DIGITAL EDUCATION FUTURES INITIATIVE CAMBRIDGE

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The Futures of Assessments

Navigating Uncertainties through the Lenses of Anticipatory Thinking

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Foreword

The multifaceted disruption of social and political processes during the most intense phases of the COVID crisis encouraged many groups and individuals to propose change and reform to education. The propositions varied from previously rejected proposals to statements of 'inevitable changes' driven by barely disguised self-interest. Groups and commissions proliferated, some highly evidence-driven, others not. It was hard to see whether the crisis represented a genuinely valuable reflective pause in normal proceedings, allowing us all to take stock of where we are in education, or whether it threatened to break a long process of careful scientific accumulation of knowledge and sensitive policy formation and system management. This current report is a distinctive voice in the debate about 'assessment futures'. Not least, it outlines the nature of human construction of the future. It acknowledges that while the future might be constrained by current arrangements and the impact of past policy and practice, the future is not 'inevitable' or fixed, but is the product of human agency: a combination of thought, decisions, actions and reactions. Who makes those decisions, on what basis, their impact, and what collective actions arise all become questions rather than inevitabilities. Rather than just listing demands, the report is the product of a systematic approach to the identification of possibilities, thus contributing to rational, evidence-based decision-making – which of course will always be a combination of objective realities and human judgement.

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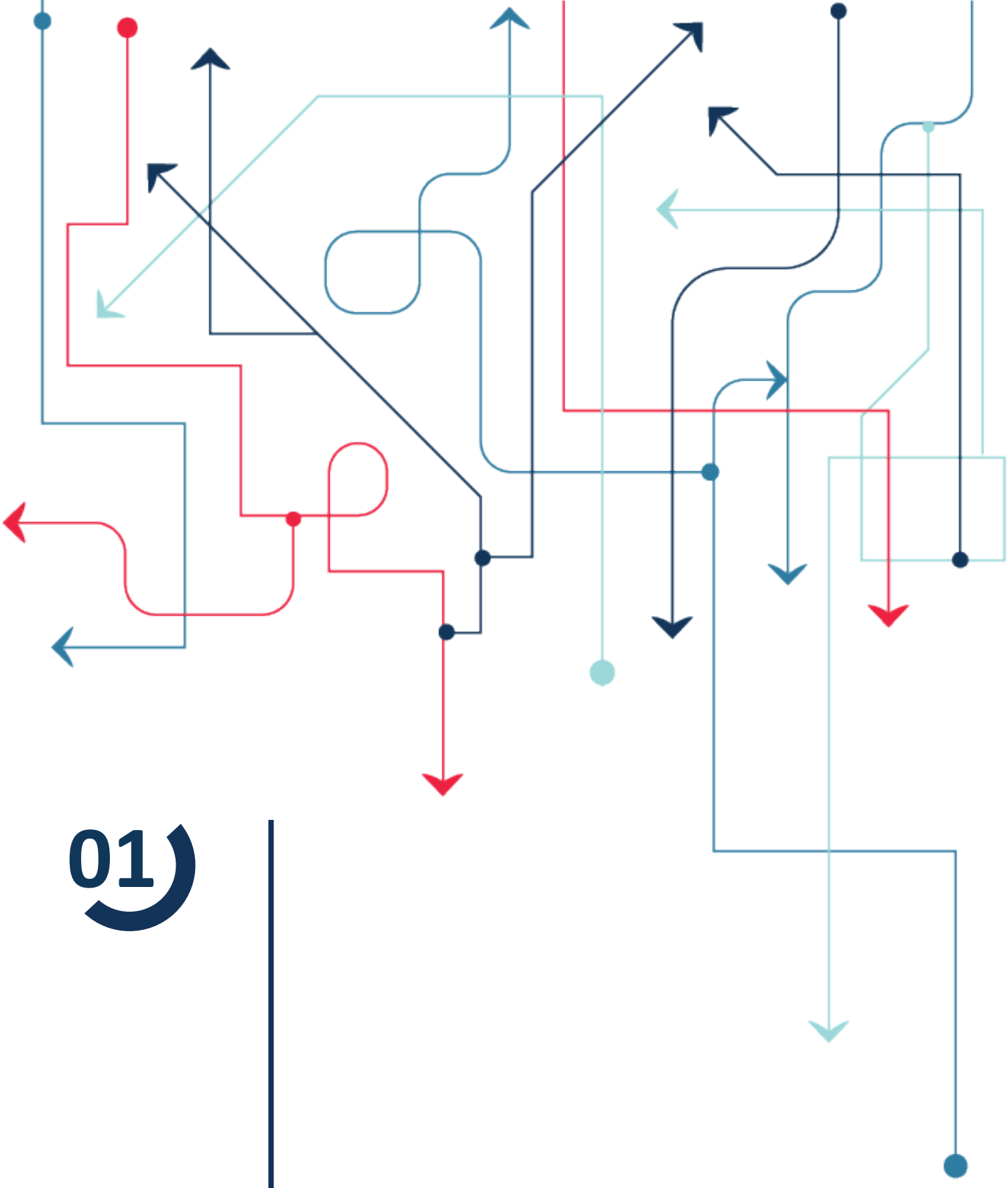


01

Executive Summary

1.1 Introduction

The aim of this research, looking forward to 2050, was not to predict the future of assessment but to use Futures Thinking as an approach to anticipate plausible future directions.

If we look back 30 years or so, we can see how different the world was then. For example, the internet started to become widely used and mobile phones became common in the 1990s. Changes in education and assessment have been seen too: computer-adaptive testing started in the 1990s; the PISA test went online in 2015; in 2020 two-thirds of students had to learn online due to the COVID pandemic. All of these examples highlight the pace of change.

In times of rapid change and uncertainty, past events and trends are unlikely to provide a reliable guide to the future: Futures Thinking provides methods and perspectives to anticipate and manage disruptive change.

1.2 Methods

The research was carried out in collaboration with individuals and groups from various departments across the University of Cambridge and two external groups. The participants took part in three 3-hour long workshops, with many completing significant work in-between the first and the second workshop.

They met in domain specific groups to identify, research and appraise signals related to their questions about various aspects of assessment.

In our research we used the following established Futures Thinking methods[i] to meet our aim:

Horizon scanning to identify disruptors or 'signals' – evidenced observations about how our world is changing – which indicate what potential futures might look like. Some of these are mega trends – the larger, long-term forces which shape society.

Futures Triangle to unpack assumptions about the present.

Causal Layered Analysis to build an in-depth insight into the assumptions of the present to create new perspectives on preferred visions for the future.

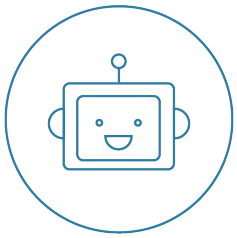
Imagining Scenarios to explore multiple plausible futures grounded in the data about existing trends and signals of change.

Visioning Preferred Futures to provide a basis for designing ways in which they can be achieved.

1.3 Outcomes

The outputs of these activities allowed us to identify key drivers of change and to backcast from 2050 to today to describe a timeline of events to take us to the preferred future.

1.3.1 Drivers for change



AI Tutors and Personalised Learning

Augmented, Virtual and Hybrid Technologies

Human Flourishing and Wellbeing

Climate Change

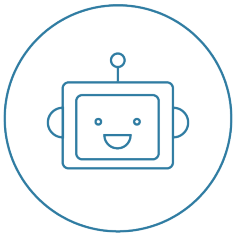
Assessment Organisations

Weak signals may or may not be harbingers of rapid change, sometimes the potential change they signal may not come to pass and on other occasions it may take considerable time for isolated practices to become established as large-scale trends. In some cases, inertia in systems mitigates against more rapid change, for example, prior investment in infrastructure or commitment to maintaining established standards. However, it is also the case that change in assessment specifically is not evenly distributed. Trusted legacy organisations have invested heavily in paper-based assessments, making change more challenging. In contrast, digital-first assessment organisations are freer to adopt new technologies. It is also the case that the future may be unevenly distributed geographically, with many children worldwide lacking internet access at home. Some areas, however, are potentially leapfrogging traditional methods and moving straight to technology supported solutions, as happened previously when some countries moved straight to mobile without investing in landlines.

For established organisations in particular, the road to digital assessment may be a bumpy one and there will almost inevitably be at least temporary pushback, from parents, teachers and policy-makers concerned about mode effects, fairness and comparability. However, today many countries globally are adopting digital assessments as illustrated by the 30+ countries involved in the flip-plus network (www.flip-plus.org). There is an important role for existing assessment organisations to play in shaping the debate and providing appropriate arguments and evidence about the integrity, fairness, reliability and validity of digital assessment.

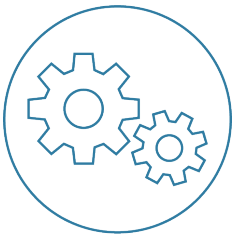
'The future is already here - it is just not evenly distributed'

William Gibson



AI Tutors and Personalised Learning

One of the more powerful signals is the emergence of AI tutors and personalised learning, both of which require considerable investment to develop and maintain. AI systems have the potential to accelerate learning and challenge geographical constraints in education. Their adoption by national education systems could transform schooling and assessment, requiring attention to reliability, fairness and diversity considerations. Collaborative learning models may also develop, impacting traditional assessment methods and raising questions about system integrity and accountability. The systems should adapt and respond to the needs of diverse student populations, supporting different mental health conditions and the neurodiverse while also accommodating a range of learning abilities.



Augmented, Virtual and Hybrid Technologies

Advancements in technology are transforming assessment methods. Learners in 2050 may well have always known a world in which AI use is common. An increased availability of augmented reality and wearable sensors could result in assessments evolving towards immersive, dialogue-based and interactive experiences. The digital divide might widen due to resource limitations. The actors involved in setting and maintaining assessment standards are changing, with educational technology companies taking on roles in integrity, standards and accountability. Climate change concerns might in future lead people to prioritise access to educational resources over assessment integrity.

Human Flourishing and Wellbeing

The COVID-19 pandemic exposed the detrimental effects of high-stakes assessments on student well-being, sparking a shift towards more enjoyable, personalised and engaging assessments. Large-scale data from student interactions with onscreen learning and assessment tasks might be used to support more effective evaluations of educational trends, school quality and student achievement. Advances in technology, such as computer-adaptive designs and AI raise the possibility that ‘stealth’, continuous and collaborative assessments (for example, as granular ‘reports’ from learning platforms) could replace examinations, which would reduce the time taken in student assessments, reduce student anxiety and washback.

Climate Change

Climate change is poised to be a defining factor in the future of educational assessments. Its impacts, including environmental disasters, economic consequences and political shifts, all contribute to increased global instability with the potential to disrupt schooling and affect student well-being. This, combined with AI-driven education and the potential decline in assessment value, could lead to more compassionate humanitarian responses and the need for flexible, location-independent assessments. Digital learning platforms could well become vital, allowing displaced and migratory students to continue their education. The combination of climate change impacts and the development of AI onscreen education might mean that formal, standalone assessments become rare as assessment is built into digital teaching and learning systems. However, climate-related delays in digital transition may create educational inequalities.

Assessment Organisations

The future of legacy assessment organisations is uncertain as they adapt to digital assessments and as formative assessment is integrated into AI-supported personalised learning. Those failing to transition within 5-10 years risk becoming obsolete. Large edtech companies could come to dominate the global online learning and assessment market, leaving established assessment organisations to rethink their roles. The landscape is shifting from historical expertise to future-oriented change drivers. An implication may be that only some organisations will have sufficient resources, capital, big data infrastructure, computational psychometrics and AI expertise to compete in the market.

1.3.2 Backcasting

With our vision of 2050 in mind, we work back to today to describe different phases in the timeline to achieve and shape the preferred future.

2045: Integration & Enhancement

Global education adopts AI tutors, almost all assessments are digital and augmented reality , Virtual reality and hybrid tech are standard. Educators and health professions collaborate to promote learner wellbeing. Schools have climate-resilient infrastructures in place.

2040: Expansion & Collaboration

AI tutors expand globally, virtual assessments surge, holistic education grows, bringing together academic knowledge and emotional growth. AI assessments empower autonomy, and traditional assessment bodies collaborate with edtech giants.

2035: Adoption & Transition

AI-driven education gains traction in leading institutions, inspiring global adoption. Assessment bodies embrace digital transformation, computer-adaptive exams are adopted as the gold standard, and there is a shift to anytime, anywhere assessment, emphasising virtual and augmented experiences. Home and mobile learning are the primary locations for learning and assessment.

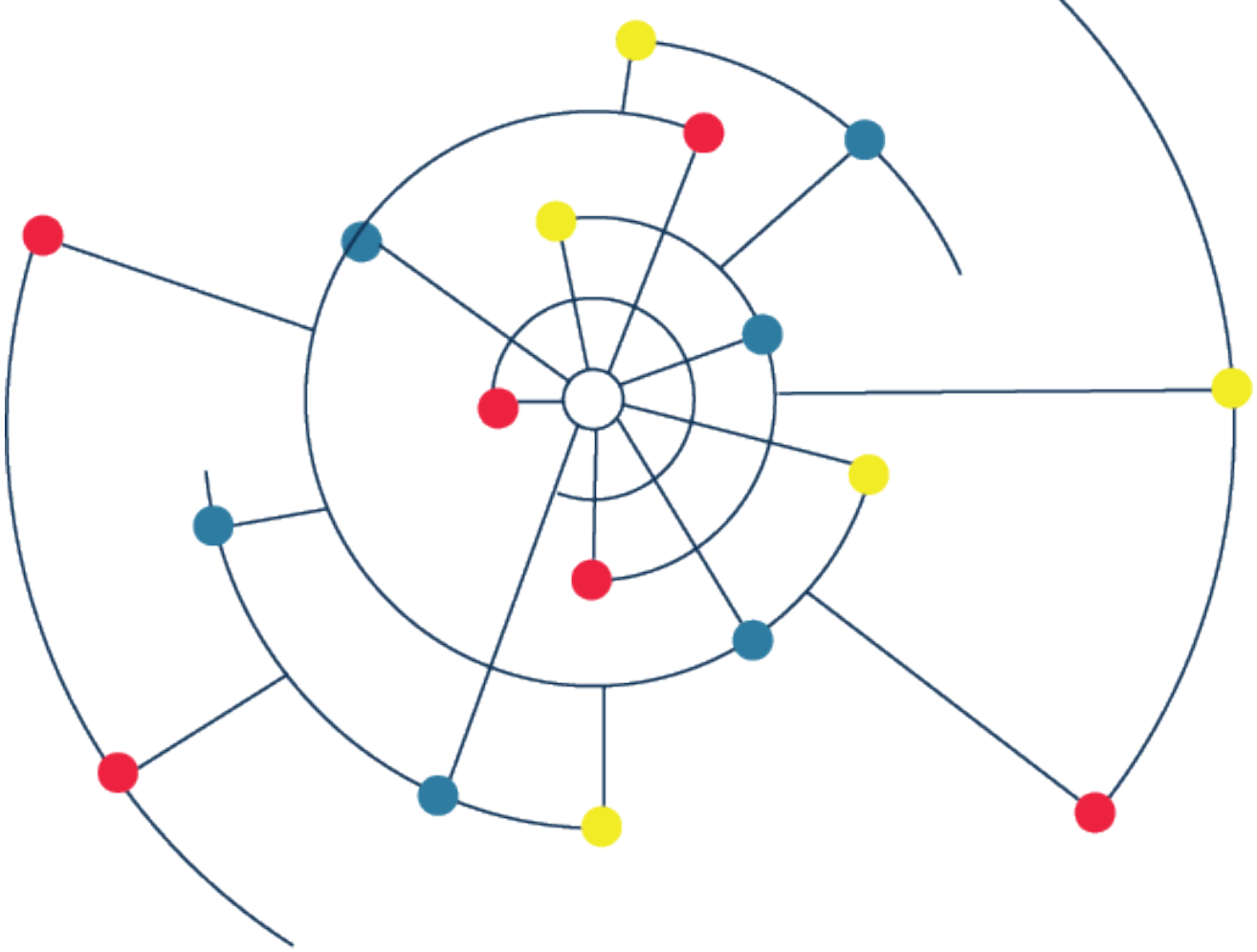
2030: Pilot & Development

Global schools pilot AI tutoring, personalised learning, and climate-resilient systems. Assessment bodies drive digital transformation. Some are collaborating with edtech giants and introducing augmented and virtual assessments. Well-being and climate-adaptive education influence policy, infrastructure and curricula.

2025: Research & Awareness

Significant investments are made in research which advances AI tutoring and computational approaches informed by reformed assessment principles. Assessment bodies adapt to the growing influence of edtech and embrace digital transition. Global conversations prioritise student well-being. There is acknowledgment by assessment organisations of the potential impacts of climate change on global schooling systems. A global trend is recognised by assessment organisations, regulators and policy makers towards increased use of onscreen, digital assessments.

[i] Read more in Appendix B and Appendix C



02

Introduction

2.1 Introduction

The use of Futures Thinking has become an increasingly important part of institutional foresight and organisational planning in recent years. In times of rapid change and uncertainty, Futures Thinking provides organisations with methods and perspectives to anticipate and manage disruptive change in situations in which past events and trends are unlikely to provide a reliable guide to the future. Many organisations now employ futurists to ensure that foresight and planning are at the heart of their institutional culture. Futures-oriented institutes are also established in many universities. The vision of the Digital Education Futures Initiative (DEFI) is to explore the field of possibility that digital technology creates for education. In this project we have focused on the role of assessment futures.

