. We can, however, provide them with a bedrock of essential facts along with the tools they need to determine for themselves if their knowledge stocks are lacking – and the ability and attitude to do something about it.



About the authors



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Peter has spent his entire career working at the intersection between business and technology. During his career he has worked in Asia, Australia, Europe and the US, lived in Silicon Valley through boom and bust, and held leadership roles in global organisations such as Deutsche Post DHL, as well as startups and research and development labs.

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Kitty O'Leary is the Summer Fellow at the Centre for the Edge Australia. Kitty is voraciously learning about opportunities on the edge of business and technology. A confident speaker and keen reader with an engaging disposition, she is currently studying Art History on exchange from the University of Edinburgh. Kitty brings perspective to her work from her experience with legal and insurance companies, including: AIG Europe Limited's Legal Department, Timothy Sammons Ltd, Fine Art Agents Broker Willis and Aspen Re. Kitty also founded and managed The Art Fund's student volunteering group, and contributed to corporate funding initiatives at Scottish charity Art in Healthcare.



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Peter Williams is an innovator and thought leader in the digital world.

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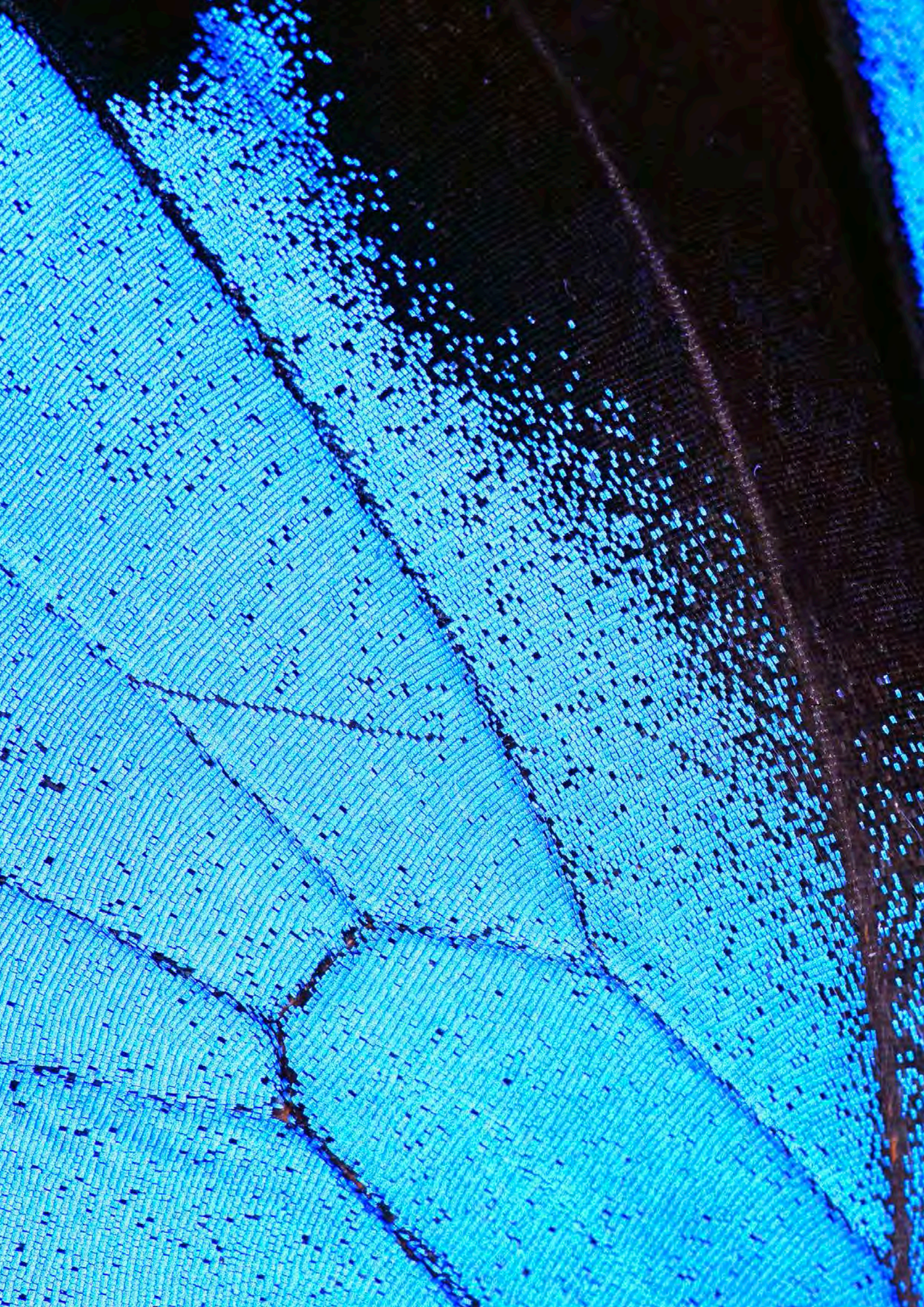
Endnotes

