REVIEW OF THE POTENTIAL FOR E-ASSESSMENT IN TECHNICAL EDUCATION IN ENGLAND

A report to the Gatsby Foundation

STUART EDWARDS

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The Gatsby Charitable Foundation
The Peak, 5 Wilton Road, London SW1V 1AP
T +44 (0)20 7410 0330 F +44 (0)20 7410 0332
www.gatsby.org.uk

CONTENTS

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Stuart Edwards, Edwardstowe Advisory

DISCLAIMER

The views and opinions expressed in this report are those of the author and do not necessarily state or reflect those of the Gatsby Charitable Foundation.

INTRODUCTION AND EXECUTIVE SUMMARY

Digital technologies are transforming the world of work and the competences required of the future workforce. Their use is also increasing in teaching, learning and assessment. Both trends have accelerated in 2020 and 2021 with the impact of Covid-19 and the requirements for lockdowns and social distancing. Technical education, and how it is assessed, should be a key point where these trends come together, or at least that would be expected to be the case.

This report focuses specifically on the current state of play and potential for further development of the use of e-assessment for assessing technical education in England. "E-assessment" refers here in broad terms to the assessment of knowledge, skills and capabilities of people through technology. Technical education is considered broadly as education and training for skilled jobs. The main focus is on qualifications at levels 3, 4 and 5 with a clear link to employment. The report also takes an interest in what is happening in the sphere of professional accreditation and licence to practice, and what employers are commissioning and undertaking on their own behalf. Geographically the main focus in on England, given that education, training and skills are devolved matters. However, when looking at issues with current assessment practices and reviewing potential for further development, examples have been considered from the devolved administrations, particularly in Wales, and to some extent internationally.

This short report is based on a selective literature review and discussion with a few key contacts. It is designed to be a 'think-piece' which exposes some of the key issues and opportunities; and can act as starting point for discussion, and possibly for commissioning more targeted and detailed work on what could be done to encourage the adoption of innovative approaches to e-assessment where that could be beneficial.

The report covers:

- the current context, issues and challenges for the assessment of technical education and skills in England;
- the current state of play with technology-based approaches to assessment and their potential for further development, particularly where relevant to issues and challenges identified for technical education and skills in England;
- the challenges and barriers that need to be addressed for progress to be made with encouraging the adoption of innovative approaches to e-assessment;
- recommendations for next steps.

Key findings and conclusions are as follows.

ISSUES AND CHALLENGES WITH ASSESSING TECHNICAL EDUCATION

- Assessing technical education is inherently complex and difficult, and it is often challenging to achieve both reliability and validity.
- The centrally-regulated sphere of technical qualifications and apprenticeships in England has distinctive features in terms of how it works as a market, the number of players involved, and the role played by Awarding Organisations.
- Significant resources are expended on a range of assessment methods, seeking to achieve both validity in the eyes of employers and reliability for the purposes of comparability and academic progression, and results are critical for how providers are funded and regulated.
- There is limited robust evidence for the effectiveness of current practices, and there are practical concerns, particularly about the amount of time and effort absorbed by assessment activities which are separate from and do not contribute to teaching and learning.

TECHNOLOGY-BASED APPROACHES AND THEIR POTENTIAL

- Technology can be used in a wide range of ways for different assessment methods, at different stages of the assessment process.
- Different technology-based approaches can be placed on a broad spectrum of transformative potential in relation to the challenges of assessing technical education.
- Many approaches offer practical ways to enhance existing assessment practices, but do not necessarily change the nature of the assessment process itself. Examples being automated multiple-choice tests and script marking, remote proctoring, e-portfolios, work-based assessment apps, and e-credentials and badging.
- Others appear to have greater transformative potential:
  - adaptive assessment using the growing capability of AI
  - data capture and performance analysis technologies used in real workplace settings
  - simulations using VR and AR to create controlled assessment environments
  - games technologies blurring lines between formative and summative assessment
- Using these technologies in combination, an alternative model for assessing technical education can be conceived, moving away from separate 'stop and test' assessment to a more continuous process embedded in the teaching and learning, and in the workplace itself.
- Such a model has potential to address some of the inherent challenges and issues for assessing technical education, and elements of what is possible can already be seen in areas such elite sports, the military and pilot training.
- Take-up of the more transformative technologies is however currently very limited within the centrally regulated system in England, and where technology is used it is largely to enhance more conventional assessment methods.
- The impact of the COVID-19 disruption has led to a greater willingness to explore alternative approaches to assessment using technology, while exposing current limitations.