Futures Thinking has been used in this study with the aim of creating a variety of plausible futures scenarios drawing on evidence of change in the present. The study was developed in collaboration with individuals and groups from various departments across the University of Cambridge. The objective was to involve as many participants from the university as possible in order to develop diverse scenarios of the future and attempt to eliminate cognitive biases that may occur from individual organisations' perspectives.

2.2 The Team

This research was led by Dr Fawaz Abu Sitta, a visiting fellow at the Digital Education Futures Initiative (DEFI) at Hughes Hall, University of Cambridge, with a core organising group of staff from DEFI and Cambridge University Press & Assessment. The research work was carried out together with experts from the Cambridge University Press & Assessment, the University of Cambridge Faculty of Education, the Cambridge Psychometrics Centre, the Department of Computer Science and Technology, the Department of Social Anthropology, the Institute of Continuing Education, a Cambridge-based company CUVA and a US-based edtech company Equitech Futures.

Experts from these partner institutions contributed to the project: Alan Blackwell, Alison Twiner, Ami Jones, Anna Greene, Ayesha Ahmed, Bhasi Nair, Bryan Maddox, Chia-Wen Chen, Chris Jellis, Claire Dembry, Cerys Burcher, Dan Bray, Francesca Woodward, Gill Elliott, Giota Petkaki, Imogen Casebourne, Irana Morrish, Jesse Dvorchak, Jing Xu, Joanna Gibbins, Jude Hannam, Juan Visser, Kathryn Davies, Kevin Martin, Kondwani Mughogho, Mark Frazer, Markus Hextall, Martin Johnson, Martina Kuvalja, Mike Cresswell, Nivedita Bose, Nork Zakarian, Nunu Tao, Peter Johnston, Roisin Vaughan, Rupert Wegerif, Sanjay Mistry, Sarah Hughes, Sylke Scheiner, Tim Oates and Tony Leech. They participated in three 3-hour long workshops with many taking part in significant work in-between the first and the second workshop, split in groups, to identify, research and appraise signals related to the questions about various aspects of assessment. Group coordinators arranged regular meetings and presented their groups' findings at the second workshop. A smaller group volunteered to review early drafts of this report.

Day 2 - workshop of the futures of assessment

2.3 Futures Thinking

Discussions of educational assessment are often oriented toward historical perspectives – particularly on its development since the 1950s, and its various periods of change, particularly concerning notions of test validity, reliability and fairness. The field is therefore oriented towards the foundational authors and their publications as they inform documents such as 'The Standards for Educational and Psychological Testing' (APA/AERA), and the International Testing Commission guidelines, and the guidelines produced by the International Testing Commission.

Of course, a longer history of educational testing and assessment goes back some 3,000 years, as Tim Oates documents in Appendix A of this report.

This report, and the workshops and research that informed it, are deliberately oriented towards the present day and the future. Despite historical attempts to reconcile periods of change in assessment theory and practice, one reading of the history is that it is not simply a process of consolidation and synthesis, but contains some major shifts and periods of rapid change. As Newton and Shaw note1, the history of assessment is actually marked by distinct epochs and periods of change.

As we consider the futures of assessment, we have to recognise that both the present day and the future may well include change that challenges our current norms and assumptions – for example, over what counts as good assessment. Anticipating such change therefore requires a willingness to consider radical departures from established thinking and practice.

Futures Thinking asks us to consider the way that assessment, past, present and future is impacted not only by continuities, but also by megatrends and periods of disruptive and exponential change. In that way, though the past is instructive, what has gone before is rarely a reliable guide to what will happen in the future.

The report builds on the wider literature on assessment futures.[2–7] It focuses on the period of time between the present and 2050. If we look back 30 years or so, we can see how different the world was then, and that puts things into perspective. For example, the internet started to become widely used, with schools receiving funding to establish internet connections, enabling web-based training. Mobile phones became widely available in the 1990s, with the first apple smartphone (iPhone) released in 2007. Computer-adaptive testing started in the 1990s and the PISA test went online in 2015. In 2020 many students had to learn online due to the COVID pandemic and others went without schooling altogether.[8]

In her book 'Foresight Infused Strategy,' futurist Maree Conway explains that most strategic decision-making today is based on historical data and current trends, extrapolated into the future without questioning the underlying assumptions. In contrast, foresight approaches systematically explore potential future scenarios to understand how external forces may evolve over time.[9]

Organisations with well-developed foresight and Futures Thinking capabilities are better positioned to seize new market opportunities, shield themselves from potential risks, and outperform their competitors.[10]

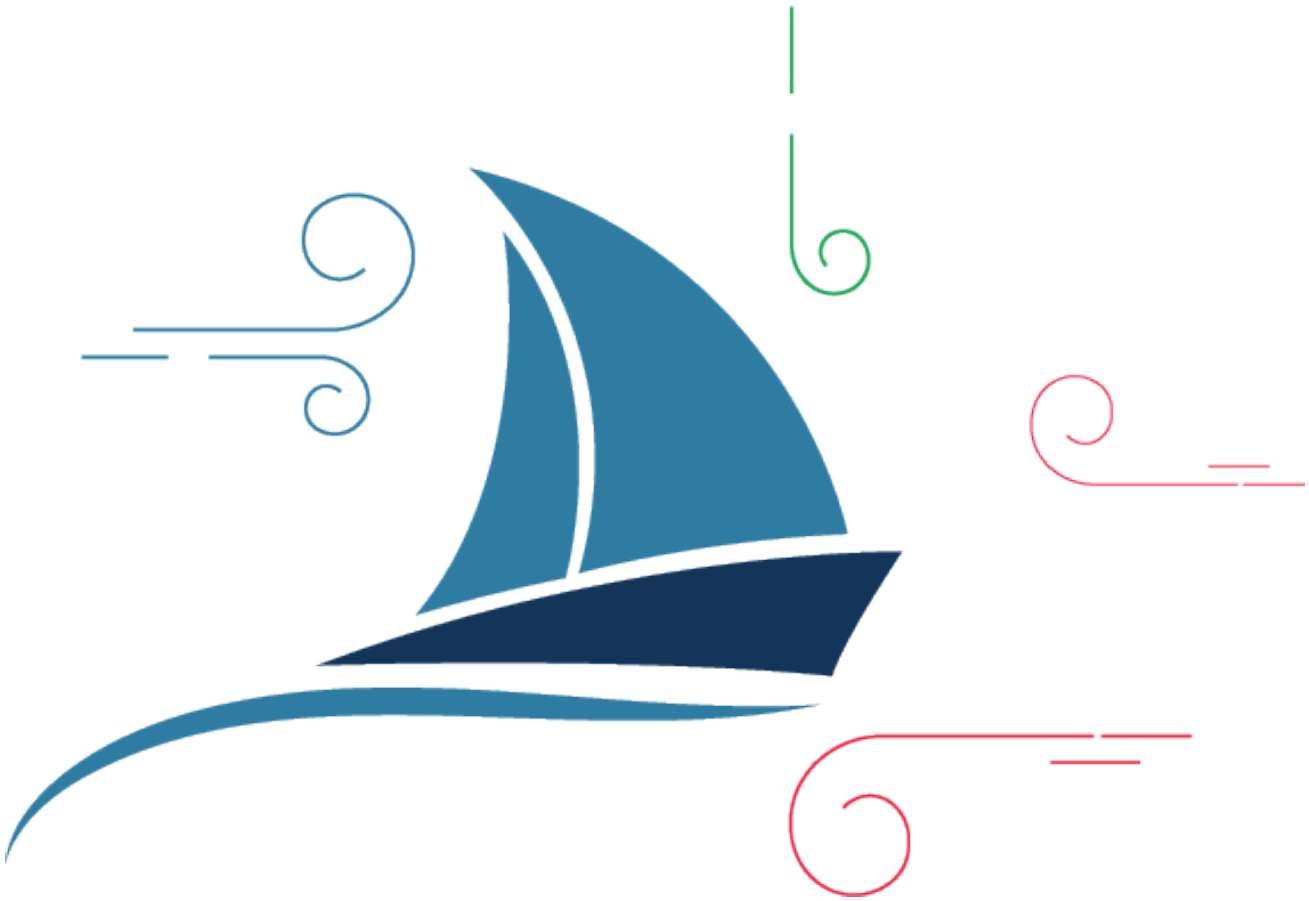
Educational institutes and ministries often develop strategic plans and educational policies with the assumption that the future will be similar to the past. This approach is limited in its ability to respond to disruptive innovation, radical uncertainty and major shifts in the education domain. For example, a focus on historical data and existing trends can blind decision-makers to weak signals and wild cards, which are often the harbingers of significant and radical change.[11] Furthermore, a single strategic plan that does not consider alternative scenarios leaves organisations unprepared for unexpected events.[12]

Strategic foresight and Futures Thinking adopt a forward-looking approach[12–14] and focus on exploring the weak signals and wild cards, emphasising that tomorrow may not necessarily resemble yesterday. This encourages the use of imagination to create new mental images of plausible futures based on an assessment of current trends. Strategic foresight also adopts systems thinking and complexity management to navigate uncertainty. A core objective of Futures Thinking is to eliminate the cognitive biases that colour mental images of the future. Infusing strategic foresight and systems thinking into the strategic planning and policy development process can enhance the educational strategic agenda and promote agility and resilience.

Futures research methods include 'horizon scanning,' which involves systematically monitoring information sources to identify emerging issues and changes.[15]

Trends are observable patterns of change over time that can offer insight into potential future developments,[16] whereas megatrends are larger, long-term forces which shape society, such as globalisation.[17] Signals offer clues about impending change; with what are termed weak signals offering subtle early warnings of disruption.[18] In our research we identified many signals and weak signals, as well as trends and megatrends.

Complementary methods in the critical tradition include the 'Futures Triangle' and 'Causal Layered Analysis' (CLA), both developed by Sohail Inayatullah,[19] as well as Scenarios and Visioning. CLA integrates empiricist, interpretive, critical and action learning perspectives, and involves four layers of analysis which together offer an in-depth insight into the assumptions of the present to create new perspectives on preferred visions for the future.[20] The futures triangle used in this project also seeks to unpack assumptions about the present. Scenarios explore multiple plausible futures, with participants invited to exercise imagination about ways in which change might occur, grounded in data about existing trends and signals of change. Scenarios enable preparation for a range of plausible outcomes.[21–23] 'Visioning' focuses on preferred futures[13] and can form a basis for design-based research into how such futures might be achieved,[24] or for 'Backcasting' where the steps required to reach the preferred future are envisaged and mapped.[25] Applied thoughtfully, a critical futures approach can enhance foresight by challenging assumptions and enabling action. Growing complexity and uncertainty (for example around the climate emergency, AI and the possibility of future pandemics) make participatory futures studies and futures literacy increasingly valuable.[14,22]



03

Drivers of Change

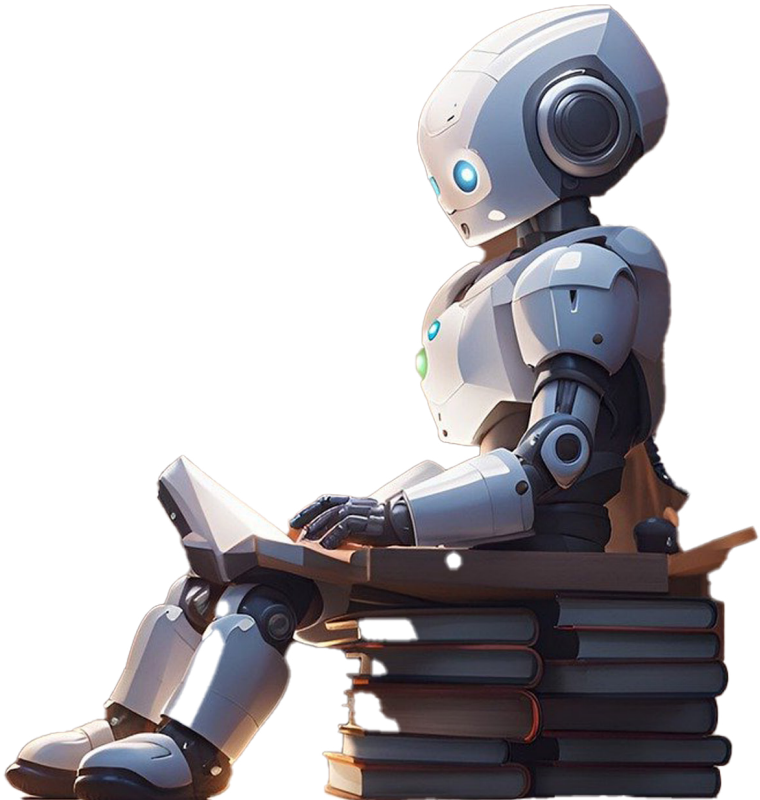
Drivers of change

Horizon scanning helped us to identify a set of signals, which we appraised and analysed using futures methodologies (futures triangle and causal layered analysis) to identify drivers of change. For details on the methodology please refer to Appendix C; the lists of signals and methodological outputs can be found in Appendix B. In this report we identified five key drivers that are likely to shape the future of assessment between the present and 2050.

3.1 AI Tutors and Personalised Learning

One of the most powerful signals is the emergence of AI tutors and personalised learning. This is one of the emergent megatrends identified in this study. There are various conceptions of the 'personalised AI tutor,' and there is currently considerable interest and investment in this area.[26] This includes big commercial and philanthropic investments and the emergence of new actors and products. Examples include companies who are early adopters of Generative AI (Chat GPT4)[27] and advances in computational psychometrics[28] such as Duolingo and Khan Academy.[29,30] There are already companies who offer AI supported personalised tutors,[31–43] and Bill Gates has heavily promoted the idea that personalised tutors can perform better than human teachers.[44] A few weak signals about this kind of initiative are significant. Some advocates claim that students may learn better and faster with these systems to accelerate human learning.[45]

It appears plausible that future generations of AI tutors could hugely accelerate learning, particularly with evolutionary feedback loops to improve these products, and in their combination of very large-scale assessment data with their own adaptive systems to modify and improve instruction. This suggests that 'assessment' might increasingly be an integrated feature[46] of these kinds of AI based learning. A second point about these AI tutors is that their delivery systems and low price-points mean that they can deliver content globally to huge populations (as other big tech companies have done in other areas). We could see a huge global growth in the numbers of people who make use of these systems. Duolingo, for example, already has more than 70 million active monthly users on their language learning platform.[29]



This suggests a major change in the provision and access of education internationally, so that access to high quality instruction is no longer primarily dependent on geographical location (i.e., challenging the idea of learning being dependent on 'education systems').[47] Teacher shortages, teacher quality and attendance[48–51] is a major challenge for educational quality and access which might in part be mitigated by AI. Such changes have the potential to transform the educational landscape, as they are already in areas such as language learning. Should they combine with other emergent technologies discussed in this report, the pace and trajectory of change might be even further impacted. For example, if there were to be significant changes in technologies such as general AI, liquid neural networks, quantum computing or nuclear fusion.[52–57] In terms of the implications of all this, there are a few key areas that require consideration.

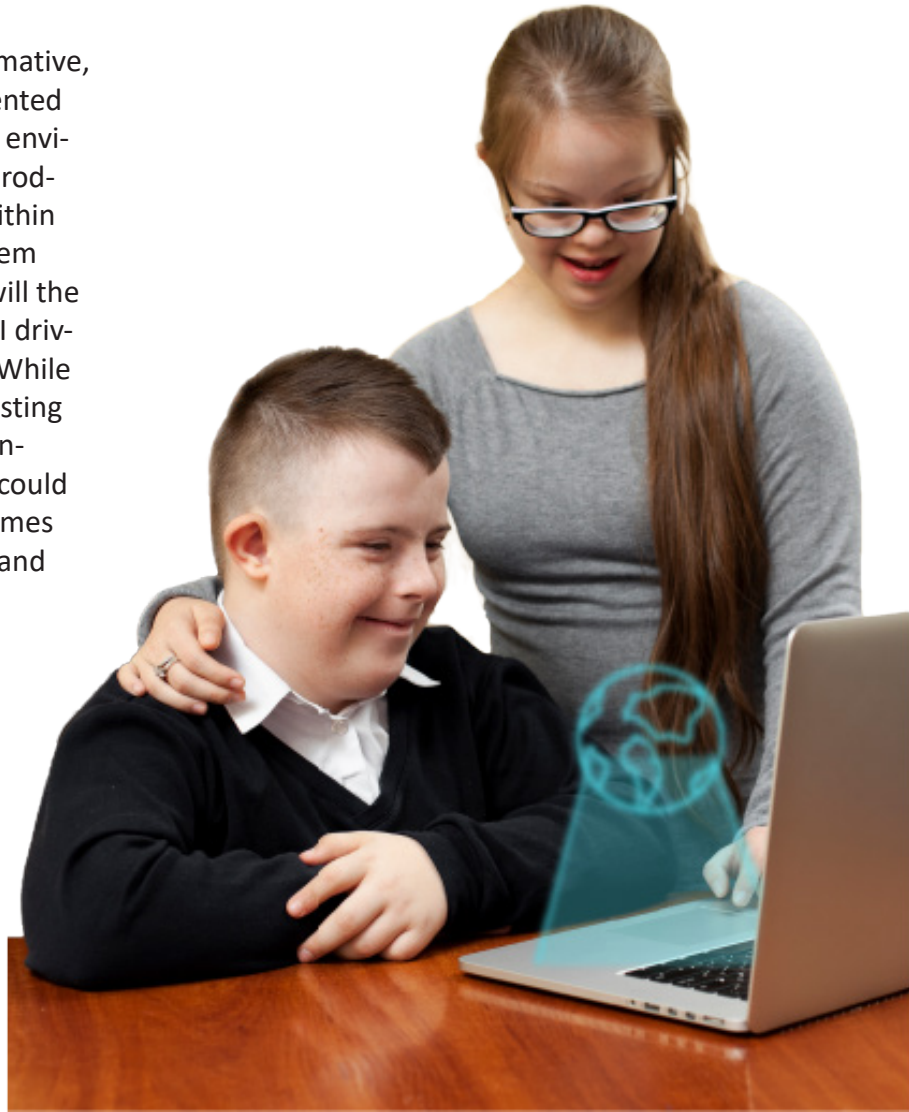
Firstly, while much change is currently being driven by private actors[58] this will not necessarily remain the case. Successful technologies and approaches may well be adopted by national education systems, and that could transform the character and provision of schooling and lifelong learning. The efficacy and efficiency of these systems might in time provide clear advantages that individual students and parents will respond to in their educational decision making, with schooling systems going on to incorporate the techniques as part of hybrid or blended forms of instruction.[59] These approaches might also come to be viewed as a way to increase the resilience of educational systems and individual learning experiences, as people are impacted by the disruptive impacts of climate change.[60–62]

Finally, such changes have the potential to impact significantly on the role and contribution of assessment organisations. For example, there would be a need to ensure that the integrated systems of assessment in personalised AI tutors have assessment integrity and to ensure their reliability, fairness and validity. There would also be a broader need to ensure curricular accountability, transparency, data ethics,[63] the equitable performance of AI systems and the absence of AI bias related to themes such as gender, race, language, and other sources of diversity such as neurodiversity and disability,[64,65] This is particularly important as data from AI tutors is likely to include access to new forms of data on the performance of students and assessments, including physiological, cognitive and affective and behavioural data that are not yet sufficiently well integrated into systems of assessment validation, reliability and fairness.