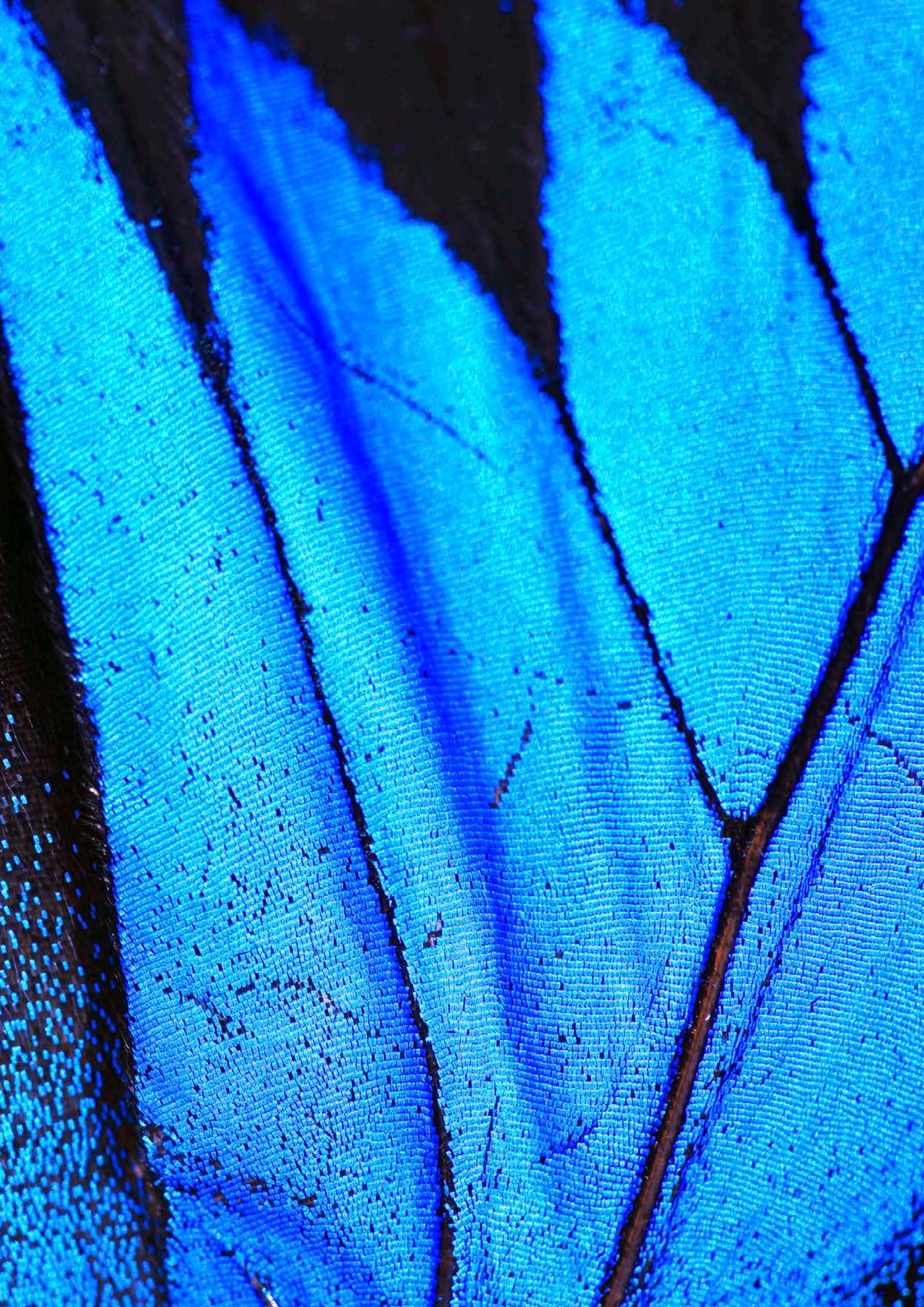
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20. James Watt (30 January 1736-25 August 1819) was a Scottish inventor and mechanical engineer. His improvements to the Newcomen steam engine were fundamental to the changes brought by the Industrial Revolution.
21. Research has always had part of its focus on exploration and discovery, and the questions research considers are not restricted to solely pragmatic concerns. There is a very definite strand of thought, for example, that knowledge leads to understanding and a desire (particularly by clerics and astronomers) to understand the universe and the mind of God. The current funding focus on applied rather than pure research tells us the value society places on the two strands.
22. Henry Ford was reportedly asked to submit to an oral test by a group of academics late in his career. They wanted to prove that he was ignorant. The test began with a scholar asking him a question such as 'What is the tensile strength of the rolled steel you use?' Ford, not knowing the answer, simply reached for one of the many phones on his desk and called his vice president who would know the answer. The vice president came in and Ford asked him the question. The vice president gave him the answer the panel wanted. The next academic asked another question and again Ford, not knowing the answer, called someone else from his staff who knew the answer. This process went on until finally one of the academics shouted 'See, this proves you are ignorant. You don't know the answers to any of the questions we ask you.' Henry Ford reportedly replied 'I don't know the answers because I do not need to clutter my head with the answers you seek. I hire smart young people from your schools who have memorised information that you think is intelligence. My job is to keep my head clear of such clutter and trivial facts so that I can think.' At that point, he asked the smart people from the world of academics to leave.
23. Wi-fi, dual-flush loos and eight more Australian inventions, Phil Mercer, BBC News, <http://www.bbc.com/news/magazine-20071644>, 2012.
24. We do not use the term 'well educated', to avoid an unnecessary value judgement.
25. Giving Teaching Back to Education: Responding to the Disappearance of the Teacher, *Phenomenology & Practice*, Volume 6 (2012), No. 2, pp. 35-49. <http://hdl.handle.net/10993/7836> Gert J.J. Biesta, 2012.
26. From comments on an early draft by Andrew Bayliss of Melbourne Grammar School.
27. MOOC is a web-based distance learning course aimed at unlimited participation and delivered via the public internet. MOOCs provide interactive user forums that help build a community for students and academic staff in addition to traditional course materials such as videos, readings, and problem sets. MOOCs are a recent development in distance education, with the 'Connectivism and Connective Knowledge/2008' (CCK8) course created by educators Stephen Downes and George Siemens commonly recognised as the first MOOC. MOOCs began to see widespread adoption in 2012 with the launch of Udacity.
28. From teaching to learning: A new paradigm for undergraduate education, *Change*, 27(6), 13-25, R.B. Barr and J. Tagg, 1995.