CHALLENGES AND BARRIERS TO INTRODUCING MORE TRANSFORMATIVE APPROACHES

- The technology exists and is developing quickly but its use in education is relatively immature.
- The centrally-regulated market within which assessment of technical education takes place in England is not conducive to the introduction of transformative change.
- The complexity, the number of players involved, the number of qualifications, the limited research base, and an understandably risk-averse culture all make innovation difficult.
- Significant ethical and legal considerations also need to be taken into account.

POSSIBLE APPROACHES TO MAKING PROGRESS

- There needs to be more concerted system leadership. Leaving it to the market with individual Awarding Organisations responding to a hands-off regulatory framework is unlikely to work.
- Areas could be identified which are most promising for change. Two key considerations are likely to be the scale to justify investment and the extent to which the occupation is digitalised.
- Scale could also be achieved by looking at assessing cross-cutting competences which underpin multiple occupations.
- Technology could be brought in from industry or gaming rather than developed from scratch.

RECOMMENDATIONS

- The main bodies regulating the assessment of technical education in England – led by the Department for Education (DfE), and including the Office of Qualifications and Examinations Regulation (Ofqual), the Institute for Apprenticeships and Technical Education (IfATE), the Office for Students (OfS) and the Awarding Organisatons (AOs) – should make a policy commitment to work with employers to encourage and explore greater and more transformative use of digital technology for assessment.
- Further work should be undertaken - which The Gatsby Foundation is ready to support, in partnership with IfATE, employers and other key interests - to identify and illustrate occupational areas of greatest opportunity to test out new and transformative approaches to using digital technology for assessment.
- A competition should be run to seek proposals that could be supported as demonstration projects, the organisation and evaluation of which should be considered by DfE alongside other Government bodies, AOs and interested parties such as JISC and the University for Industry Trust (Ufl).
- To support the broader development of EdTech, Innovate UK should be asked by DfE and Department for Business, Energy, and Industrial Strategy (BEIS) to review the research and innovation landscape, with a view to assessing the case for an "EdTech" Catapult or similar mechanism.

ASSESSMENT OF TECHNICAL EDUCATION IN ENGLAND

Before looking directly at the scope and potential for e-assessment, it is important to reflect on what is distinct about assessing technical education, the particular context for such assessment in England, and some of the practical issues it gives rise to. Assessment of technical education is in many respects more complex than assessing academic education and poses certain distinctive challenges. The technical qualifications market in England, and how it is funded and regulated, also has distinctive features which need to be recognised when considering the scope for deploying e-assessment approaches.

CHALLENGES OF ASSESSING TECHNICAL EDUCATION

The content of technical qualifications relates to the knowledge, skills and behaviours required for an individual occupation or a group of occupations, which may collectively be described as occupational competence. Typically, there is a combination of practical skills and related theory, and in addition, technical qualifications quite frequently include components of more academic general education, such as English and maths. The dominant assessment philosophy for assessing occupational competence in England is 'competence-based assessment', which involves the objective assessment of transparently described learning outcomes, decoupled from the learning setting. (Field, 2021)

Relevant considerations in respect of assessing technical education include the following.

Complexity

Technical assessments are much more difficult than academic assessments. A single job requires a combination of a vast range of competences, and there is a huge range of jobs. Occupational competence is often best measured in a real-world working context. A diverse range of assessment tools can be used. This contrasts with academic assessment where usually a single competence is being assessed and the dominant mode of assessment is a standardised written exam undertaken in controlled conditions.

Reliability vs validity

Assessments need as far as possible to be both valid (they measure what they are intended to measure), and reliable (they do so consistently across different contexts and over time). Traditional examinations and standardised practical tests are easier to make consistent and reliable, but their validity can be questioned for measuring complex occupational competences. Practical assessments embedded in working practice with the involvement of employers are often seen as more valid, particularly by employers, but they raise challenges in terms of achieving reliability in variable contexts.

Dual-purpose assessment
Where technical assessments link to qualifications, they often serve two purposes:

- to confirm occupational competence for an employer;
- to provide a reliable (and often graded) measure of more academic knowledge and skills as a means of accessing further learning.

This duality of purpose can accentuate the tension between achieving reliability and validity.

Practicality and manageability
Assessments need to be manageable for those administering them. Specialist equipment and technology may in theory be able to facilitate better technical assessment, but this may not be practical to use if it cannot be made affordable and reliably accessible for all those who potentially need to be assessed.

Lack of evidence
There is a weak evidence base on what makes for effective assessment. Research evidence on the validity and reliability of different methods of assessment is very limited. It is also difficult to create such an evidence base for technical assessments and would require complex and costly research studies, with longitudinal follow-up of subsequent job performance, and retesting of examinees to check assessment reliability. This lack of evidence also hampers innovation as it is difficult to prove the case for investing in alternative approaches.