Separately, there is considerable potential for the development of alternative, less individualistic models of AI-supported schooling and learning – for example, AI approaches to enable collaborative, scaffolded and networked learning and teaching.[66–69] Should collaborative AI systems become more widespread, there will be a need to create new mechanisms for those systems to reflect educational policy and priorities and to develop related systems of democratic accountability and equity. There is scope for increased use of AI to assist teachers in orchestrating collaborative and group learning. Research is underway into AI that can support teachers with assigning children into groups,[66,70] that can alert teachers when groups are struggling[71] and into uses of AI to provide initial formative feedback to groups of students.[72–75] This is likely to be of particular value for younger children who have not yet developed autonomous learning skills.

All of this raises questions about how formative, diagnostic and summative credential-oriented assessments would operate in those new environments.[76] Might they in future be the product of in-built assessment techniques[55] within AI providers (raising questions about system integrity and accountability)? If so, how will the concordance and comparability of such AI driven assessment practices be established? While there may well be some parallels with existing systems for assessment validation and concordance,[77] it seems plausible that these could develop and expand to integrate new themes and procedures that improve the quality and breadth of inferences that are available.

In particular, responding to questions about the reliability of assessments conducted at a particular point in time, in comparison with continuous assessments, and to demands that assessments take effective account of sources of diversity and potential disadvantage - such as those experienced by neurodiverse learners, students with learning disabilities, and any other form of disability that compromises students' ability to sit a traditional 3-hour assessment.[72] Adaptive AI-based tutor systems should also be able to diagnose, respond to, and monitor neurodevelopmental ability to conditions over time and to identify and quickly flag, direct attention, and account for periods of disruption in student learning experience brought on by wider disruptions related to personal circumstances or climate change related disruptions.[60] There are strong signals for these types of response in existing practice.



3.2 Augmented, Virtual and Hybrid Technologies

Advances in technology are likely to continue to drive assessment designs, particularly in terms of the screen-based assessment experience, but also involving augmented, virtual, and sensor-based and multi-modal and multi-sensory activities. A transition to onscreen assessments (from paper) is well underway in most assessment systems and contexts. Such assessments may evolve to support the provision of augmented reality functions,[79,80] including the ability to digitally interface via a screen, keyboard, and mouse and use a variety of tools, information, software and data - much of which is already significantly more accessible and multimodal than paper-based assessments.[81–84] Looking forward, it seems plausible that assessment designs may develop in contrasting ways - towards greater sophistication of AI-supported immersive, virtual and multimodal and multi-sensory experiences,[85–87] and at the same time enabling augmented interaction and data capture in physical and hybrid environments.[88]

It seems plausible that the current anxieties in education about the presence and use of tools such as spell checkers, readers and more sophisticated AI resources (such as integrated AI-tutors, adaptive scaffolding, generative AI, and simultaneous language translation)[89] may dissipate in the near future as new generations of 'AI native' children and adults take these technologies for granted. This would enable new approaches to assessment design and validation (as is already happening in many assessment systems and products). Digital, onscreen assessments are also likely to fully embrace and accept the idea of augmented humanity,[90] supported by developments in neuroscience[91–95] – with measures of assessment performance being able to integrate understanding of the ways that people interact with digital tools and resources.[46,96] This is already happening with log data analytics[97]

(clickstream, keystrokes, navigation) as a built-in feature of 'process oriented' assessment constructs. Moving in the other direction, augmented reality devices and continued advances in natural language processing (NLP), gesture recognition,[98] wearable sensors[83,99] and digital pens[100] could lead to assessment becoming less screen-based, more dialogue-based and more interactive. As a result, some future assessments may involve less text and more talk, interaction and applied, action-based tasks. There are already signals of this taking place in some innovative designs and domains. This transformation may also be driven by concerns about the negative cognitive and developmental impacts of individual, sedentary screen-based activities.[101,102] Technologies such as AI supported augmented reality glasses[103] may become widely available, and that could support hybrid teaching and assessment of reading and other subjects.[104] Unlike personal AI-tutors, such developments have the potential to expand the digital divide,[105,106] as they may only be available in home, school and employment contexts where there are sufficient resources.

The assessment world and public perceptions of assessment involve a degree of inertia. This is in part because it has historically viewed (and to some extent still regards) standards, regulation and comparability as some of the key characteristics of assessment validity, reliability and fairness including public trust in assessment results.[107] In that sense, it is open to the charge of hampering rather than fostering assessment innovation. However, that is already beginning to change, for example as responses to diversity, equality and inclusion, and as real-time adaptive designs depart from the idea that everyone should sit the same assessment in the same way.[81,108–110]

It seems plausible that some of the historically central roles of assessment organisations on assessment integrity, standards and accountability could be taken over by edtech companies.[79,111] The current experience of small-scale educational software providers, big tech companies, and large assessment organisations who are using log data suggest that those organisations may not consider historically established systems of accountability to be part of their core business.[112–114] In the future they may be required to report against frameworks and laws on the ethics, transparency and accountability of their valuable, IP-protected, 'black boxed' products. However, in the context of the likely catastrophic impacts of climate change,[61,62,115] it is possible that people might view access to prestige educational resources as of primary concern rather than more nuanced questions about the integrity of their assessment data.[116,117]

3.3 Human Flourishing & Wellbeing

The Coronavirus Pandemic stimulated the articulation of concerns about the potential for assessment – particularly high-stakes assessments and examinations - to impact negatively upon student wellbeing at a time when many students suffered from mental health difficulties - notably depression and anxiety (the 'tidal wave' of mental health problems that has recently been discussed in the press).[118–120] The pandemic also lifted the lid on concerns within the assessment community and the teaching profession about the importance of assessment supporting student wellbeing and human flourishing. The end of the lockdowns did not lead to a cyclic return to normal. School attendance has remained poor after the pandemic, and it is questionable whether students and parents any longer tolerate the level of mental health damage associated with high-stakes assessments such as UK GCSE's.[121]

There were already some advance signals of difficulty with social movements against school testing and high-stakes examinations (the US 'quit testing' movement), and the academic literature about student test anxiety. It also appears that certain groups – such as students with special educational needs and disabilities, and those with underlying mental health conditions, are especially vulnerable to such unintended negative consequences.[122] Linked to this is the rise of 'climate anxiety' experienced by young people.

The duty of care of teachers and test designers suggests that there is likely to be growing intolerance of the pressures of standardised high-stakes testing, and a growing preference for more enjoyable, personalised and engaging assessments,[123–126] and test designs and interfaces that are attentive to enjoyment and wellbeing - what Duolingo describe in terms of a 'delightful' Test Taker Experience.[127]

In retrospect, it seems that the assessment community had made a virtue of necessity in the design and administration of large-scale, standardised examinations. Computer adaptive testing is becoming increasingly widespread in a wide variety of subjects and applications and is already well-established in some high-profile assessments. Claims made for computer adaptive tests include that they enable shorter assessments due to their adaptive designs, and offer greater fit and granularity than linear tests.

However, there are also challenges, for example, in pedagogy where teachers and students may want to review standardised items, and in perceptions of fairness around everybody having the opportunity to tackle the same questions.[76] Additionally, there are some subject areas that may be more difficult to assess using computer adaptive models. Nonetheless, it is a rapidly evolving technique which, combined with developments in AI, could eventually replace linear-based testing[46,128–130] and in some form underpin platforms offering formative feedback on student learning.[42,46,131,132] It also seems likely that alternative sources of assessment data such as large-scale computational psychometric data from student interactions with onscreen learning and assessment tasks might be better used to support more effective evaluations of educational trends, school quality and student achievement.[133,134] AI powered teaching and learning could also rapidly accelerate student learning and intellectual flourishing, and in some scenarios might rapidly 'de-link' the relationship between the age of students and their educational achievements, as well as 'de-linking' the relationship between geographical location and access to high-quality schooling. This implies that assessments might in future be taken at the right time for children's educational development and achievements (in most cases, integrated into online teaching), rather than in annual cycles of examinations. Taken together, such developments have the potential to enhance human flourishing.

The idea that pen and paper sit down examinations, taken in a hall full of highly stressed students will continue far into the future seems increasingly unlikely, especially given the alternatives that now exist.

It is also questionable whether students will continue to consent to such examinations, and whether they could be conducted in a fair and reliable way across education systems that are suffering the pervasive disruptions of climate change and/or pandemics.[8] Many assessment systems have already moved or are moving to onscreen assessment designs that make whole cohort, exam-hall-type test administration impractical or undesirable.[135] This raises questions about the types of future assessment data that would satisfy requirements for judgements of student achievement (in or out of school), that may have 'high stakes' consequences for things like school and university entrance requirements, migration and citizenship status, and decision making in the employment market. It is plausible that in the medium-term that 'stealth', continuous and collaborative assessments (for example, as granular 'reports' from learning platforms) might come to replace examinations. That would reduce the time taken up by student assessments, reduce student anxiety, and remove washback associated with preparation for high-stakes exams that is currently so influential in teaching decisions. Cultural expectations of exams as ritual rites of passage and technology push-back may, however, continue to shape assessment decisions in national education systems.[101,136,137]

3.4 Climate Change

Climate change and climate shocks and emergencies are likely to be one of the most powerful drivers of change in assessment futures.[62,115,116,138] Climate change is a megatrend that will shape assessment futures. Climate change impacts are already causing floods, droughts, extreme heat, massive biodiversity loss, and fires that are disrupting lives, and causing economic impacts and migration. Climate change is already forcing child migration and displacement, as recently highlighted by UNESCO.[139] Its political impacts are also being experienced now, with populist politics and right-wing, authoritarian responses. However, there are also more compassionate humanitarian responses, and those may play out more and more in education and in assessment.[140,141]

There are likely to be severe resource constraints, infrastructure damage, and disrupted schooling in most countries. This may mean that large-scale standardised examinations become difficult to conduct.[142-143] As climate anxiety, and related political upheaval and conflict increase, this could worsen teacher absences and shortages in many countries.[48,144]

Such developments could combine with other drivers discussed in this report, such as the availability of personalised AI tutors,[47] to lead to parents opting not to send their children to school, or at least, to reduce their attendance. That could in turn decrease confidence in the value of assessment credentials in some contexts in response to declines in school quality.

There is scope for positive humanitarian responses[116,145] and work with governments to develop systems of resilient and mobile assessment.[146] These might include formative assessment for learning being integrated into digital learning platforms, supporting systems of accreditation that can be taken whenever the time is right, and which can travel with people who migrate within or between countries, being recognised internationally. Digital learning and assessment ('cloud-based' individual learning data profiles available via satellite links and collaborative digital classrooms) might support mobile, displaced, and migratory students to continue learning and to maintain links with school friends and family, as well as their linguistic and cultural identities, thus supporting student and teacher wellbeing.

There are already strong signals of these types of changes with educational provision for communities impacted by conflict, climate change and natural disasters. By 2050 this could be the experience for large populations, with digital assessments and qualifications being the only form of provision.

Additionally, the combination of climate-related disruption and climate anxiety[147] could mean that future assessments come to demonstrate more sensitivity to the emotional needs and wellbeing of test takers, and the requirement for flexibility in the location and timing of assessments. This combined with an increased focus on developing engaging and enjoyable assessment experiences, could lead to the abandonment of large-scale, standardised assessments. Assessment might increasingly take place in digital activities outside of the school[28] (such as the home and workplace) driving the development of remote proctoring techniques[148] and the integration of personalised learning and assessment.[149,150] In summary, by 2050, a combination of climate change impacts, and the development of AI onscreen education could mean that formal, stand-alone assessments become rare (the exception rather than the rule), as assessment is built into digital teaching and learning systems.[151]

Conversely, climate-change related impacts also have the potential to increasingly disrupt and delay digital transition across many education systems, creating inequalities in schooling and resource burdens to which schools and governments are unable to respond.

Climate change, shocks and emergencies are likely to be one of the most powerful drivers of change in assessment futures

We can already see signals in the UK, where current inequalities in digital equipment and infrastructure mean that onscreen assessments risk the introduction of new sources of inequality and disadvantage. This may lead to a push-back, as parents, schools and governments choose to delay the introduction of onscreen assessments and to develop associated arguments and experiences to suggest that standardised, paper-based assessments are the most equitable for high-stakes assessments. However, delays in digitalisation of educational assessments are likely to increase future disadvantage and inequalities as the impacts of climate change increase significantly over time.

3.5 Assessment Organisations

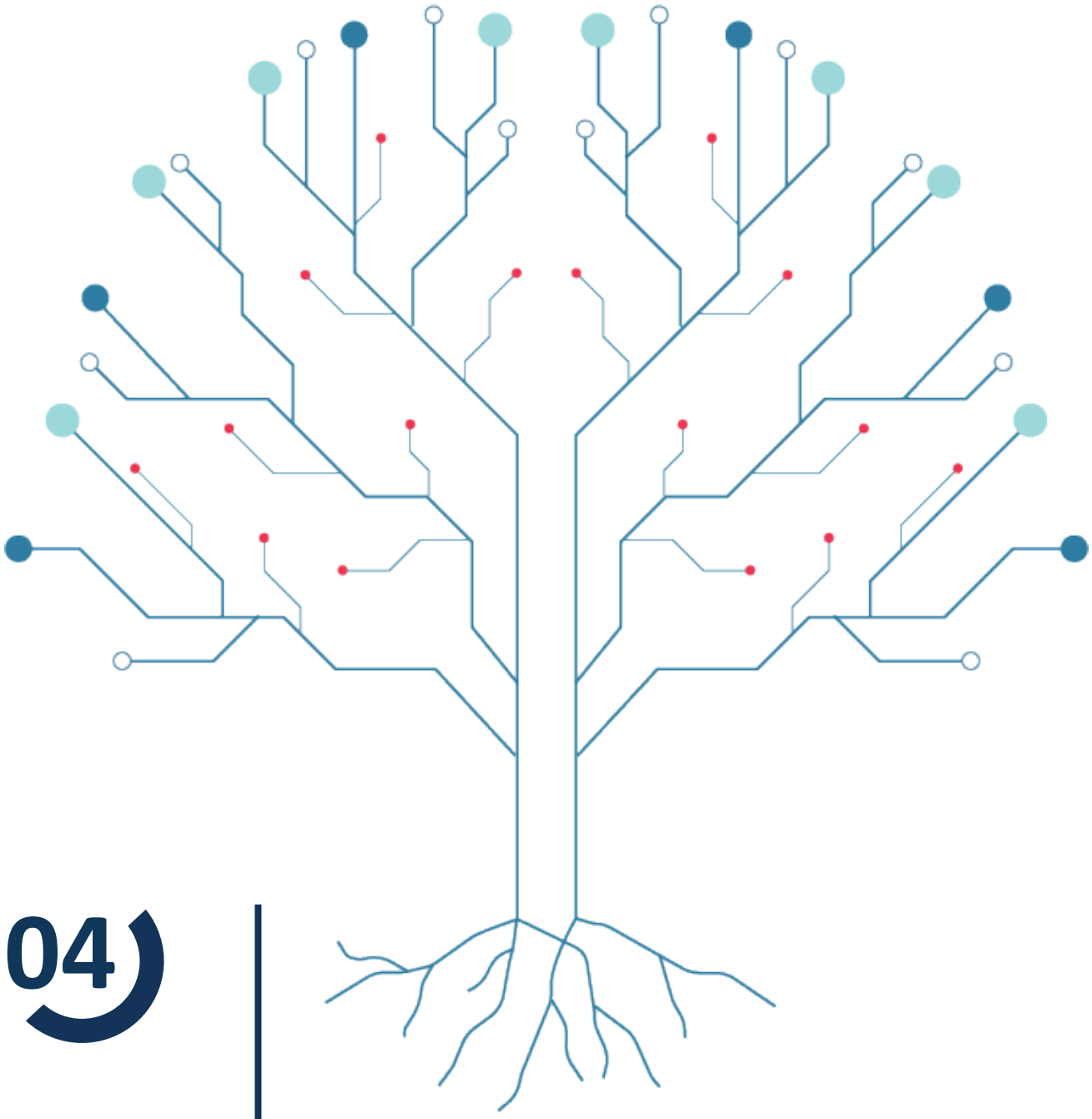
Looking forward, it is questionable whether conventional assessment organisations will continue to exist. The answer depends largely on how well they can anticipate, adapt to and shape assessment futures. For example, the transition to digital assessments is already well underway, and it is not impossible that organisations that have not made that transition completely in the next 5-10 years could find themselves obsolete and overtaken by 'digital first' providers. Secondly, it seems plausible that educational assessments could increasingly become integrated into AI-supported, personalised learning, which would in turn rapidly reduce and then entirely remove the role of 'stand-alone' assessment providers. There are also some uncertainties about those changes as some education systems are likely to want to retain digital, stand-alone assessments as educational rites of passage linked to nationalist movements, anti-globalisation and beliefs about educational equity. Finally, there are certain to be huge opportunities for assessment organisations to shape and take advantage of the many affordances of new technologies to provide new forms of assessment design that vastly improve and accelerate human learning and flourishing, influence the futures of schooling, and support creative and equitable responses to the challenges of climate change.