29. From an interview conducted during our research.
30. Difficulties in diffusion of tacit knowledge in organizations, *Journal of Intellectual Capital*, Vol. 1 Iss 4 pp. 357-365. <http://dx.doi.org/10.1108/14691930010359252>, Tua Haldin-Herrgard, 2000.
31. In Head-Hunting, Big Data May Not Be Such a Big Deal, *The New York Times*, <http://www.nytimes.com/2013/06/20/business/in-head-hunting-big-data-may-not-be-such-a-big-deal.html>, Adam Bryant, 2013.
32. The effect of R&D, technology commercialization capabilities and innovation performance, *Technological and Economic Development of Economy*, 17:4, 563-578, DOI: 10.3846/20294913.2011.603481, Seo Kyun Kim, Bong Gyou Lee, Beom Soo Park and Kyoung Seok Oh, 2011
33. Improving University Technology Transfer and Commercialization, *Issues in Technology Innovation*, Number 20. http://www.brookings.edu/~media/Research/Files/Papers/2012/12/05_tech_transfer_west/DarrellUniversity_Tech_Transfer.pdf, Darrell M. West, 2012.
34. Open-source software is computer software with its source code made available with a licence in which the copyright holder provides the rights to study, change and distribute the software to anyone and for any purpose.
35. The maker movement is the name given to people and communities employing do-it-yourself (DIY) and do-it-with-others (DIWO) techniques and processes to develop unique technology products.
36. Product Innovation in a hyper connected world: The Australian Maker Movement, Kitty O'Leary and Eddie Harran, Centre for the Edge Australia, Deloitte, 2014.
37. *The Road Ahead*, Bill Gates, Viking Penguin, 1995.
38. *The Machine That Changed the World: The Story of Lean Production*; James P. Womack, Daniel T. Jones and Daniel Roos; HarperBusiness; 1991.
39. *Systems Thinking: From Heresy to Practice*, Keivan Zokaei, John Seddon and Brendan O'Donovan, Palgrave Macmillan, 2011.
40. Culture Change is Free, talk at the conference of the Human Givens Institute. <http://vimeo.com/4670102>, John Seddon, 2009.
41. *Science, Strategy and War*, Frans P.B. Osinga, Routledge, 2007.
42. We note that Bloom's Revised Taxonomy states that higher skills build on lower ones, implying that creation builds on, rather than replaces, analysis and evaluation.
43. Introducing the Collaboration Curve, John Hagel III, HBR Blog Network. <http://blogs.hbr.org/2009/04/introducing-the-collaboration/>, John Seely Brown and Lang Davison, 8 April 2009.