THE CONTEXT IN ENGLAND

Assessment of technical competence in England is undertaken in three main broadly-defined spheres:

1. a centrally-regulated sphere that includes publicly-funded vocational qualifications, apprenticeships and the new T-levels;
2. an industry- and professional body-led sphere where assessment against standards is linked to 'licence to practice' and continuing professional development;
3. an individual employer-led sphere where assessments are made of employees and potential employees to support internal business needs and training and development programmes, without seeking accreditation against externally set standards.

The main focus of this report is on the centrally-regulated and funded sphere, though there may be lessons to be learnt from elsewhere. The regulated, vocational qualifications market in England has distinct features not commonly found elsewhere. It is complex and resource-intensive, and training providers are dependent on results achieved for how they are funded and regulated. (Frontier Economics, 2017) Relevant features when considering the scope for e-assessment include the following.

Role of awarding organisations

Awarding Organisations (AOs), of which there are currently some 160 recognised in England, design the content of vocational qualifications, both the curriculum and how it is assessed; they support the delivery by training providers; and are responsible for the assessment and awarding of certificates. This arrangement is unusual internationally, where it is more common for qualifications attracting public funding to be developed and supplied by Government, and it creates a unique form of market for qualifications. The AOs vary greatly in size, with the ten largest being responsible for around 70% of the vocational certificates awarded and a long tail of smaller specialist AOs. Various questions have been raised about how effectively this market operates, in particular whether there are sufficient incentives to maintain quality and rigour, or whether there is a risk of a "race to the bottom" to attract provider business, and whether the market encourages or stifles innovation. For the new T-levels, the Government has consciously chosen to change how the market works, so AOs compete for a licence to be the sole body responsible for an individual T-level rather than providers having a choice of AOs.

Large number of different qualifications

Despite considerable efforts made in recent years to rationalise the number of individual qualifications, there were still more than 17,000 vocational and other non-academic qualifications available in 2019-20. (Ofqual, 2021) As with the AOs, there is a long tail of fairly niche qualifications for which only small numbers of certificates are being awarded, though further rationalisation is now underway.

Complexity of regulatory and funding arrangements

Regulatory and funding arrangements are complex and differ between the generality of vocational qualifications, apprenticeships and T-levels. Overall policy is made by the Department for Education (DfE). The Office of Qualifications and Examinations Regulation (Ofqual) is responsible for regulating vocational qualifications including the new T-levels, but not apprenticeships. It does so largely indirectly through regulating the A0s and setting rules and expectations they are to abide by, including for how assessment is undertaken. The Office for Standards in Education, Children's Services and Skills (Ofsted) regulates the quality of learning, teaching and assessment in training providers, including apprenticeship providers. For the assessment of apprenticeships five separate agencies are currently involved in the quality assurance – Institute for Apprenticeships and Technical Education (IfATE), Education and Skills Funding Agency (ESFA), Ofqual, Ofsted, and Office for Students (OfS). The ESFA is the main national funding body, setting funding formulae and paying providers. However, their funding regimes differ significantly between 16-19-year-olds and adults; a growing proportion of the adult budget is now devolved, and funding bands for apprenticeships are set by IfATE.

Market size and costs

Around 5.8 million vocational and other certificates were awarded in 2018-19 (the last full year pre-Covid). (Ofqual, 2020b) The complexity of technical assessment and the different forms of assessment used mean that it can be costly and resource intensive. It is difficult to calculate precise costs, but the following pieces of information provide some pointers and suggest that annual costs could run into many hundreds of millions.

- Evidence from the Association of Colleges (AoC) suggests that FE Colleges spend on average around 3% of their income on examinations which equates to around £215 million annually. (AoC, 2015) This figure includes academic as well as technical qualifications but excludes other types of training provider. It is based on examination fees, so does not take account of the substantial amounts of time spent by both trainers and learners on assessment activities, which may not be directly linked to the acquisition of learning and could therefore carry a significant opportunity cost.
- The cost of an end-point assessment (EPA) for an apprenticeship is not expected to exceed 20% of the cost of the whole apprenticeship programme. (ESFA, 2021) Early research undertaken for IfATE and the ESFA gave an average cost of 17% or £1554, with a further 14% (£1253) spent on other assessment excluding the EPA. (IFF, 2020) With the total levy-based spend on apprenticeships in England estimated at around £2 billion, that would suggest a total annual spend of £600 million on all forms of apprenticeship assessment.