As digital infrastructures replace the testing centre, assessment organisations may have to consider and negotiate their relationship with big edtech providers of 'digital first' services in online learning and assessment.

Some - those with sufficient resources and expertise, and perhaps with backing from national governments - may choose to go it alone, to produce their own digital products and services. However, the technology-driven innovations described in this report may require large amounts of capital and certainly human expertise in assessment design, computational psychometrics, and data analytics – which are not evenly distributed. That means that for some digital assessment products, only certain organisations may have sufficient resources and expertise to be in the game and to generate market advantage. In the longer term, it may be that some of the technical expertise could be taken over by machines. The situation appears analogous to the way that the big tech companies have generated huge global markets, for example, in mobile phones and data services, that they use to maintain a technical advantage over their competitors.

It is possible that a global market in online learning and assessment could be captured by a relatively small number of very large edtech companies (or Big Tech companies who enter the digital learning and assessment space). The recent initiative and announcements of Bill Gates on his investments in personalised AI tutors illustrates that potential. The experience of Khan Academy and Duolingo with early access to ChatGPT illustrates the way that market dynamics and computational expertise can impact on the assessment field. The question therefore is what legacy assessment organisations might bring to the table, what their roles would be, and whether they can continue to operate in that emergent global market? There are already some answers to those questions in the signals that we have reviewed in this project.

For example, in relation to the pace of change, and the need to reconceptualise core expertise and vision in areas such as innovative assessment design, test quality and integrity. Recent experience suggests that long-established relationships and functions with national governments, regulators, and school networks are unlikely to be sustained for long if assessment organisations are not able to compete. Paper-based assessments were driven by a service-oriented delivery of assessment, and were informed by long-established historical expertise and standards. However, current signals suggest that assessment futures might become driven by value-based missions, market-driven product design, big-data infrastructures, computational psychometrics, and AI expertise (i.e., radically different human capital and financial capital needs). As a result, assessment organisations and regulators are increasingly led by future-oriented drivers of change, rather than by those whose role was to retain continuities with long-established standards and expertise.



04

Preferred Futures

4.1 Anticipating Assessment Futures

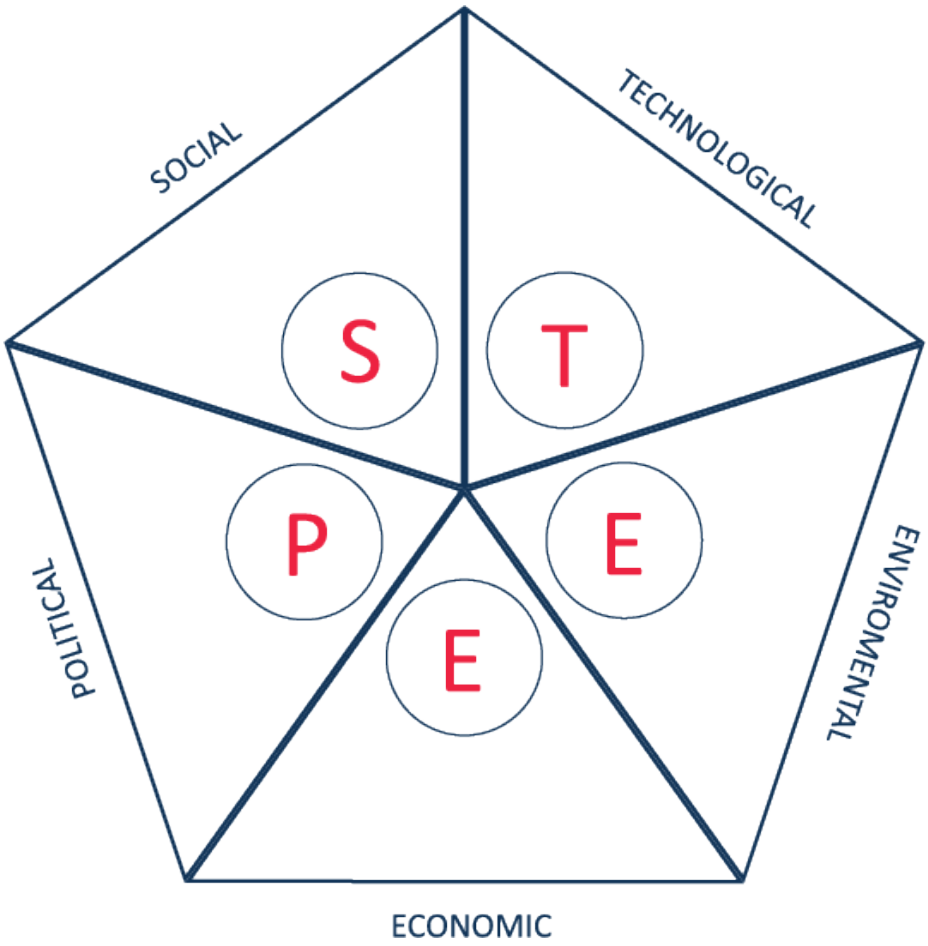
As we have stated earlier in this report, the purpose of Futures Thinking is not to predict the future, but to anticipate and understand likely scenarios, to weigh up and appraise evidence and to consider its implications. In Appendix C we described four scenarios that were developed as part of this work. In this final part of the report, we move toward one of the most important parts of Futures Thinking - we demonstrate ways in which we use the work to shape and contribute to our preferred futures, and plan for future trends and events.

From the horizon scanning activities and the futures workshops, it is clear to us that by 2050, educational assessments could be transformed, and that many of their central features and most cherished practices and standards may no longer exist. The drivers discussion in section five highlighted some of the key reasons for that supposition. The rapid pace of technology-driven innovation together with the unfolding consequences of climate change present us with some compelling challenges and opportunities. It is clear that it will be necessary for assessment organisations to respond to these developments.

We can reasonably anticipate that there will be high-stakes choices and inflection points for assessment organisations that have the potential to shape their futures. To pursue preferred futures, and to remain in the game, some difficult decisions will likely be necessary. Of course, each assessment organisation will have its own vision (or visions) of their preferred futures, and those are likely to be grounded in their own institutional purposes and responsibilities.

In our workshops, we agreed on some preferred futures and principles. For example, the idea that future assessments should involve unobtrusive learning-oriented assessments designed so as to support student wellbeing, creativity and happiness. We considered it desirable that students should be able to access cloud-based digital profiles, digital learning and assessment anywhere globally, and free of charge.

We felt that future assessments should be supported by new approaches to assessment integrity, with codes of ethics and the responsible use of data, and that assessment design should continue to be informed by the latest developments in technology and neuroscience. We recognised that to achieve those desired futures assessment organisations may well need to work collaboratively with edtech companies, governments and transnational organisations and assessment networks, to leverage their strengths, rather than relying solely on 'in-house' solutions.



Our utopian ideas had to accommodate the sometimes harsh realities of 'STEEP' (Social Technological, Economic, Environmental and Political) considerations. Those suggest the need for future planning to have the necessary organisational, political and financial backing, so that change processes are not disrupted by political short-termism or by technology pushback. We are also aware that many plausible visions of 2050 would 'break the mould' by creating new approaches to what have historically been regarded as the fundamental qualities of 'good' assessment. We can already see similar dynamics in the present, such as the shift away from standardised test content and test administration towards more personalised test content and accommodations.[110] We also see signals in the present about the rise of 'anywhere, anytime' assessments. By 2050, as we suggest in the timeline below, there are sure to be many other innovations in assessment that challenge long-held beliefs, standards and practices.

4.2 A flourishing Epoch: An Educational Odyssey of 2050

In the bustling metropolis of Neolearn, the first rays of the sun illuminated the Horizon Learning Center. As 10-year-old Mia and her two friends entered their classroom, her teacher and their AI assistant, Artemis, greeted her, 'Good morning! Ready for today's adventure?' Today, Mia and her friends weren't just studying history; they were experiencing it. With her VR glasses, they stood amidst ancient civilizations, feeling the exhilaration of discovery. The lesson includes discussion, reflection, and play. It had been prepared in collaboration between Artemis and Joy, their human teacher.

They were joined virtually by Isabella, a refugee displaced due to a recent climate upheaval, who accessed the Global Learning Platform from her temporary accommodation. Isabella brought along her own AI assistant, Pepe who had accompanied her in her learning and journeys since she was young. Artemis and Pepe instantly translated all the lesson content and interaction into their preferred languages. That provided Isabella with a seamless continuation from where she left off before her migration. Her digital learning profile, accessible from anywhere, and entitlement to participation and resources enshrined by international agreements. Their assessment wasn't a test but an interactive dialogue with Artemis, who adapted their lesson content and pace, based on their interest and understanding.

Across town, elderly Layla Roshan who had once been a traditional assessment designer, collaborated with representatives of several edtech giants to monitor and refine the AI and hybrid-augmented learning systems, to ensure that they were accountable, and imbued with a human touch. They were able to access AI supported data on student progress, and to ensure that nobody was left behind. Leyla reflected on her learning journey. The high-stress exams her grandparents spoke of seemed like tales from a distant past. Today, her assessments felt like enlightening conversations, focusing on her holistic growth. Assessment organisations had transformed into digital hubs collaborating globally. The legacy assessment giants, rather than being threatened by edtech companies, formed symbiotic partnerships, leveraging each other's strengths. At the heart of Neolearn's education system was its unwavering commitment to human flourishing. Students and teachers felt seen, heard, and valued. The digital tools and resources, and their AI tutors weren't just machines but allies in their growth.

The vignette above was created by human-in-the-loop AI informed by prompts generated in our futures workshops. As a creative artefact, it is designed to help us to counteract the restrictive and limited horizons of the present, and to imagine the kinds of future that may be plausible. We present a more conventional description below of the various themes and elements of our preferred futures as they may appear in 2050.

4.3 A VISION OF EDUCATIONAL ASSESSMENT IN 2050

1. AI-Integrated Personalised Learning:

- The educational landscape becomes a harmonious blend of traditional teaching and AI-driven personalised tutors. Systems evolve to enhance collaboration, and to understand and adapt to each student's unique learning pace and preferences.

- AI assessment systems are meticulously designed to ensure fairness, eliminate biases, and accommodate diverse student populations. This addresses concerns around fairness, inclusion and diversity.

- Collaborative learning flourishes, enhanced by AI models that support and uphold the core principles and values of education. Traditional classrooms are complemented by global virtual spaces where students from different parts of the world connect and collaborate.

2. Immersive Digital Assessment Experience:

- Traditional paper-based assessments have transitioned to augmented, virtual, and hybrid technologies, offering a more dynamic, interactive and real-time adaptable assessment experience.

- Assessments become more dialogic and learner-focused, aiming for a deeper understanding rather than rote recall. Screen-based assessments are complemented with VR experiences for more immersive and augmented testing environments.

- Edtech companies play an influential role in this transition, emphasising user experience, adaptability and interactivity. Efforts are made to ensure that technological advancements don't exacerbate the digital divide.

3. Emphasis on Human Flourishing:

- High-stakes assessments no longer dominate the educational scene. Instead, more holistic, continuous, adaptive and climate resilient models emerge which prioritise students' well-being.

- Stress and anxiety around assessments reduces significantly. Assessment models pivot from mere academic evaluation to holistic approaches that include emotional, social and creative metrics.

- Climate change impacts drive a global emphasis on flexibility, adaptability, and student emotional well-being. Personalised assessment tools consider the global and local challenges students face and are designed to be compassionate and inclusive, including recognition of diverse cultures, geographies, histories and languages.

4. Resilient Education Systems in the Face of Climate Change:

- Climate change's undeniable impacts lead to significant reimagining of educational systems. Traditional brick-and-mortar schools are supplemented, and sometimes replaced with AI-powered digital learning platforms to ensure continuous learning and assessment amidst disruptions.

- By 2050, standalone assessments have become the exception. Integrated digital assessments, tailored to the teaching process, are the norm. They cater to diverse student needs, especially those of students displaced due to climatic challenges.

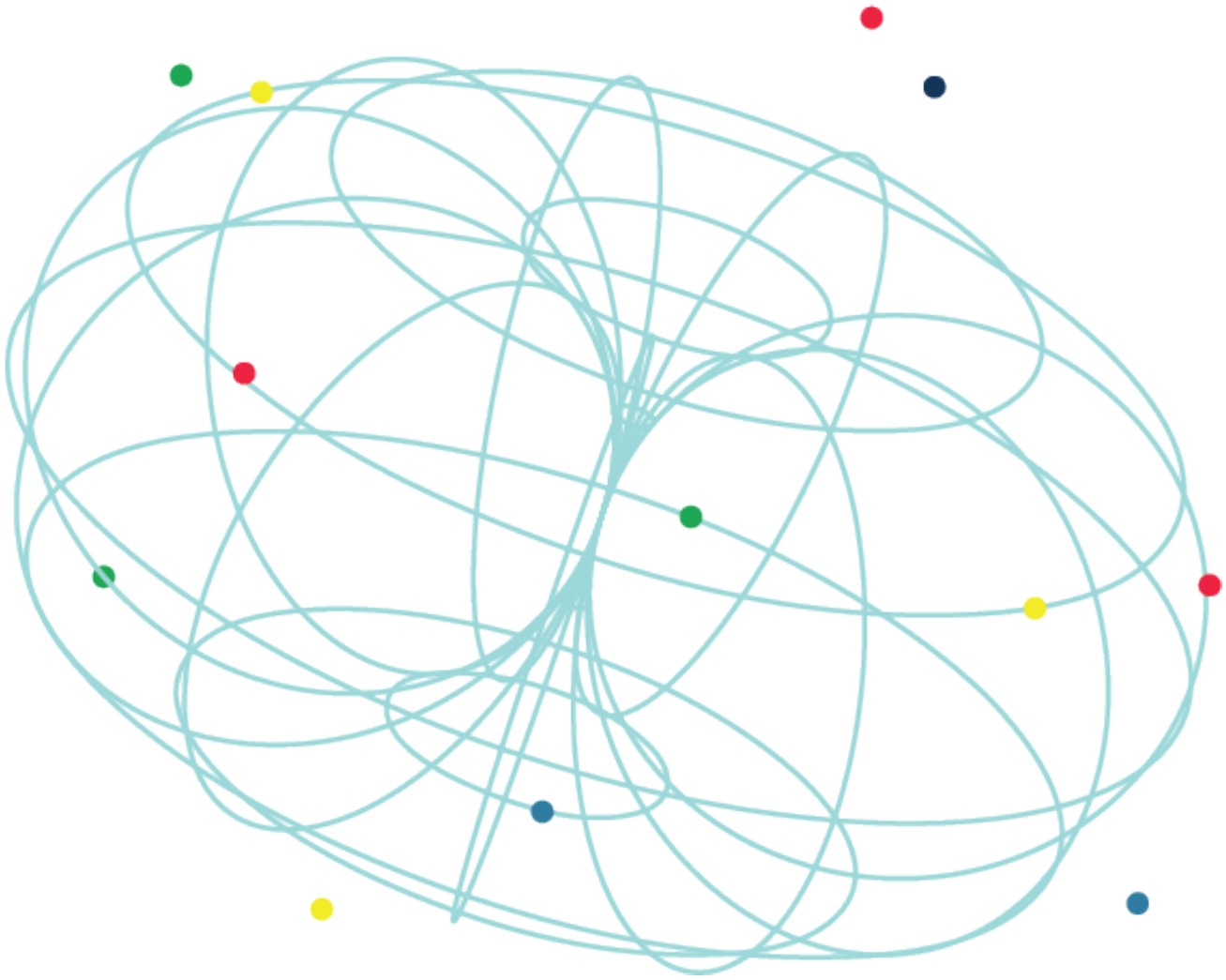
- Digital educational profiles, accessible globally, become a staple. These profiles not only store academic credentials but also track a student's holistic development.

5. Reinvention of Assessment Organisations:

- Legacy assessment organisations either adapt rapidly or make way for 'digital-first' providers. Collaborations between traditional assessment bodies, edtech giants and governments are widespread.

- Standalone assessment providers witness a diminishing role, but niche areas emerge where they still hold value, especially in regions with strong nationalist or anti-globalization sentiments.