44. Data from the Wharton Business School shows that 78 per cent of individuals who registered for an online business course came from outside the United States; the executive MBA programs attracted only an average of 14 per cent of foreign students while part-time or flexible MBA programs attracted 10-32 per cent foreign students, depending on the type of program. Forty-five per cent of the placings for full-time two-year MBA programs were taken up by foreign students. 'MOOCs Won't Replace Business Schools — They'll Diversify Them', HBR Blog Network, <http://blogs.hbr.org/2014/06/moocs-wont-replace-business-schools-theyll-diversify-them/> Gayle Christensen, Brandon Alcorn and Ezekiel Emanuel, 3 June, 2014.
45. Completion rates for MOOCs can approach 40 per cent (and occasionally exceed it), although most MOOCs have completion rates of less than 13 per cent. 'MOOC Completion Rates: The Data'. <http://www.katyjordan.com/MOOCproject.html> Katy Jordan, 2013.
46. The flipped classroom – also known as backwards classroom, inverted classroom, reverse teaching, and the Thayer Method – is a form of blended learning in which students learn new content, usually online at home, with class time devoted to what used to be homework with teachers offering students more personalised guidance instead of lecturing.
47. Enquiry-based learning (also inquiry-based learning) starts by posing questions, problems or scenarios rather than simply presenting established facts. Inquirers will identify and research issues and questions to develop their knowledge or solutions, often assisted by a facilitator.
48. A key recommendation of MIT's Institute-Wide Task Force of the Future of MIT Education was to make curriculum more modular. 'The future of MIT education looks more global, modular, and flexible', MIT News Office. <http://newsoffice.mit.edu/2014/future-of-mit-education-0804> , Steve Bradt, 4 August 2014.
49. Which creates a chicken-and-egg issue: how do they know what they need to learn?
50. Coursera introduced learning hubs to formalise the informal meetings that MOOC students were already organising. <https://www.coursera.org/about/programs/learningHubs?>
51. During the development of this report several interviewees mentioned 'getting past the resumé screen' as a primary driver for obtaining a post-graduate qualification.
52. The University of California, Davis, has launched a digital badging initiative within the agriculture programme – also called Skills Qualifications – in an attempt to bridge the gap between the theoretical knowledge taught by professors and the practical knowledge learnt in the field. <http://hsgg.ucdavis.edu/skill-qualifications/>
53. A Smart Way to Skip College in Pursuit of a Job, The New York Times. <http://www.nytimes.com/2014/06/18/business/economy/udacity-att-nanodegree-offers-an-entry-level-approach-to-college.html>, Eduardo Porter, 17 June 2014.
54. From a case study discussed in an interview during the preparation of this report.





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