ASSESSMENT METHODS

A wide variety of assessment methods is used. The Qualification Manager's Handbook produced by the Federation of Awarding Bodies (FAB, 2017) sets out the main methods, with indications of what they are best suited for and their advantages and disadvantages. Eighteen example methods are listed:

- multiple-choice test
- written examination
- 'open-book' examination
- oral examination/test
- interviews/oral questioning
- professional discussions
- assignments
- observation
- aural examination
- product or artefact production
- skills or trade test
- simulation
- coursework
- project
- dissertation
- case studies
- reflective logs, journals or casebooks
- personal statements e.g. diaries, vlogs, blogs etc.

Some of these are best suited to assessing knowledge and understanding, others to assessing practical skills. Another important distinction is between 'standardised tests' where all candidates are asked to perform the same tasks, and 'context-dependent tests', where the tasks vary from student to student. Often a mix of methods is used to assess a single qualification, seeking to achieve the best combination of validity, reliability and practicality.

Generally speaking, for vocational qualifications a portfolio approach to assessment remains most prevalent, in which candidates are required to accumulate naturally-occurring evidence, such as work products and evidence drawn from professional discussions and observations. The portfolio is a means of collecting evidence together from a range of assessment methods over time rather than being an assessment method in itself. In so far as it relies on naturally-occurring evidence, the exact nature of evidence can vary between candidates and is context-specific. Reliability and consistency are sought through specifying clearly the standard of evidence required against the assessment criteria, and by procedures for both internal and (sampled) external verification of assessors' judgements based on the evidence provided in the portfolio.

For apprenticeships in England, there is also the requirement of an independent end-point assessment (EPA). This is designed to be a synoptic assessment of the apprentice's ability to bring together the knowledge, skills and behaviours learnt throughout the apprenticeship. Its purpose is to make sure the apprentice meets the standard set by employers and is fully competent in the occupation. An assessment plan is agreed with employers setting out what is to be assessed, how it is to be assessed (that is the assessment methods) and who is to do the assessing (for example minimum requirements for assessors and ensuring their independence).

For T-levels, there are also Government requirements on what is to be assessed and how it is assessed (DfE, 2018). Core knowledge and understanding must be assessed through an external test that is set and marked by the AO. Core skills must be assessed synoptically through a practical employer-set project (typically implemented by the AO with design input from employers). Occupationally specialist content must also be assessed synoptically to establish a threshold level of competence has been met, and AOs are encouraged to review methods used to assess corresponding apprenticeship standards. These requirements reflect the dual pressure for comparability with academic qualifications to enable progression, whilst maintaining credibility with employers.

SOME PRACTICAL INSIGHTS

As noted previously there is limited research evidence about the assessment of technical education. However, one interesting source of evidence for practical issues with current arrangements for assessing technical qualifications in England comes from a series of sector reviews undertaken by Qualifications Wales. Although arrangements are devolved, the qualifications recognised and used in Wales are largely the same as in England, and it is likely that issues identified relating to assessment are equally applicable to the English context, other than those relating specifically to use of the Welsh language.

Four sector review reports have been published to date (September 2021), covering: Health and Social Care; Engineering, Advanced Manufacturing and Energy; Construction and the Built Environment; and Information and Communications Technology. (Qualifications Wales, 2016, 2018a, 2018b, 2020) These are based on stakeholder interviews, discussion groups with learners, online questionnaires, technical reviews of qualifications and international comparison studies. Assessment issues are prominent in each of the reports. Although there are some differences of emphasis between sectors, common themes emerge, including the following.

- Over-assessment – concerns about the volume of assessment, its impact on the time available for high quality teaching and learning, and it becoming unmanageable and demotivating for learners.
- Repetition of what is assessed – content such as health and safety appearing in multiple units and being assessed separately each time, adding to the burden.
- Over-reliance on written work – particularly as evidence of the completion of practical tasks, and where learners' digital skills are being assessed by having to write about them separately or print screenshots of their work.
- Inconsistency between assessments and between external quality assurers – this includes inconsistent approaches to assessment between centres and limited use of observation in the workplace, which is often constrained by costs and practicalities and can be a tick-box exercise when it happens.
- Limited availability and expertise of assessors – recruitment and retention is a significant challenge, particularly in specialist subjects such as electronics, and rail and motor vehicle engineering.
- Lack of currency in what is being assessed – this goes wider than assessment, but there is a strong theme that what is being assessed through qualifications is struggling to keep up with technological developments in industry such as artificial intelligence, robotics, automation and the introduction of new materials.