- The assessment market becomes increasingly competitive, with a few big players potentially dominating. However, amidst the competition, the core focus remains on enhancing learning outcomes, promoting equity and fostering human flourishing.



05

Shaping The Future

To conclude, we undertake 'backcasting' to develop a timeline of events that might lead toward our preferred futures. Those are presented with the understanding that when futures-thinking becomes integral to assessment strategies it means shaping the future, and anticipating challenges, rather than merely reacting to them. With our vision of 2050 in mind, we work back the way, to 2045, 2040 and so on, to work out how we should start planning today for the future.

5.1 2045: Integration & Enhancement

The majority of schools globally integrate AI tutors with traditional methods.

Almost all assessments have transitioned to digital, with AR, VR, and hybrid tech becoming the standard.

Mental health professionals and educators collaborate extensively, creating frameworks for the promotion of wellbeing and human flourishing in education.

New digital and school infrastructures are built for continuous learning and assessment in the face of major climate events.

Assessment organisations explore ways for their text-based screen assessment activities to be replaced by more active immersive, dialogic, embodied and hybrid, augmented realities.

5.2 2040: Expansion & Collaboration

AI tutors are accessible in most schools, with a continued trend towards global reach.

Virtual assessment experiences are becoming widespread.

Educational systems place equal emphasis on academic knowledge and emotional growth.

Increased emphasis on student and teacher autonomy in AI and augmented assessments.

Edtech giants and traditional assessment bodies begin significant collaborative projects.

5.3 2035: Adoption & Transition

AI-based learning and assessment is adopted in top educational institutions, setting a trend for others.

Assessment organisations fully adapt to digital change and develop strong alliances with tech providers.

A form of computer-adaptive assessments with personalised content is increasingly adopted in high-stakes assessments and examinations.

Assessment organisations abandon the use of exam centres and exam-halls, and exam-like provision in favour of anywhere, anytime provision.

A noticeable shift from traditional to virtual and augmented assessment experiences.

The home and mobile learning takes over as the primary location for learning and assessment.

5.4 2030: Pilot & Development

AI tutoring, personalised and collaborative learning systems are piloted in various school systems around the world.

Initial designs of flexible and mobile education systems, catering to climate change-induced challenges, are piloted. Assessment bodies embrace and promote the digital transition, with some initiating exploratory collaborations with big edtech companies.

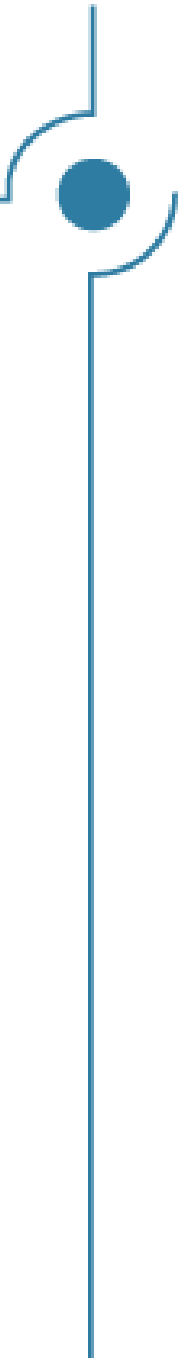
Onscreen assessments have become the norm, with the initial introduction of augmented and virtual experiences in some regions.

Well-being becomes a part of the academic discourse, with institutions recognising the need for change.

Governments and institutions recognise the long-term impact of climate change on education and begin strategising.

Increased emphasis on student wellbeing begins reshaping curriculums and assessment methods.

Plans and policies are laid out for educational infrastructure that is resilient to potential climate disruptions.



5.5 2025: Research & Awareness

Significant investments are made in research on AI tutoring and its integration with computational approaches and underlying principles of assessment.

Assessment organisations become more aware of the rising dominance of edtech companies and the role of AI and consider collaboration.

Assessment organisations acknowledge the imminent and ongoing digital transition, and adjust their business models, plans and vision.

The aftermath of the COVID-19 pandemic, and increased climate anxiety leads to global conversations around student well-being and mental health.

Initial acknowledgment by assessment organisations of the potential impacts of climate change on global schooling systems.

A global trend is recognised by assessment organisations, regulators and policy makers towards increased use of onscreen, digital assessments, laying the groundwork for future tech integrations.

This study highlighted fundamental distinctions between linear and nonlinear approaches to future forecasting. It emphasises the necessity for unconventional methodologies to anticipate discontinuities and surprises resulting from radical shifts and disruptive innovation. Trends typically serve as the primary drivers for formulating strategic plans and future perspectives. The current study, while still valuing empirical data, has integrated elements of imagination and nonlinear thinking into the process in an attempt to mitigate cognitive noise that could distort future projections.

Appendix A: Histories of Assessment

An understanding of the processes of change in educational assessment to date, including the major shifts and periods of change in assessment theory and practice, gives insight into the pace and magnitude of potential change, as well as making visible recurrent patterns from the past that might influence current thinking. In this Appendix Tim Oates, CBE, Group Director of Assessment Research Division at Cambridge University Press & Assessment, documents the history of educational assessment to bring this understanding to this report.

It is common for historical accounts of assessment to look back some 3,000 years to find the earliest documented example of organised examinations - specifically to the Chinese Imperial examination system for selecting bureaucrats on the basis of merit.[152,153] But if assessment comprises a judgement as to whether an individual is demonstrating a specific level of acquired knowledge and skill, then the preceding millennia of effective intergenerational transfer of knowledge and skill required by agricultural practice, trade and organised labour must surely have included a process which we could describe as 'assessment'.[154] It should be seen as intrinsic to human development. The Chinese examinations are interesting, since accounts include descriptions of lists of successful candidates, differentiated levels of attainment, systematic cheating, and comprehensive invigilation. Often ignored, the development of cuneiform writing in Mesopotamia around 3500 BC, predating the Chinese exams, led to systematic education of scribes, with the history revealing harsh punishment for failure and mistakes, while success led to access to the priesthood or senior bureaucratic roles - positions of considerable power and influence.[155]

Centuries later, while the Roman Empire sustained an education system devoid of formal examinations, evidence exists for highly formal assessment of teachers.[156] With the decay of the Roman Empire, the focus on oratory and literacy remained within schools of grammarians and rhetoricians and was supported by monastic culture, later spawning the great universities of Europe. Within these institutions, oral examination was preeminent - the concept of 'examination' derives from the oral disputation and debate central to this process. Both the Confucian and European tradition placed established scholars or bureaucrats as the location of 'standards and judgements'.[157]

Histories of assessment also frequently forget remarkable universities such as Sankore in Timbuktu, endowed by a Malinke woman in 988 AD, accruing one of the largest libraries in the world in support of its teaching of mathematics and astronomy. Assessment followed the tradition of supervision and judgement by scholars.[158] Also founded by a woman, a century before Sankore, the school incorporated in the Al Qarawiynn mosque has a legitimate claim as the world's oldest university, the assessment system awarding the first degrees associated with different levels of study.[159]

Most histories of assessment focus on the rise of universities as essential to the emergence of modern examinations, for example Wilbrank's 1997 work.[153] Indeed, a line does run from their establishment through the move from oral to written examination, to the extension of written exams from institutionally-based to being public examinations for use in national school systems - which became widespread in the late 19th century. But this ignores a long tradition of 'qualification' in vocational education and training. Apprenticeship was present in ancient Egypt, Asia, Greece and Rome, and became a mature system in Europe from the ninth century - heavily regulated by guilds, local government and the State. The modern concept of 'qualification', now so associated with public examinations, was fundamental to these arrangements.[160,161]

With the twin 'tracks' of the development of assessment in the academic and vocational spheres, the origins of modern assessment accompanied the 'massification' of education accompanying the emergence of modern states.[162] School inspections began to establish concepts of 'national standards' of educational attainment, even in the absence of national examinations.[163] The needs of burgeoning bureaucracies and the administrative needs of empires, just as with the Chinese
civil-service exams centuries before, spawned interest in meritocratic assessment and progression. Shortly after the emergence of widespread public school examinations, the two global conflicts of 1914 and 1939 stimulated interest in systematic and consistent identification of skills and knowledge. Modern psychometrics was accelerated due to the needs of military training and quickly became utilised in both vocational and academic pathways.[164]

Systematic theorisation of validity and reliability spurred a scientific interest in both the focus of assessment and the performance of assessment itself.

By the late 1940s, reconstruction and reform of education in a post-conflict context led to widespread and rapid development of education systems right around the globe, with considerable 'international export and import' of educational philosophies and assessment techniques. 'National standards' became established as a public good, sound management of assessment became part of wider educational improvement, and widespread experimentation in assessment began to emerge.[165] From the 1960s onwards, with techniques of evaluation of assessment well-established, many experiments in curriculum and assessment were undertaken: coursework; variation in forms of questions; modular assessment; portfolios of attainment. With this explosion of innovation, academic discussion began to explore issues of bias, purpose and focus of assessment, as well as washback of assessment into learning and 'assessment for learning'. Assessment organisations full of assessment professionals became a feature of education systems, resulting in an 'industrialisation' of assessment.

Although assessment associated with 'qualification' always has carried high stakes, those stakes were raised considerably in the late 1980s with the association of assessment with 'targets' and 'school accountability'. This represented a step-change in the function of assessments, making them pivotal in individuals' lives, in the functioning of schools, and in the political realm.

With the importance of 'standards as a public good', the increasing complexity of the delivery of assessment, and the expansion of its function and impact, state regulation of assessment has also increased. This extreme elaboration of the function and operation of assessment in both vocational and academic domains looks to be permanent.[166]

If this represented a major shift in assessment, the introduction of digital technology and, more recently, AI represents the next step-change. From seamless integration of assessment into learning to adaptive assessment, auto-marking, quality assurance, and auto-generation of exam questions, AI may affect a thousand minor and major transformations in the operation of assessment. But in this rapidly shifting landscape of innovation, the carefully accumulated principles of high-quality, trusted assessment must not be forgotten; we now have a well-established science of measurement and of evaluation of the impact of assessment. With the large scale international assessments of achievement (PISA, TIMSS and PIRLS) now servicing both politicians' and educationalists' needs for insights into the relative performance of education systems, we stand well-positioned to ensure that assessment can be used to enhance education - to ensure that assessment does not contribute to inequality but reveals it in ways which help us to both raise attainment and improve equity.

Appendix B: Signals of Change

B.1 The Signals

This appendix presents findings from the initial exploring phase of the study. It offers an overview of signals, the scanning results and the results of an exercise in which signals were ranked for plausibility and credibility. The 19 signals of change explored by our study are introduced below.

Adaptivity and Personalisation

The provision of computer-adaptive and personalised assessment is already well underway and present in many assessment products. We wanted to investigate the likely future impacts of advances in computational psychometrics and generative or general AI for the personalisation of assessment activities. As the report highlights, this became one of the major themes identified in this project, as something that is likely to significantly impact upon learning and assessment.

AI Tutors

In upcoming years, artificial intelligence (AI) might either supplement or take over roles of human educators. Many of a teacher's regular tasks can already be mechanised. AI has the potential to enhance student learning rates and efficiency compared to solely human instruction. As detailed in our report, this is pinpointed as a significant trend projected from our study, with various potential repercussions in education and learning processes. Specifically, it underscores a new domain where educational evaluations might be conducted.

Assessing Collaboration

The challenge of assessing collaboration has been the focus of researchers and test developers over the last decade. It has a number of really important potential impacts - such as facilitating networked learning and assessment and supporting AI-powered teaching and learning in areas such as problem solving, dialogue and creativity. The idea of isolated learners working only with machines has a distinctly dystopian feel and it does not necessarily reflect the type of educational experience that learners value.

Climate change

As a group, we were acutely aware of the very significant impacts of climate change for the planet and for human lives. But we wanted to go deeper; to consider the likely impacts on schooling and assessment. We identified many climate-change related themes - such as disruption associated with fires, floods, heat, drought and food insecurity, as well as the impacts of climate anxiety on children's learning, school attendance and wellbeing, and increases in displacement and migration. It seems almost certain that those will be accompanied by economic and political impacts and conflict. Those collectively represent one of the megatrends in this study.

Collapse of general knowledge

This theme is not widely discussed in the research literature or in the media. However, we wanted to consider how the ability of people to pursue a wide array of learning interests might lead to a departure from

established notions of curriculum and general knowledge. In the past, knowledge acquisition was controlled by schools and existed to allow more wealthy elites to pursue book-based learning. That might be changing radically as internet-based learning and personal AI tutors offer a very wide set of learning opportunities. If so, what are the implications for assessment?

Collapse of language learning

Is it plausible that smart translation technologies could remove language barriers efficiently enough to discourage language learning? It is already questionable whether language proficiency is still the large barrier to things such as travel, citizenship and university learning that it once was. How might that process accelerate? Google's universal translator has the ability to translate videos in real time while synchronising the speaker's lips with the translated words. At the same time, for those who want to learn new languages, there are a host of AI-based alternatives. What future effects might this have on the language assessment industry?

Emergence of new assessment models

The Coronavirus Pandemic created shockwaves through the assessment world - including encouraging people to re-evaluate assessment values, purposes and priorities, and to consider the affective impacts of assessment on student wellbeing. It also accelerated the adoption and use of online learning and assessment tools and practices - and the greater involvement or teacher based assessments. Will standardised and stand-alone examinations and assessments survive the test of time? What new models and approaches might emerge?

Emergence of new organisational models

With the rise of powerful big edtech companies, and as wider political and environmental changes shape the contexts of assessment, what kinds of changes might that bring in terms of new organisational models. Current signals suggest that big edtech actors could increasingly attempt to develop private commercial markets within educational assessment. How might relationships with technology providers, new types of technologically-driven online learning and assessment, and new forms of future schooling impact organisational models?

Generative AI

The rise of ChatGPT, Stable Diffusion and numerous other generative AI apps seem set to have a transformative effect on many industries such as law, finance, education, music, journalism, arts, leadership, idea generation and movies - just to name a few. There are already a variety of smart device-oriented applications that let the user identify, for example, plants and songs, in mere seconds. In the future, the diagnosis of illnesses and identification of tastes, among other things, could be made through an application. What will the implications of generative AI be for assessment designs, assessment integrity and the test-taker experience? Will (or should) generative AI systems entirely replace the role of the teacher and test administrators?

Immersive, wearable and embedded & thought reading technologies

A future immersive internet could be closer than anticipated. Here, individuals won't just consume information but actively engage in a 3D virtual reality as avatars.

Virtual and augmented reality more generally creates the potential for immersive, multi-sensory experiences. What kinds of body and brain implants and interfaces (such as smart glasses, or Elon Musk's Neuralink) might we expect in the future? What impacts are they likely to have on assessment?

Inclusion and equality

The transition to digital modes of assessment suggests opportunities and challenges in terms of inclusion and equity. These include opportunities for more inclusive accessibility features in onscreen assessments, the promise of more inclusive adaptive systems and 'affective' assessment designs. How might new technologies impact inclusion and equity in future assessment? What types of systems might be developed and desirable to ensure 'transparent AI', democratic accountability, a reduction of digital divides and to prevent unintended negative consequences?

Neuroscience, biology and genetics

Recent years have seen rapid and very significant advances in the fields of neuroscience, biology and genetics. How could 'thought reading' technologies change assessment? How might developments in biological and neurological sensors and cybernetic interfaces transform our understanding of learning and cognitive development? Is it likely that brain imaging and physiological sensors, or controversial genetic research could start to impact assessment thinking? What would such technologies mean for notions of assessment performance, engagement and affect? What are the ethical implications?

Value of degrees

During the current cost of living crisis and as a result of concerns around the climate emergency, some young people have started to question the value of degrees, especially given their high costs. Furthermore, the increasing focus on individualised learning systems and problem-based curricula could lead to degrees that are more personalised and reflective of a student's unique learning journey. At the same time, vocational education, facilitated by advancements in technology such as AR headsets and immersive environments, is blurring the lines between learning and practical application. How might these types of change impact on the types of assessment that is conducted at university?

Quantum Computing

It has been suggested that quantum computers might in the future be able to perform calculations that would be impossible for traditional computers and that they could be used to train generative AI models in new ways.[54,56,167–169] People are currently actively trying to imagine new algorithms that are not currently achievable with traditional computers.[17,170] The evidence for some of these aspirations is currently uncertain, but were they to evolve as envisaged, they might make aspects of computing more rapid than is currently possible. How might future advances in quantum computing and massively increased data processing impact on assessments? Could it impact test security? If so, on what timescales?

Regulation and ethics of AI

Progress in artificial intelligence is paving the way for unique ethical queries related to technology, which are projected to gain significant attention in the future.

The ethical discourse, laws, and practical directives concerning AI development and usage are evolving into major discussion points. Pressing issues that require prompt resolution include the intellectual property rights pertaining to AI-generated creations and the application of AI in warfare.

Slowbalisation & anti-globalisation

Slowbalisation denotes the diminishing pace of globalization, characterized by a decrease in the expansion of international trade and investment. This trend is influenced by factors such as increasing protectionist policies, the impact of the Covid-19 pandemic, the situation in Ukraine, and the emergence of digital technologies. While the full ramifications of slowbalisation are still under exploration, potential outcomes might include elevated consumer costs, limited economic growth and rising inequality. Notably, slowbalisation is a slowdown in globalization, not its complete undoing, which would be termed deglobalisation.

Teacher shortages

Teacher shortage is a global challenge that affects the quality and equity of education. It is caused by various factors, such as low salaries, high attrition, poor working conditions and lack of training and support. In the future changing demographics (an ageing workforce) may also play a role. Might edtech address some of the challenges of teacher shortage, such as providing access, personalisation and feedback? How might it impact on the resources spent on teachers, their future skillsets and roles or the attractiveness of the teaching profession?

Technology pushback

Research on the use of pen and paper, and other traditional manual exercises (gesture and movement), have found that these methods activate the brain more than, for instance, taking notes on a digital device. The rise in 'screen time' and perceived negative impacts and the challenges of assessing in the context of generative AI have already led to widespread 'pushback' against technology use in favour of adopting pen and paper exams. Will the public and politicians accept the idea that exams do not need to be taken at the same time, or that they might present students with different content and items? Is it possible that there could be an increase of anxiety or unhappiness about the roles of automation in teaching and learning? Could these anxieties in turn produce feelings of isolation or psychological or cognitive difficulties? How might those current trends and signals develop and change over time?

Virtual schools

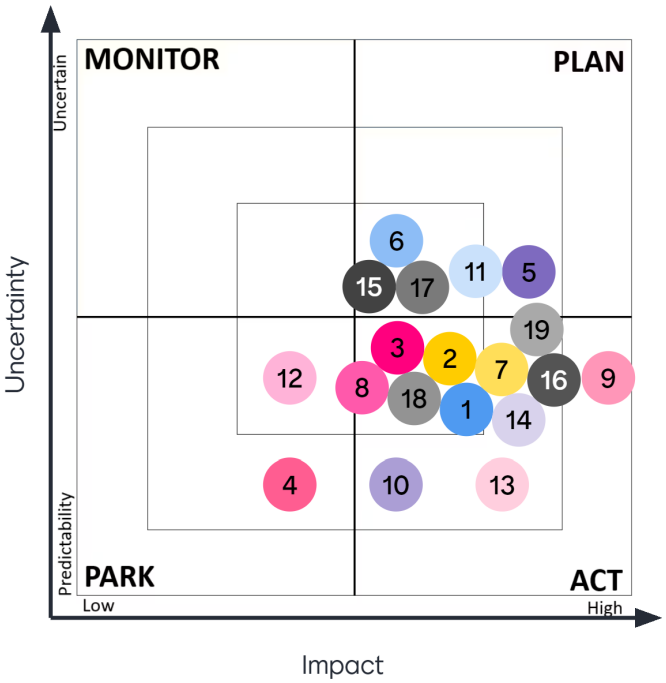
Virtual schools are a form of online education that aims to provide access and quality to students who face barriers or challenges in traditional schooling. They are especially relevant for regions where there are shortages of teachers, resources or infrastructure. However, virtual schools also pose challenges, such as ensuring connectivity, equity, and engagement. The effectiveness of virtual schools depends on various factors, such as the curriculum, pedagogy, technology and support systems. Might climate change and future pandemics disrupt the physical and social environment, making virtual schools a necessity?

B.2 Horizon Scanning

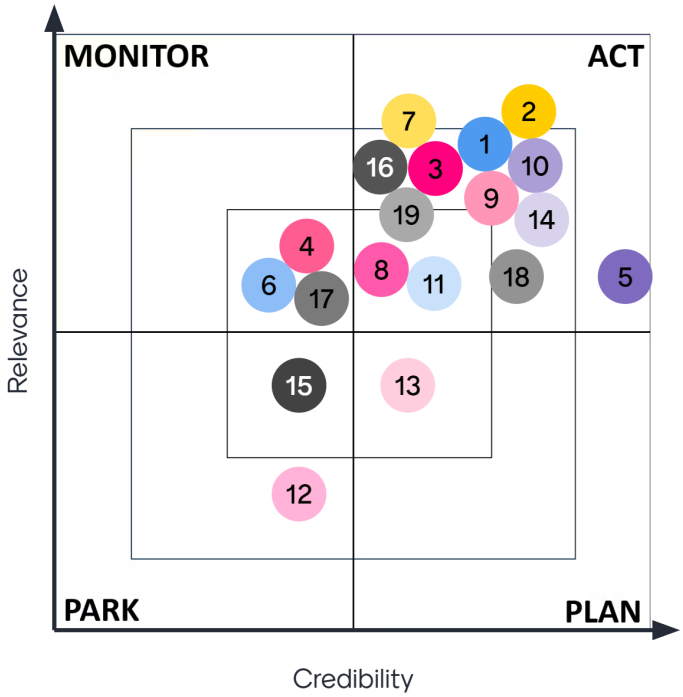
The team identified[194] 'scanning hits' (sources of information on trends, events and signals of change) in total. These included sources ranging from academic papers to blog posts, newspaper articles and videos (sometimes with material that only published in the last few months). While conventional academic research usually focuses on published, peer-reviewed journal papers, we extended our search because we wanted to identify 'weak signals' that had not yet generated academic research. Academic research often takes several years to conduct and to publish. In what is a fast-moving field, we wanted to make sure we included more recent events.

Mapping the signals: The axis of uncertainty

The visuals below show the collective outcomes of the group 'axis of uncertainty' tasks conducted after the working groups had identified, read and discussed the likely impact and credibility of the evidence collected through the horizon scanning activities. In the diagrams below (for impact against uncertainty and for credibility against relevance) you can see how the collective view of the project team is distributed and the numbers of horizon scanning hits that we reviewed.



1 Adaptivity, Personalisation and Collaboration (7 hits)
2 Emerging of New Assessment Models (3 hits)
3 AI Teacher (5 hits)
4 Emerging Organizational Model (6 hits)
5 Climate Change (6 hits)
6 Collapse of General Knowledge (2 hits)
7 Collapse of Language Learning (4 hits)
8 Assessing Collaborative Work (4 hits)
9 Generative AI (25 hits)
10 Inclusion and Equality (1 hit)
11 Immersive, Wearable and Embedded & Thought Reading Technologies (15 hits)
12 Neuroscience, biology and genetics (0 hit)
13 Quantum Computing (12 hits)
14 Regulation and Ethics of AI (14 hits)
15 Slowbalisation & anti-globalisation (2 hits)
16 Virtual Schools (4 hits)
17 Technology Pushback (6 hits)
18 Teachers Shortage (2 hits)
19 Value of a Degree (4 hits)



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16 Virtual Schools (4 hits)
17 Technology Pushback (6 hits)
18 Teachers Shortage (2 hits)
19 Value of a Degree (4 hits)

We can also see how the 'impact' versus 'credibility' tools operated as methodological 'filters', offering contrasting perspectives and triangulation (a bit like the way that the different frequencies of light used by the James Webb space telescope offer different perspectives on cosmological features). Intense interest in the scanning themes led to many of the signals being placed in the ACT quadrant. However, on reflection, some of them might have suggested 'act now, in the next five years (for example, for themes such as the rise of Generative AI), while others might have implied 'act when the time is right' (for example, for quantum computing, or the the impact of immersive technologies). In a few cases we also had overlapping themes that created ambiguity in our results, such as having virtual schools and the AI teacher, for example. Finally, the analysis did not include a consideration of how successful outcomes might be achieved. So, for example the regulation and ethics of AI was regarded as important, but it is not necessarily clear how it might happen.

This process produced a few methodological reflections. One of the features of the scanning hits is their bias toward current themes and fashions, as well as their tendency to reflect commercial promotional materials. That is why there is sometimes a discrepancy between the number of hits on a particular theme and the significance attributed to that theme by the team. For example, immersive technologies and augmented realities are widely represented in the media in terms of the 'Metaverse'. But our considered view is that 'Meta' as a company might not have a lasting long-term presence as other providers enter the field.

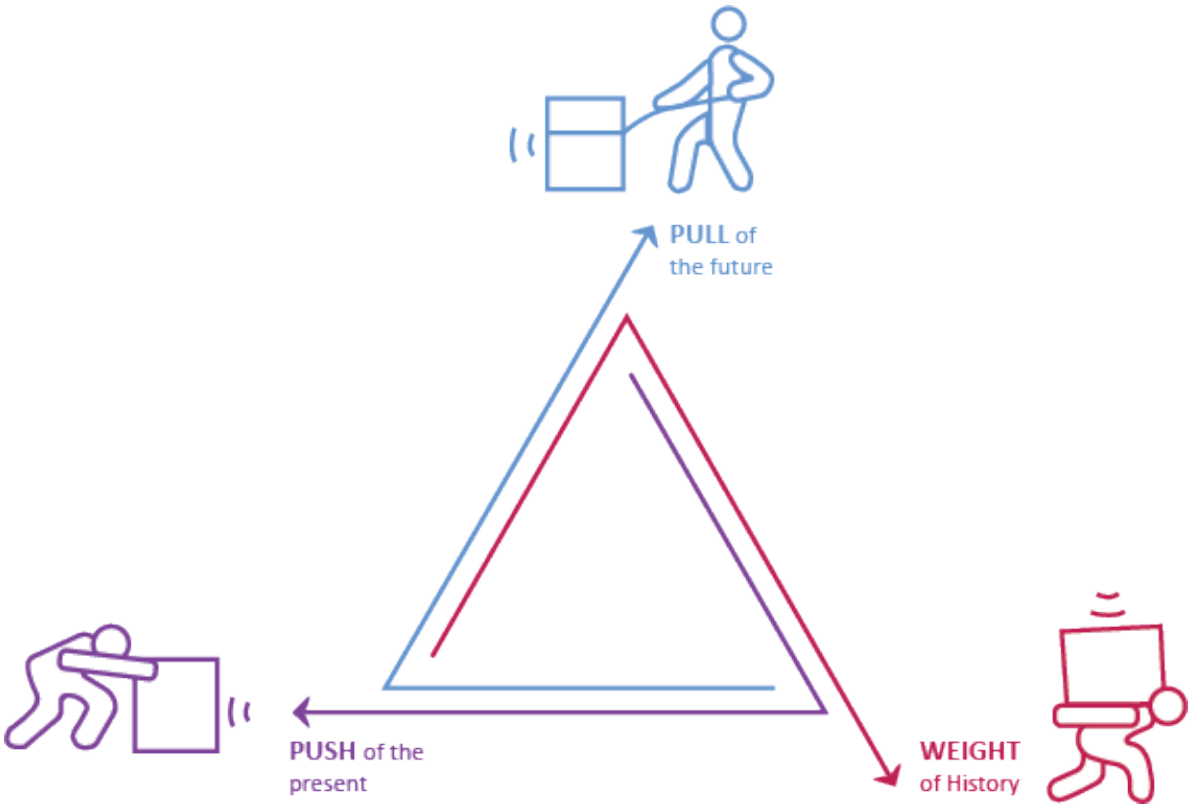
Similarly, while there is a lot of current interest in themes such as quantum computing, our current view is that while they have the potential to have very significant impacts on assessment, those impacts, were they to occur at all, are likely to be towards the end of the timescale (to 2050) that we have considered in this project. For that reason, they are described as significant and impactful, but due to that longer timescale, they do not appear as major themes in our findings.

Appendix C: The Workshop Methods

In this part of the report we describe the key activities undertaken in the workshops and present their results. Those ultimately led to the future visions and timelines presented in chapter 7.

C.1 The Futures Triangle

The Futures Triangle is a tool developed by futurist Sohail Inayatullah. It can help unpack the complexities of the future by focusing on three key dimensions:



1. The Weight of the Past: the historical context and legacy issues that have shaped the present and may also influence the future.

2. The Push of the Present: current trends, events, and changes that are actively shaping the future.

3. The Pull of the Future: a vision or visions of a desirable future. The Futures Triangle provided a framework for understanding how these three forces interacted and converged to create plausible futures of assessment.

The Weight of the Past

The 'weight of the past' refers to the influence of historical trends, established practices and past experiences on our present situation and decision making. The past naturally has a strong influence on our perceptions and actions in the present, thereby also influencing the trajectory of future developments. It can manifest in various ways, such as resistance to change (pushback), adherence to traditional methods (traditional learning), challenges that persist over time and the (slow) pace at which innovations are adopted. This concept helps recognise potential barriers to progress and devise strategies to overcome them.

Pushback (6 mentions): This theme captures resistance or opposition to change, particularly in relation to technology. It includes concerns about basic skills, like handwriting being lost, pushback from individuals who are reluctant to engage with technology and general resistance against tech.

Traditional Learning (7 mentions): This theme relates to conventional or established methods of education. It includes the value of pen and paper, concerns about handwriting and spelling, the inherent conservatism of A/Os and their link to 2-year learning cycles, government preference for traditional assessment methods and the value of traditional university routes versus vocational education routes.

Challenges (9 mentions): This theme highlights potential difficulties or obstacles in the context of education. It includes concerns about quality and risk associated with big brands like Cambridge, market expectations, issues with universal connectivity, integrity of assessment with wearables, limited resources due to climate change, limited degree spaces requiring A* filtering, politics interfering with education and risk aversion.

Innovation (4 mentions): This theme relates to new or emerging trends or technologies in education. It includes concerns about how integrity of assessment works with wearables and the value of traditional university routes versus vocational education routes.

The Push of the Present

The concept of the 'push of the present' refers to the current trends, forces and phenomena that are shaping our world and influencing the trajectory of future developments. These 'pushes' can be seen as the momentum of the present, propelling us into the future. The pushes drew on the previous mapping of signals, with signals placed in the ACT quadrant providing a starting point for this activity. The pushes were grouped into a number of key themes.

Teacher Shortage and rising demand for online and home learning (5 mentions): the group noted the global issue of teacher shortages, encompassing the general lack of teachers and the quality and experience of available teachers. Conversely, there were indicators of a rise in online and virtual schools and home learning, together with a post-covid reluctance among some groups for children to return to school. There were questions about the extent to which these might propel the adoption of AI teaching assistants or teachers.

Climate Change (3 mentions): despite not having featured extensively in the scanning hits, perhaps because it was difficult to tie the broad issues of the climate emergency with specific issues around assessment -

climate change and its impacts was recognised as an important driver of change, with a need for a broader understanding of the effects of climate change on various aspects of life and the environment.

Artificial Intelligence (6 mentions): the group considered several aspects of artificial intelligence (AI), including the regulation and ethics of AI, the trust placed in generative AI over humans for assessments, the potential of AI to enable the personalisation of learning and also the potential future role of quantum computing in enabling further advances in the field of AI.

Assessment (4 mentions): discussions explored various facets of assessment, such as collaborative work assessment, changes in assessment value, growth of formative assessment, evolution of digital summative assessment, tech-enhanced learning and assessment and the demand for microcredentials.

Collaboration and Partnership for innovation (7 mentions): a variety of forces together constituted a push towards partnerships and collaborations with edtech or big tech organisations. This might be driven by an increased expectation of delight in learning and assessment, with gamification, gaming, and play setting expectations for some young people and starting to feature in some assessment contexts. Additionally, further shifts to technology-enhanced assessment models involving wearables or immersive or augmented environments might be driven by the technology companies investing heavily in this area.

Inclusion and Inequality (2 mentions): there was a focus on issues related to inclusion and inequality in an educational and assessment context.

Language Learning (1 mention): a potential collapse of language learning caused by AI translation was seen as impacting on assessment more generally.

The Pull of the Future

The 'Pull of the Future' represents future aspirations that draw us forward. It's about what we aspire to achieve, what motivates us to move beyond the constraints of the present and the weight of the past, towards new possibilities. The pull of the future is not a fixed destination but rather a direction of travel that is constantly evolving as our visions and aspirations change. Here a clear emerging finding was the strong interrelationship between the various signals and themes when it came to envisioning a positive future. The pulls drew on the previous mapping of signals, with signals placed in the PLAN quadrant providing a starting point for this activity

Evolved relationships between learning, teaching and assessment and between learners and organisations (15 mentions)

It was recognised that in a desired future changes related to organisations and individuals, as well as learning, teaching and assessment, were inextricably linked. Personalised, adaptive and problem based approaches to learning seemed desirable and might need to be delivered by institutions that were interdisciplinary and global, drawing on new curricula as well as new assessment designs - for example capturing collaborative work via multimodal process data and focusing on creativity. Inclusive and equitable assessments would be enabled by new design approaches and ongoing formative assessment might reduce or eliminate the need for high-stakes summative assessments and current assessment modes such as essay writing.

In considering a desired future, it was anticipated that a combination of innovations might address current challenges, for example, in relation to learning and assessment with AI teachers reducing teacher workload and in relation to more general challenges. New energy sources and other innovations might halt global heating and mitigate some of the worst effects of the climate emergency, while advances in quantum computing might have the potential to increase the speed of other developments (although there was debate about the time frames in which this might happen).

Technology and Innovation (4 mentions)

Fields such as quantum computing, nuclear fusion and artificial intelligence (AI) have the potential to revolutionise the future. In considering a desired future, it was anticipated that a combination of innovations might address current challenges, for example, in relation to learning and assessment, with AI teachers reducing teacher workload and in relation to more general challenges, new energy sources and other innovations might halt global heating and mitigate some of the worst effects of the climate emergency, while advances in quantum computing might have the potential to increase the speed of other developments (although there was debate about the time frames in which this might happen).

Global and Social Issues (3 mentions)

The broader vision was of increased global collaboration, equity of flourishing and pluralism, highlighting a desire to move towards a more inclusive and equitable future.