The ICT review includes a particularly telling finding from the perspective of learners:

> *"Learners told us that they are often assessed on practical tasks by producing written evidence. They reported that this approach to assessing practical skills favours learners with strong literacy skills, rather than those with strong digital skills. Learners also told us that this approach to capturing assessment evidence is very disengaging and demotivating."*

SUMMARY

It needs to be recognised that assessing technical education is inherently complex and difficult. Currently a huge amount of effort and resource is being expended, particularly within the regulated technical education system in England, trying to address the twin goals of reliability and validity, and achieve multiple purposes for different audiences. Although there is generally a lack of research evidence, it would appear that current approaches have their limitations and may in some instances be detracting from the wider learning experience. That raises two questions.

- How far do technology-based approaches have the potential to address some of the inherent tensions and limitations in assessment of technical education?
- Is the current context within which technical education in England is assessed conducive to the introduction of technology and exploitation of its potential?

TECHNOLOGY-BASED APPROACHES TO ASSESSMENT

Just as there is a wide range of assessment methods that can be used in technical education, there is a wide range of ways in which technology can be used to support different methods, and at different stages of the assessment process.

PRINCIPAL EXAMPLES

Some of the main examples include the following.

Multiple-choice tests

It is relatively commonplace to assess knowledge and understanding using multiple choice tests taken on a computer, and and these can be marked automatically and provide instant feedback to the learner. They are relatively easy to create and very efficient to administer. They are reliable and replicable, and it is possible to create question banks which can be drawn on selectively so that it is difficult to anticipate what will be asked in advance. Technology can also enable a much richer range of stimuli for questions beyond simple written text, such as videos, animations and audio recordings, which may be more engaging and accessible for learners.
The main downside is the limitation on what can assessed in a multiple-choice format. It is only likely to be appropriate for testing knowledge and understanding, rather than practical skills, and even then there is a limitation on what can be reduced to a set of simple correct/incorrect choices. It is therefore likely to need to be used in combination with other methods, or else there is a risk of over-simplification and loss of validity.

Adaptive multiple-choice tests

A significant way in which technology can enhance multiple-choice tests is by making them adaptive. This involves the content of the test changing so it is tailored to the individual depending on how they answer the questions posed. This can enable the same the test to be used with learners at different levels of capability, and can be helpful for grading and diagnostic purposes, though it does not alter the fundamental limitations of a multiple-choice approach.

Automated marking of written and spoken tests

There is increasing interest in and some significant examples internationally of artificial intelligence (AI) being used to automate the marking of both written and spoken tests, where answers are open and free-form rather than closed as in the case of multiple-choice tests. This is most easily done for relatively short free-form answers, but as the capabilities of AI techniques such as natural language processing continue to grow, there is an expectation that application will be possible in areas requiring longer and more complex responses such as essays. However, the use of AI to mark tests and exams remains controversial and has its risks, with concerns about systems being 'gamed' and originality of thought marked down.

Remote assessment and proctoring

Exams can be taken remotely, with technology being used to replace the traditional physical role of a proctor/invigilator in ensuring the integrity of an exam. This involves identity verification technologies such as face recognition, voice recognition or analysis of key stroke dynamics, and remote monitoring through a webcam to protect against other forms of cheating. Use of such approaches has grown rapidly with the

constraints imposed by social distancing in the COVID-19 pandemic, and there are numerous companies offering remote proctoring services. There are also significant concerns being expressed, particularly by students, about the intrusive nature of some of these technologies and the impact on personal privacy. (McKie, 2021)

e-Portfolios

Specialist software is increasingly replacing paper-based portfolios to gather and organise evidence for assessment purposes. A significant advantage is the wider range of evidence that can be gathered and stored electronically, such as images, videos and voice recordings, which can be particularly useful for the assessment of practical skills. Other advantages are that evidence can be uploaded and shared with assessors in real time, it is easy to track progress, and these systems can be integrated as part of a wider management information system. There appear to be few disadvantages other than the cost and effort of adoption, but it should be noted that this is primarily a means of gathering together assessment evidence rather than changing the way assessment is undertaken, though it may facilitate that.

Workplace-based assessment recording apps

Technology can help address the particular challenges of recording evidence in the flow of work at remote settings. Mobile phone apps can now be used to record evidence and assessments undertaken at any location (such as by video and audio recordings), and download the data into an e-portfolio as soon as there is a mobile or wifi connection. The main uptake so far has been for medical and veterinary training where numerous observational assessments of clinical practice are required, though there are also examples in teacher training and other workplace environments. The main advantages are in being able to capture and sign off evidence instantly in the flow of work rather than it being a retrospective paper-based exercise. This can be particularly beneficial where more senior work colleagues are expected to contribute to the assessment. It can also enable trainees to be more proactive in gathering evidence, though they may require some training first, and care needs to be taken with issues like privacy and confidentiality.