C.2 Causal Layered Analysis

This technique moves beyond traditional single-layer forecasting to probe deeply into the multi-layered causality of issues. It begins with the 'Litany' at the surface level, representing commonly perceived problems often highlighted in the media. Beneath this, the 'Social Causes' layer examines systemic social, economic and political factors. Digging deeper, the 'Worldview/Discourse' layer probes the underlying paradigms and deep narratives shaping these systems. At its core, the 'Myth/Metaphor' layer uncovers foundational archetypes, myths and metaphors guiding the narratives above. By navigating these layers, CLA offers a comprehensive understanding of an issue, creating spaces for imagining alternative futures by challenging and redefining deep-rooted narratives and beliefs.

CLA was used to consider the foundational issues shaping the futures of assessment. The five groups were tasked with crafting CLA frameworks that revolved around the five domain-specific questions. Notably, the results derived from the Futures Triangle directly informed the creation of the CLA. For instance, the elements recognised as 'pushes of the present' from the Futures Triangle seamlessly transitioned into issues identified within the CLA's Litany layer with marginal changes. Similarly, the points marked in the 'weight of the past' of the Futures Triangle became influential inputs for both the Litany and the Worldview layers. Through this integrated approach, we sought a multi-dimensional understanding of the intricate factors and narratives shaping the prospective trajectories of assessment.

Analysing the Present and articulating the preferred futures

CLA considering the five domain questions from the perspectives of today and tomorrow are illustrated here.

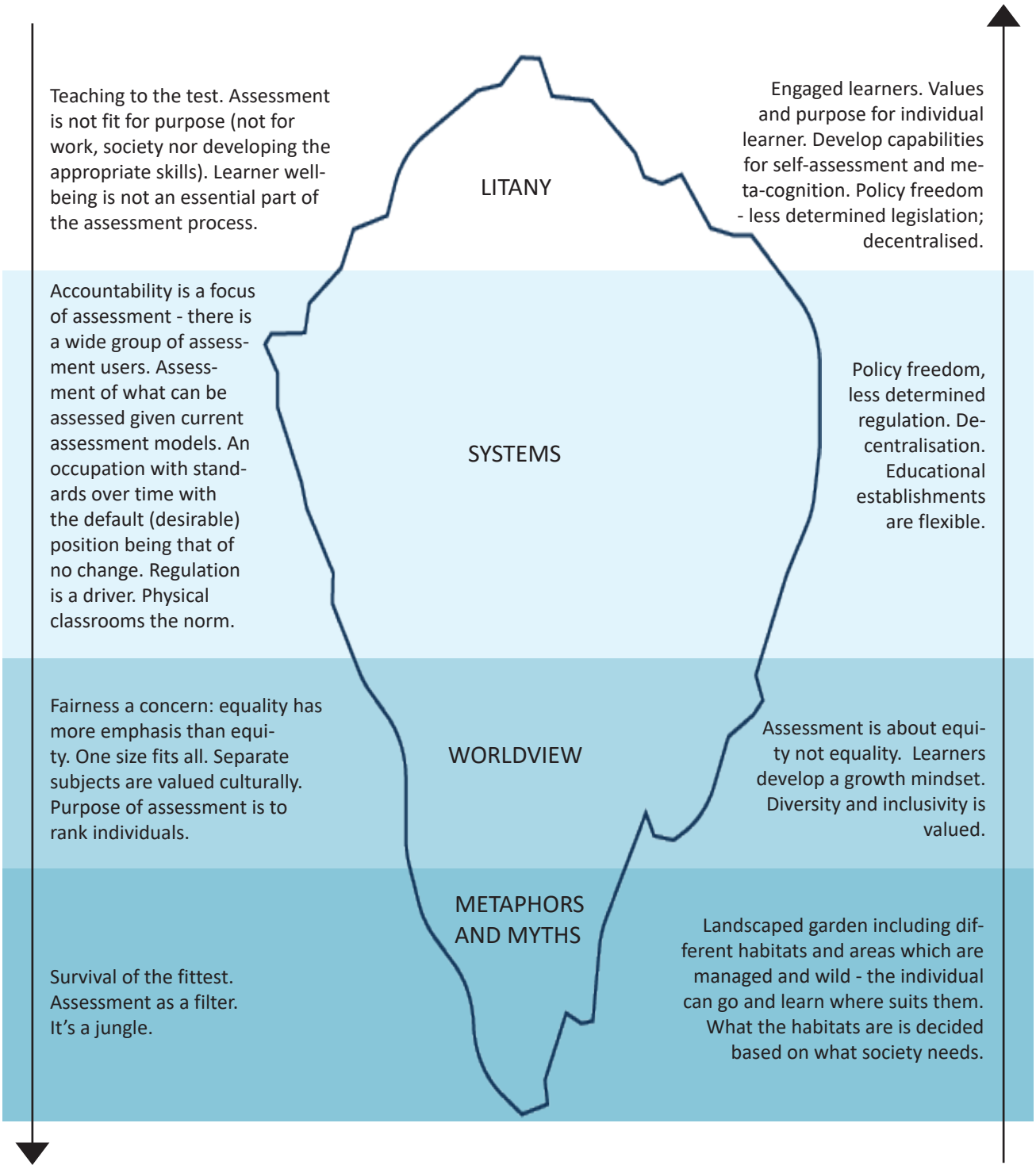
Participants embarked on the transformative journey of Causal Layered Analysis (CLA), moving from the depths of metaphor to the tangible realm of litany. They began by immersing themselves in the profound, symbolic narratives of metaphors that underpin the collective consciousness. Through collaborative discussions and reflections, participants have tried discovering the foundational stories that shape their domain questions. First, they redefined their metaphor to aspire to the futures of their domain. Progressing upwards, they translated the metaphors into worldviews—structured frameworks that dictate how they perceive and interpret reality. This step bridged the gap between deep-seated metaphors and tangible systemic patterns. As they further ascended, these worldviews helped the participants identify and comprehend systemic causes, shedding light on why specific patterns persist in their domains. Finally, upon reaching the surface, they imagined novel litanies—the immediate, observable events and trends in their respective fields. The following figures illustrate the aspired futures perspective of assessments.

PURPOSE

How assessment will be used, why and by whom.

Present

Future

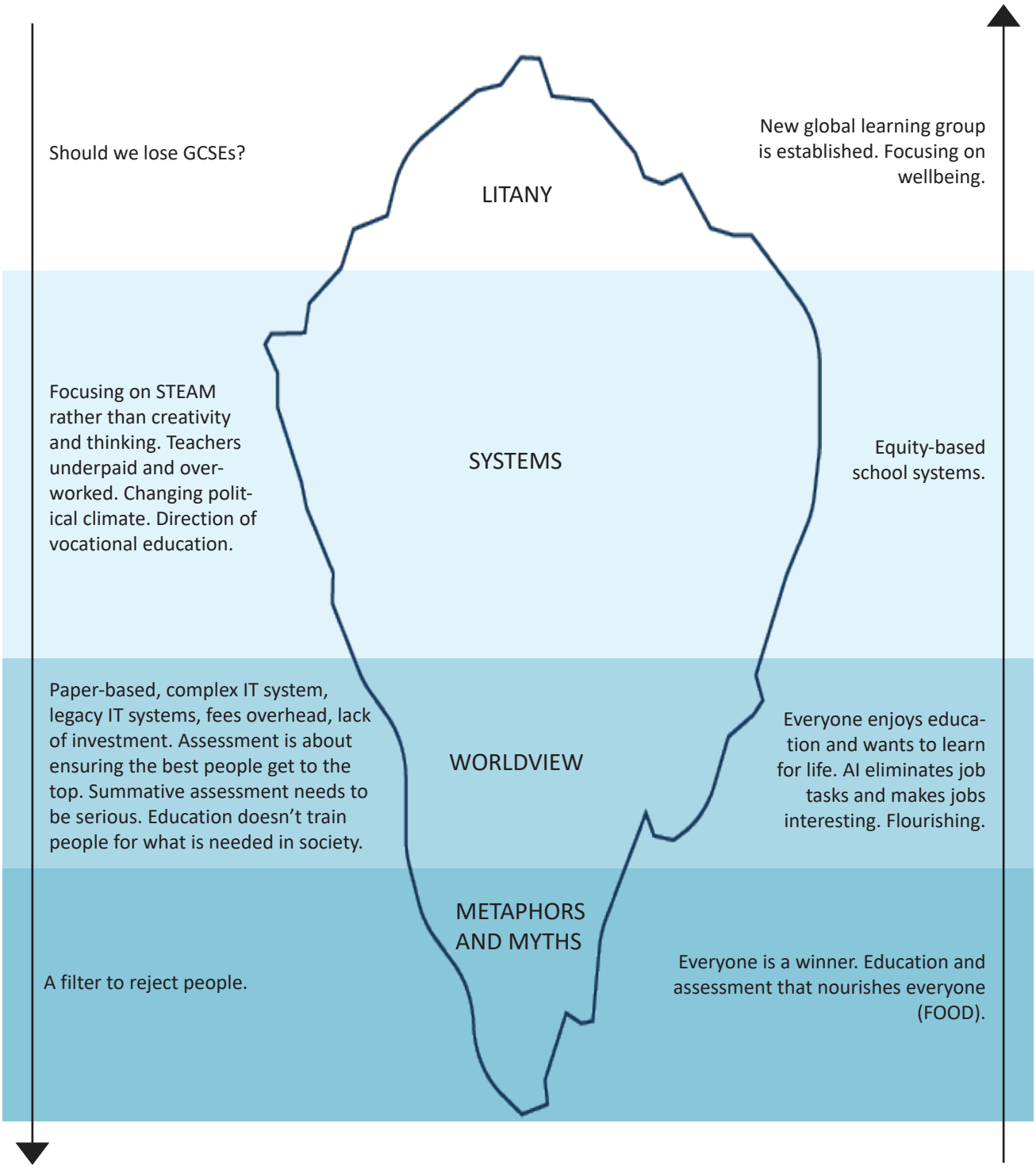


DESIGN

What assessment will be like and what the process for designing assessment might be and who will be the assessment designers of future.

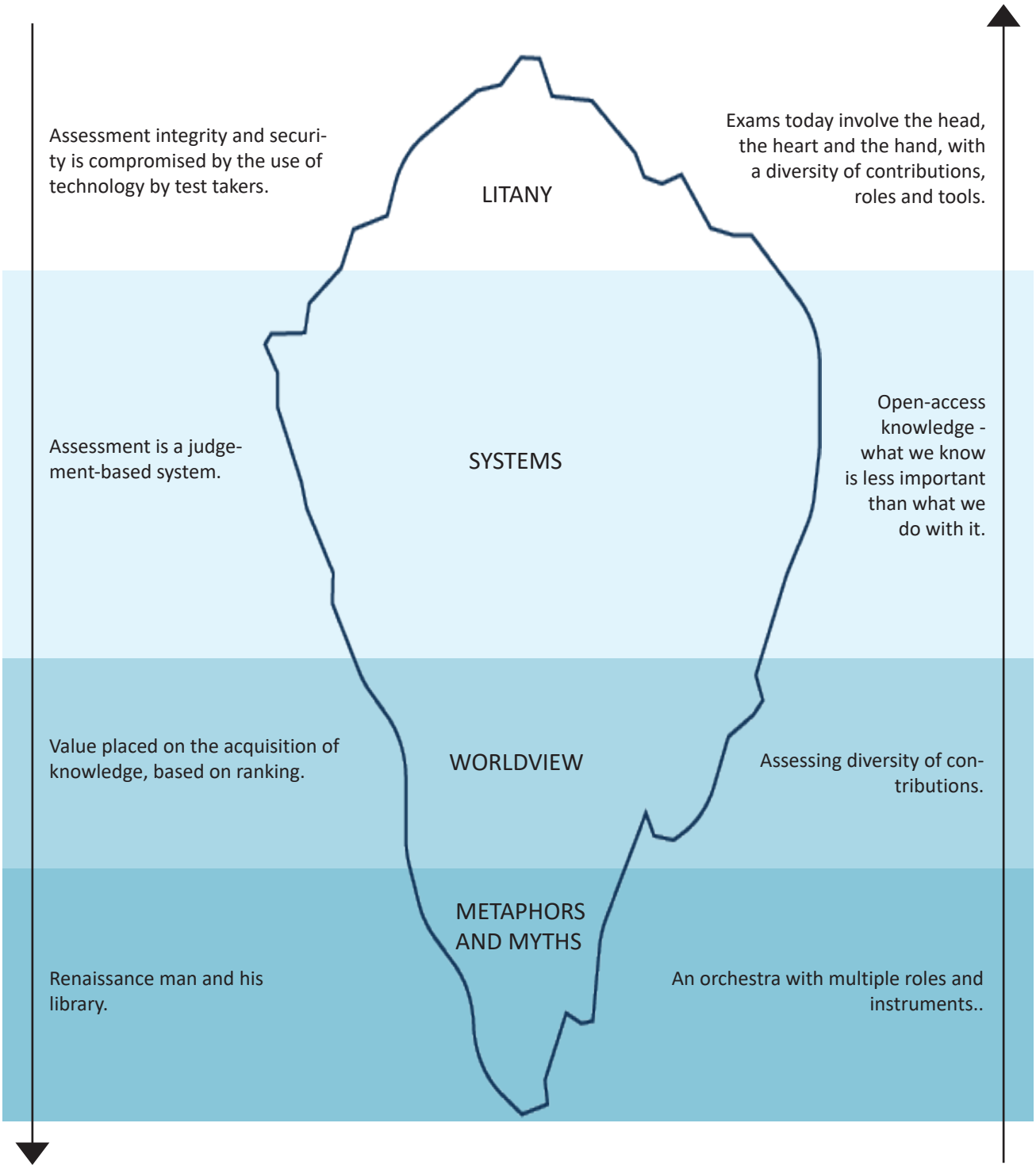
Present

Future



INTEGRITY

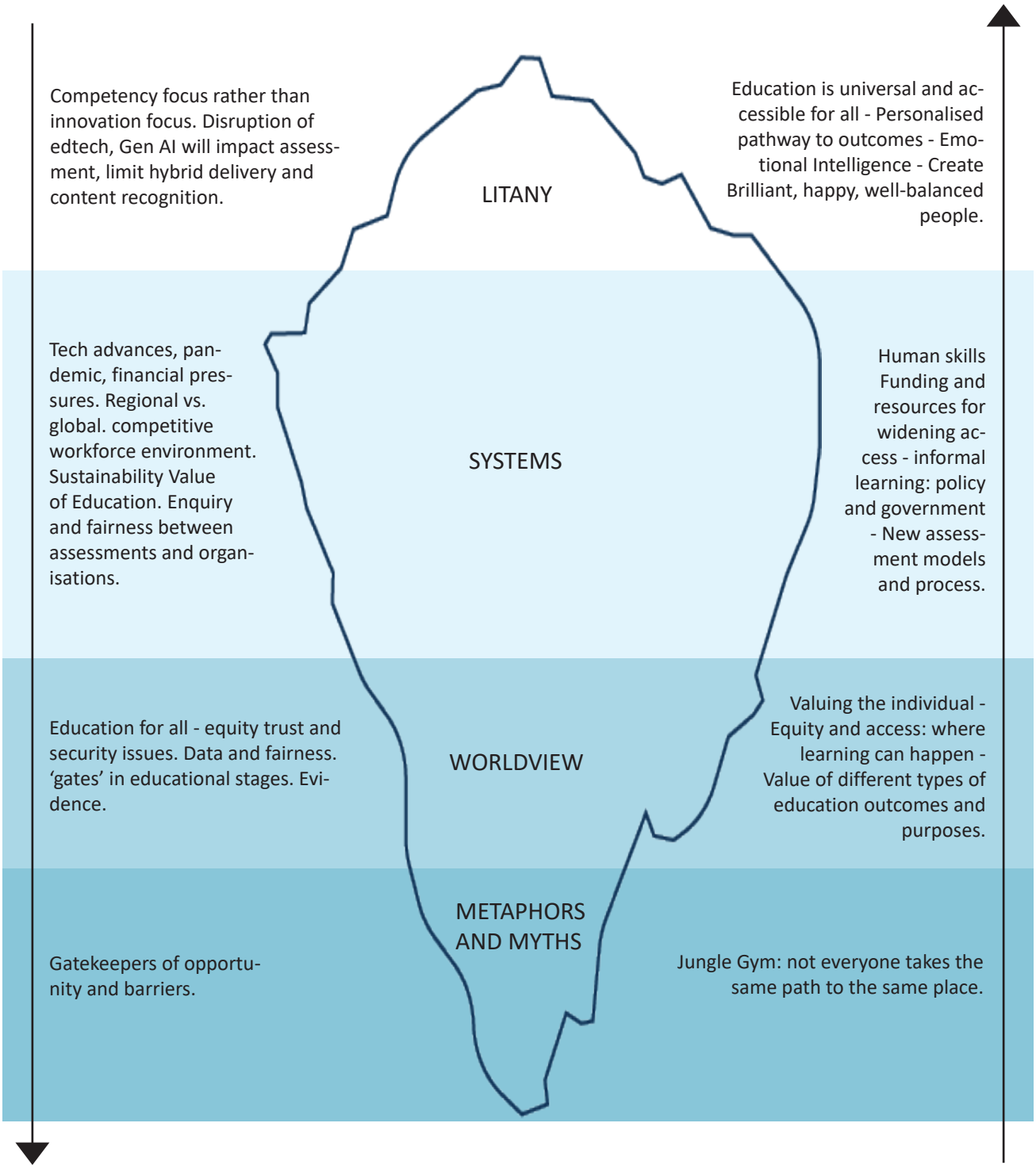
How validity, reliability, comparability, fairness and accessibility will be redefined in the future.



ORGANISATION

The roles, forms and types of assessment organisations which will be needed in the future, and how they will need to interact with their stakeholders.

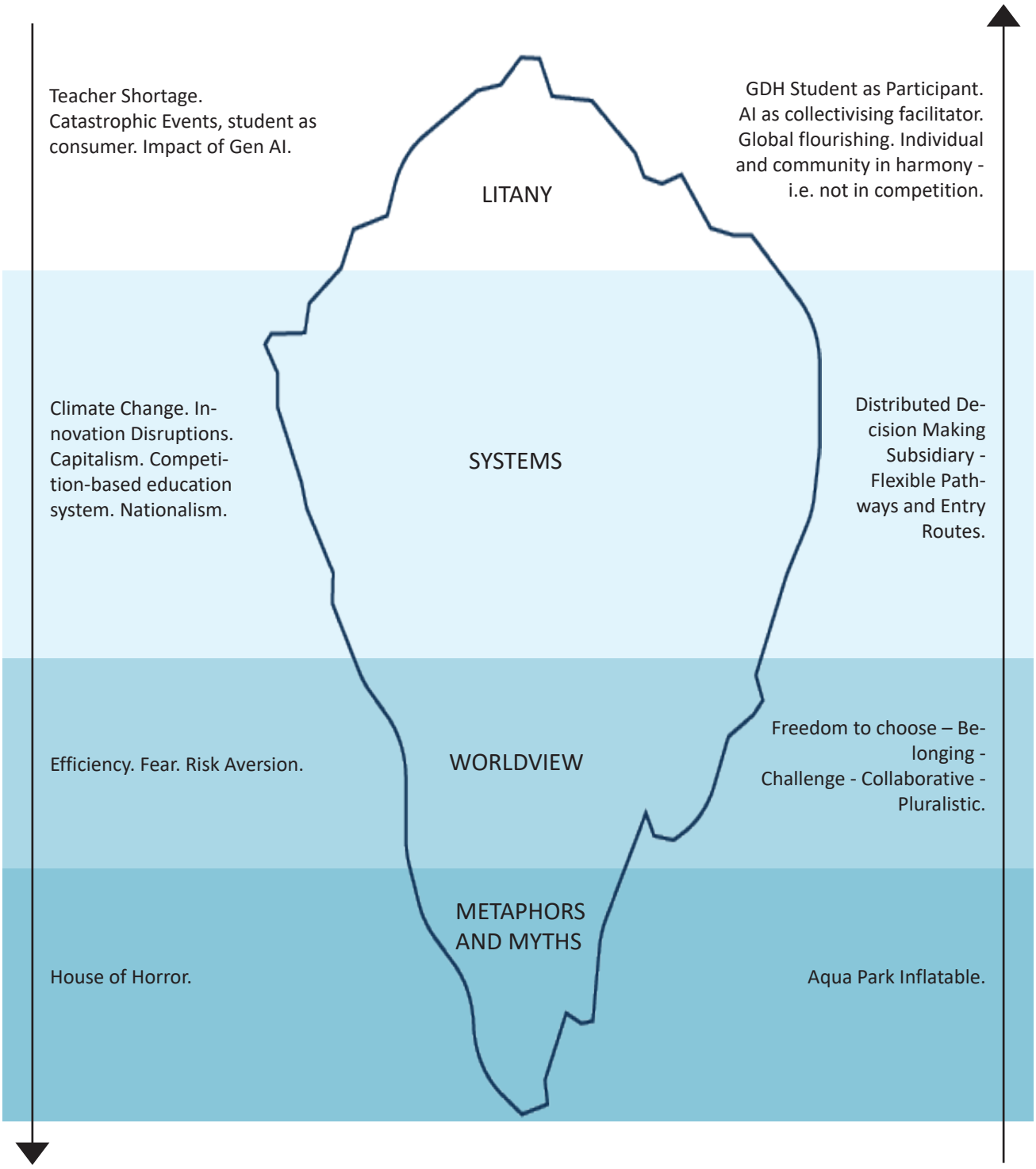
Present Future



LEARNING

The ways that learners will develop the target constructs and the role of the teacher.

Present **Future**



C.3 Exploring Alternative Futures Perspectives

Introduction to scenario planning and the four archetypes

The four archetypes in futures planning are a method of creating scenarios based on four conceptions of the future: baseline, collapse, equilibrium and transformation. These are not predictions but narrative patterns that describe how the future can unfold in different ways. This method was developed by Jim Dator in 1979.

The four archetypes that were drawn on in this exercise were defined as follows

- **Baseline:** This is a future of continuation and enhancement of the current trajectory, but also of current problems. An expansion of the present. This future is very similar to business as usual (BAU), but not exactly the same. Technology may be viewed as a problem.

- **Collapse:** This is a future of breakdown and decline of the current system, due to internal or external factors. This future is often seen as undesirable and dystopian.

- **Equilibrium:** An evolution from Dator's original framework, this scenario envisages how society might find equilibrium following a collapse scenario. Building on the dystopian collapse scenario, it imagines opportunities for renewal and innovation.

- **Transformation:** This is a future which seeks to disrupt the basic assumptions of other futures. Transformation might occur through dramatic technological or material change or via a change in values.

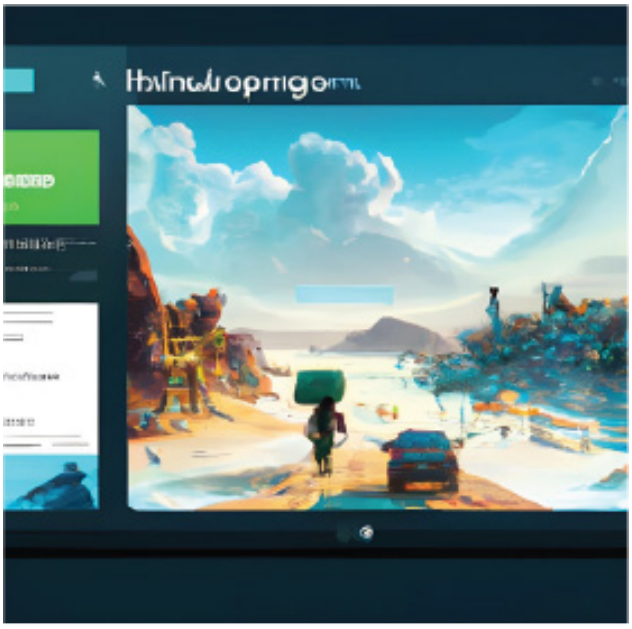
The Baseline Scenario

In the year 2050, the realm of assessment and teaching stood as an unyielding institution amidst a world in flux. Large educational bodies held steadfast in the face of change, maintaining the status quo. Despite the transformation of the world due to climate change and technological advancements, the core of education remained the same. Timed assessments, closed book exams and the use of paper and pencil continued to be a norm, with some adoption of digital methods.

However, the advent of new technology, particularly generative AI for essay-based assessment, posed a significant challenge. This looming threat initially prompted a reluctant transition back to more traditional forms of assessment. Closed classrooms, paper, and pencil made a comeback. Devices were banned from classrooms. Institutions, trying to develop capacity for new models, faced barriers that slowed change. Incremental adjustments were necessary, as they couldn't move quickly. They had a reputation to uphold and were reluctant to take risks. Competitors' actions and workplace skills efficiencies were the main drivers for change.

However, parents, being risk-averse themselves, were the loudest voice against change. Convincing them that computer-adaptive testing was a fair assessment method proved to be a challenge. Despite the reluctance, slow transition was inevitable, marking a new era in the realm of assessment and teaching. The need for a backup plan was recognised. A hybrid model emerged as a safety net, ensuring that when digital infrastructure failed the old models could be relied upon, but that digital assessment was available when physical infrastructure failed. Incremental changes were made to maintain the status quo. For instance, in response to climate change, students started going to school in the morning, wearing shorts, and painting roofs white. Overcrowding in schools led to teaching in shifts, with morning and afternoon sessions.

The Collapsing Scenario



@vxyz 192 had always dreamed of Greenland, the last refuge of civilization in a world ravaged by climate change. He had escaped the horrors of Spain, where war and famine had reduced the population to a desperate mob, by playing games on his device and impressing VXYZ Cambridge, the tech giant that had bought the name and reputation of the ancient university. They had offered him a chance to migrate to their headquarters in Greenland, where he would work as a drone operator for their deep-sea mining division as part of their inclusion programme. He had accepted without hesitation, eager to start a new life in the land where the snow and ice had long melted, revealing a truly green and pleasant land.

He had been living in Greenland for six months, and he had grown to love it. He enjoyed a comfortable room in a communal building provided by VXYZ Cambridge, where he shared meals and conversations with other young migrants from different countries. He delighted in the peace and tranquillity of the landscape, where the only sounds were the wind and the waves.

But he also felt a constant pressure, a nagging fear that he could lose everything at any moment. His work as a drone operator was demanding and stressful, requiring him to guide the underwater machines through the dark and dangerous depths of the ocean, extracting valuable minerals and metals from the seabed. He had to work fast and accurately, following the instructions and feedback from his chip and headset, which monitored his every move and thought. He knew that his performance was constantly evaluated and compared with other workers, and that if he failed to meet the standards, he would be fired and deported back to Spain, where his life would be in constant danger.

And today, his worst nightmare is coming true. He receives a message from VXYZ Cambridge, informing him that his employment has been terminated due to his low productivity and quality.

He is given 24 hours to pack his belongings and board a flight back to Spain, where he will be replaced by another hopeful young person. He feels a surge of panic and despair as he realises that he has lost his dream, his new home, his future. He has no choice but to accept his fate, and to say goodbye to Greenland, the last paradise on Earth.

The Transforming Scenario

The metaphor for the 'transforming' scenario is that of a train station with infinite platforms and destinations. Learners travel in collective carriages and they can decide to get onto another line to an alternative destination. In 2050, in a tranquil rural community, Mia lives a life of harmony and abundance. Following some very difficult times, climate change has been stabilised, and clean energy is freely available to all. Global peace and food security are the norm, ensuring fair resources for everyone. In this idyllic setting, Mia's journey of learning begins.

Mia's community embraces a collective but also personalised approach to education, like a train station with infinite destinations but shared carriages. Learning is equitable and accessible for all, tailored to each individual's needs and context. Mia's education is a blend of immersive, multi-sensory technology and access to learning hubs. At these hubs, she embarks on holographic history lessons, virtual field trips, and interactive experiments. The learning hubs also foster friendships that transcend borders, enabling Mia to collaborate with peers who share her passions and values.

Mia's teachers are a blend of human mentors and Gen AI-powered educators. The human teachers serve as facilitators, mentors and guardians of well-being. They encourage students to explore diverse worldviews and follow their own interests. The Gen AI-powered educators, on the other hand, leverage significant advancements in quantum computing to seamlessly integrate assessment into the learning process. Assessment has become invisible, woven into the fabric of learning itself.

Throughout Mia's life, her behaviour and skills are continuously evaluated and evidenced, providing her with a clear understanding of her strengths, skills, and attitudes. This holistic education pathway empowers Mia to envision her contribution to society as she grows up. The fertile soil of knowledge nurtures her growth, enabling her to flourish.

Mia's story exemplifies the transformative power of education when it is inclusive, flexible and focused on the holistic development of individuals.

The Equilibrium Scenario

In the aftermath of a climate collapse, society found its way back to a stability that has emerged from a period of chaos. Amidst this new world of leisure and sufficiency, we find a mid-teen student named Kim. A climate migrant from Southern Europe, she journeyed north to the Scandinavian haven of Norway as a small child, escaping the climate-related catastrophes that had ravaged her homeland. Kim and her parents value security and a community that echoes their strong values. Kim prizes a sense of belonging.

Her goal is to earn a modular qualification, a testament to her resilience and determination, and to become one of the rare workers finding meaning in useful work. Ubiquitous access to AI has reshaped the employment landscape, leading to a mass loss of jobs. In response, a universal basic income has been introduced. Nation-states like Norway have partnered with global tech companies, pooling resources to fund this initiative and implement new qualifications and assessment standards. This is a world where not everyone needs to work, where technology has been harnessed to create a more equitable society.

Kim's learning is marked by continuous assessments, each a milestone in her educational journey. As a teenager, she is also navigating the digital landscape, consciously curating her online persona. Her learning is facilitated by an AI tutor, a digital companion in her educational journey. Yet, the traditional school venue still holds relevance. She visits a few times a week, not always with her peers, but in a mixed-age environment. Kim's learning space is nestled within her community, a hub of screens and networks. It is a testament to the evolving nature of education, a blend of tradition, especially valued after a time of climate shock and change, and technology. The essence of human nature has remained constant, but the methods of assessment are more diverse, offering numerous possibilities.

In this future, the image of Kim in her learning space is a symbol of resilience and adaptability. It is a testament to the enduring nature of human potential, a reminder that while the methods of assessment might change, the human capacity to learn remains largely the same.

Appendix D: References

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Appendix E: Glossary

Foresight (Futures Thinking) is the process of anticipating, exploring, and preparing for plausible future scenarios. It involves exploring emerging new changes that might shape the future. Foresight aims to help organisations and individuals establish an anticipatory system and make informed decisions and strategic plans navigating uncertainties. It often involves methods such as scenario horizon scanning, planning, and backcasting. Foresight is valuable for proactively managing change, identifying opportunities, and mitigating risks in a rapidly evolving world.

Horizon scanning is a continuous process of monitoring and analysing information to identify emerging trends and potential future issues. It helps organisations and governments stay ahead of changes, make informed decisions, and prepare for the future by detecting early signals of impact and uncertainty.

Megatrends are large-scale, transformative forces that shape and influence developments across multiple sectors and have a profound and lasting impact on society, the economy, and culture. They are typically overarching and enduring patterns that persist over a long period, often decades. Megatrends are characterized by their longevity and widespread influence. They transcend specific industries and regions, affecting global and cross-sectoral dynamics. Megatrends have a significant and enduring impact on how people live, work, and interact. Urbanisation (the ongoing growth of cities and urban areas) and digitalisation (the widespread use of digital technologies) are examples of megatrends.

Trends are well-established patterns or developments that have been identified based on historical data and observations. They represent a clear and sustained direction of change over time. Trends are typically widely recognised, have a significant historical basis, and are often supported by substantial data and evidence. They are considered more certain and likely to continue into the future. The global shift towards renewable energy sources is a well-documented trend, supported by years of data and investment in clean energy technologies.

Weak Signals are subtle and often early indicators of potential future changes or disruptions. They are emerging developments that might not be widely recognised or understood and may lack substantial supporting data. Weak signals are characterized by their uncertainty, ambiguity, and limited information. They can be challenging to interpret, and their significance may not be immediately apparent. In the early 2000s, the concept of electric vehicles was considered a weak signal; while the technology existed, it wasn't widely adopted or considered a significant trend. However, it later gained momentum and became a major trend in the automotive industry.

Wild Cards are unforeseen and low-probability events that can disrupt organisations and society. These unpredictable occurrences, though rare, have a significant impact and challenge established strategies. Acknowledging the existence of wild cards and preparing for them through contingency planning is essential for building resilience in strategic decision-making.

Scanning Hit refers to the detection of an event, trend, or development with the potential to impact an organisation or industry in the future. It involves monitoring various information sources to identify early signals of change, providing organisations with the crucial insights needed to anticipate emerging opportunities and threats. A scanning hit can be a piece of information, news, data, or insight that suggests a potential future opportunity or threat. By recognising these scanning hits early, organisations can better adapt and make informed decisions to navigate the evolving land-

scape effectively.
Drivers (Driving Forces) are factors or influences that push or propel change within a system, organisation, industry, or society. These forces have a significant impact on future developments and trends. They can be both external and internal and are often key elements in scenario planning and futures studies. Rapid innovations in technology can be a driving force, leading to changes in products, services, and the way businesses operate. Growing awareness of environmental issues can drive changes in regulations, consumer demand, and corporate sustainability efforts.

Scenarios are stories about potential future outcomes that are used for strategic planning. They explore various plausible, often divergent futures, embracing uncertainty and helping organisations prepare for different possibilities. Scenarios inform strategic decisions by identifying risks and opportunities, and they are a valuable tool for addressing uncertainty in complex situations. Scenarios are particularly useful in industries and situations where uncertainty is high and where the consequences of different future states are significant. They enable organisations to be more adaptive and resilient by considering a range of plausible outcomes and developing strategies that are robust across multiple scenarios.

Futures Triangle is a method for understanding the forces that are shaping the futures. By considering the pull of the future (emerging trends, visions, and preferred future), the push of the present (current trends and forces), and the weight of the past (deep patterns and structures that resist changes).

Causal Layered Analysis (CLA) is a four-level analysis of the factors that shape a given issue or situation.

> *Litany:* This level includes quantitative trends, often exaggerated and used for political purposes.
> *Social causes:* This level includes economic, cultural, political, and historical factors. Dis*course/worldview:* This level includes the different perspectives and values that shape how we think about the issue or situation.
> *Myth/metaphor:* This level includes the deep-seated stories and archetypes that inform our understanding of the world.

Systems Thinking is a problem-solving and decision-making approach that considers complex issues as interconnected systems, viewing them holistically rather than as isolated parts. It examines the relationships, feedback loops, and causality among various elements within a system to understand the dynamic behaviour and emergent properties. By embracing a broader perspective, systems thinking is instrumental in addressing multifaceted challenges in diverse fields, such as business, environmental science, public policy, healthcare, and engineering. It helps uncover root causes, identify leverage points for change, and navigate the details of complex problems, making it a valuable tool for improved decision-making and solutions in an increasingly interconnected world.