Data capture and performance analysis technologies

Another angle on workplace-based assessment comes from the increasingly sophisticated technology used in professional sports. The performance of individuals and how they interact together in teams is now assessed in minute detail in both training and actual games. Systems deployed include multiple semi-automatic cameras recording high definition video (VID), local positioning systems using radar (LPS) and global positioning systems (GPS). While it may some way off before such technologies can be deployed practically and affordably in 'ordinary' workplaces, the potential for an affordable mass market can already be seen in the GPS-based apps commonly used by amateur athletes to monitor their fitness.

Simulations

An alternative to real workplace assessments is to create an authentic simulated workplace environment that can be used for training and assessment purposes. Technologies such as virtual reality (VR) are changing the boundaries of what is possible. Simulations can be quite complex and expensive to create; examples include those used to train aircraft pilots, train drivers and ship's crew, or for nuclear reactors and oil rigs, or for learning factory facilities. But there are also apps that can be used to create much simpler VR-based scenarios for specific purposes. The main advantage of a successful simulation is that a controlled, authentic environment with replicable scenarios can combine reliability and validity.

While it may well still be necessary for some aspects of practical assessment to be undertaken in a real workplace, simulations can be particularly helpful for scenarios that are dangerous or costly or rarely occur in real life. Costs remain a significant inhibitor to wider uptake of more complex simulations, but as the workplace is increasingly digitalised, and the distinction between the real world and digital world becomes more blurred, it will become increasingly easy to create 'digital twins' that could be used for assessment purposes.

Games technologies

Assessment can be 'gamified' with varying levels of sophistication. This can be linked to simulated environments and made adaptive in response to how the learner plays the game. One feature of a gaming approach is that it can blur the lines between formative assessment undertaken during training and practice, and summative assessment which can support certification. The learner simply plays the game until they reach a certain level without the need for a separate summative assessment. A gaming approach can be used for quite simple forms of rote learning and multiple-choice tests of knowledge and understanding, but can also enable more complex synoptic assessments, and can be particularly valuable for training and assessment in areas like strategy, systems thinking and team-working where multiple players can interact in an evolving scenario. Games with the highest levels of production value and sophistication tend to have been developed commercially for entertainment purposes, though 'serious games' have been deployed successfully for some time in areas like the military and demonstrate what is possible. More widespread use though is often inhibited by the costs and expertise required for more sophisticated games development.

e-Credentials and badging

Although not directly part of the assessment process, e-credentials and badges are noted here for completeness as a technology application increasingly used to enable the outcomes of assessment to be communicated and verified in a consistent manner. In particular, they can assist with credit accumulation, enabling an individual to prove what they can do and that their credentials are genuine. This is supported by an international standard for open badges. (IMS, 2021)

TRANSFORMATIVE POTENTIAL

Looking across these examples, there is a broad spectrum of transformative potential in relation to the challenges of assessing technical education. Many of these uses of technology are practical ways to enhance existing assessment practices, often making them more flexible, accessible and efficient. However, they do not necessarily change the nature of the assessment process itself to take advantage of the full potential of what technology could do. Automated multiple-choice tests and script marking, remote proctoring, e-portfolios, work-based assessment apps, and e-credentials and badging can all be considered primarily in these terms as practical enhancements of existing assessment practices rather than being transformational.

The approaches which would seem to have greater transformational potential are:

- adaptive assessment, of any form, that can respond in real time to actions and behaviours of the learner, using the growing capability of AI
- data capture and performance analysis technologies that can monitor and analyse data on performance in real workplace settings

- simulations that use digital technologies like VR to create controlled assessment environments and scenarios
- games technologies that can blur the lines between formative and summative assessment.

These do not necessarily need to be considered separately or as alternatives. Much of the future potential of technology to transform technical assessment is likely to come from combined approaches. For example, it is possible to imagine a simulation designed using data captured from performance tracking and analysis in a real workplace, using a gamified approach for assessment that adapts intelligently to how the game is played.

In general/academic education, there is increasing interest in how AI in particular can change how knowledge and understanding is assessed. For example, Professor Rose Luckin has made the case that traditional 'stop and test' assessments are blunt instruments, and the technology now exists for it to be realistic and affordable to build a superior assessment system underpinned by AI. (Luckin, 2016, 2017) She argues that decades of research show that knowledge and understanding cannot be rigorously evaluated through a series of 90-minute exams. Furthermore, the prevailing exam paradigm is stressful, unpleasant, can turn students away from education, and requires that both students and teachers take time away from learning. Her proposed alternative model harnesses the capabilities of AI to integrate assessment within the learning process so that the learning can be continuously monitored and shaped by assessment and analysis of what is happening, including emotional well-being and motivational factors as well as knowledge and understanding.

In respect of assessing technical education, in so far as it is concerned with knowledge and understanding, the same case could be made directly. There is though the additional challenge of assessing practical skills and how they are brought together with applied knowledge and understanding. Nevertheless, it is possible to conceive of a similar model of continuous assessment which brings in additional elements based both on technology used to monitor performance in digitalised workplaces and linked digital simulations that can generate scenarios designed specifically for learning and assessment purposes. The potential can already be seen in well-resourced areas where the stakes are high, such as elite sports training, military training and the training of airline pilots. As 'Industry 4.0' principles and technologies become more prevalent, and are capable of generating and analysing huge volumes of data about how humans interact with machines, with each other and with their wider environment, the opportunities should become more widespread for adopting a different model of assessment in many other areas of technical education. The challenge here is to take further advantage of what is happening with 'Industry 4.0' and define what 'Assessment 4.0' might look like in a range of specific circumstances.

ADDRESSING CHALLENGES AND ISSUES

The table below sets out briefly how a more transformative approach to using technology could help address some of the key challenges and practical issues for the assessment of technical education that were identified earlier.

Issues with technical education assessment	Potential for technology solutions
Reliability vs validity	As workplaces become more digital and data-rich, and simulations more sophisticated and authentic, new opportunities are emerging to address the fundamental challenge for assessing technical education – bringing together reliability and validity.
Lack of evidence	Technology also creates opportunities to link data on real world performance with assessment data, which could help evidence the validity of assessment. For example, individual performance on training programmes for salespeople has been correlated with sales figures.
Volume and unmanageability	If performance can be assessed automatically in the flow of training or work, without stopping to test or record as separate processes, this could significantly reduce the time spent on assessment, whilst increasing its scope and depth.
Repetition	It may be easier to develop digital assessments that can be used for multiple contexts, avoiding repetition. It is also possible to 'skin' a digital assessment rather than developing from scratch for each different work context.
Over-reliance on written work	If more evidence can be produced automatically through technology recording learner interactions, this will reduce the need for the learner and/or assessor to describe separately what they have done.
Inconsistency of assessors	Objective recording and analysis of performance can reduce the scope for subjectivity and inconsistency, and also help address the constraints of costs and practicalities in terms of use of assessors' time.
Shortage of expert assessors	If more of the assessment process can be automated and less needs to be separately observed and recorded, better use could be made of expert assessors' time and the overall demand for assessors could be reduced.
Lack of currency	Adopting digital approaches makes it easier to update as industry updates, for example with industry and education versions of software being developed and rolled out alongside each other. If digital technologies prevalent in the workplace are not used this almost guarantees technical education assessment will lack currency (and hence validity).

CURRENT STATE OF PLAY

Looking now at actual take-up and use of technology to assess technical education, it is difficult to be precise, but from the discussions and literature surveyed for this initial report, the broad position would appear to be as follows.

Some use of technology is made to assess technical education, but – particularly within the centrally-regulated sphere – this tends to be at the less transformational end of the spectrum of applications, such as multiple-choice exams that can be taken on-line and marked automatically, and e-portfolios.

Assessment of technical education seems nevertheless to be ahead of general/ academic education in some respects, such as moving away from traditional pen and paper exams. Two main reasons suggested for this are as follows.

- The content in terms of knowledge and understanding can lend itself more readily to assessment methods that are easily automated, such multiple-choice tests.
- There is greater scope for on-demand testing – a significant barrier to moving large-scale, high-stakes exams like GCSEs and A-levels online are the logistics and risks involved when thousands of students are taking exams at the same time. (Ofqual, 2020a)

Some concerns remain that use of technology could disadvantage learners who lack digital skills or access to the necessary equipment.

More transformative uses of technology for assessing technical education can be found beyond the centrally-regulated sphere. These tend to be in relatively well-resourced areas, where there are practical barriers to making valid assessments without the use of technology, and the stakes are high whether in terms of safety or commercial reward.

IMPACT OF COVID-19

The impact of the COVID pandemic has so far probably been more significant for attitudes than practices. There has been a significant growth of interest and some additional uptake in readily available but less transformative uses of technology, especially remote assessment and remote invigilation for both paper-based and online exams. Limitations have also been exposed. The experience in respect of apprenticeships is illustrative as shown by the short case study below.

IMPACT OF COVID ON ASSESSMENT OF APPRENTICESHIPS

IfATE responded to the emerging difficulties with administering EPAs safely and consistently within COVID restrictions by issuing guidance offering a series of flexibilities. These included some uses of technology, for example gateway review meetings between employers and providers taking place remotely, and in some circumstances assessments undertaken through remote observations or in simulated environments.

With over 600 different, employer-led standards, each having its own assessment requirements, the need for such flexibilities and the capability to take advantage of them varied significantly. In some sectors technological capabilities already existed or were relatively easy to put in place, but in others there were inherent limitations to what could be done with readily available technology, and some trainees and assessors expressed concerns about the ability to demonstrate and assess the full range of skills. Nevertheless, it came to be recognised that in some circumstances these flexibilities enabled greater efficiency without detriment to the integrity of the process, and when IfATE updated its COVID-19 guidance in August 2021, it was confirmed that some flexibilities would be retained permanently. (IfATE, 2021)

The area posing the greatest difficulties was the assessment of functional skills qualifications regulated by Ofqual, where DfE took a policy decision that centre-assessed grades could not be used. While some AOs and providers were able to facilitate remote online assessments where needed, it proved impossible to do so consistently and at scale across the system as a whole within the timescales required. It turned out to be too complex with the large numbers of employers, providers and AOs involved, each with their own systems and security arrangements, and many trainees struggled to get reliable access to the technology needed. As a result, according to estimates from the Association of Employment and Learning Providers (AELP), at one stage there were up to 60,000 trainees unable to complete their apprenticeships because they could not take a functional skills assessment.

Whatever the limitations in practice, enforced disruption to the whole assessment system has been a prompt to change attitudes. Whether for academic or technical assessment, it has clearly made people question the status quo and look more seriously at what technology could offer. For example, a shift in attitude to online exams has been reported at the DfE, the Federation of Awarding Bodies has recently set up a working group on technology in assessment, and Simon Lebus, the Chief Regulator at Ofqual recently spoke of the experience of the pandemic in these terms:

> *"Longer term, however, there is clearly going to be scope to reflect on what we have learned during this time and what implications it might have for assessment. I am thinking especially of the large-scale of adoption of technology and online learning and its integration into pedagogy, and whether that will ultimately have a washback into assessment."* (Lebus, 2021)

The impact of the pandemic has not been wholly encouraging for e-assessment. In January 2020 Ofqual launched a competition to explore how AI could be used in exam marking. (Black, 2020) By August this initiative had to be put on hold in the wake of the furore generated by the failed attempt to use algorithms to allocate A-level marks. (Kempsell, 2020) Although there was not really a direct connection, it illustrates the risks and sensitivities when technology is perceived to have been misapplied.

SUMMARY

There is a wide variety of ways in which technology can be used to support assessment, and some of these approaches have the potential to transform how the assessment of technical education is undertaken and to address some inherent challenges and issues involved. Currently, there is some uptake of technology, but it tends to be at the less transformative end of the spectrum. There are though examples of more transformative approaches, particularly beyond the centrally-regulated sphere, and the COVID experience has changed attitudes to create more willingness to explore how things could be done differently using technology.

The remainder of this report looks at the challenges and barriers that will need to be overcome to realise more of the transformative potential of technology for assessing technical education, and at what approaches might help to start to move this forward.

CHALLENGES TO ADOPTION, AND WHAT MORE COULD BE DONE TO ENCOURAGE PROGRESS

To understand what more might be done to encourage the uptake of more innovative and transformative approaches to the use of technology for assessing technical education, it is important to be clear and realistic about the challenges and barriers that need to be overcome. These can be looked at from the perspective of the technology itself, the specific context and systems into which it might be introduced, and broader legal and ethical considerations.

TECHNOLOGY AND TECHNICAL CHALLENGES

The underlying technology required – AI, data analytics, sensors, VR, AR, simulations, gaming etc. – exists and is developing quickly, becoming cheaper and more capable every year. However, its use in education, particularly for assessment, is relatively immature. (JISC, 2021) Costs and affordability remain important considerations, as do the availability of hardware and IT infrastructure, and systems interoperability.

The main barrier is not the technology itself, but appears to be a lack of drive and motivation to support the investment necessary for it to be customised and deployed at scale to support assessment of technical education. Given the overall resource absorbed by assessment activities across the system, the efficiency and effectiveness of which is at least questionable, this is not purely an issue of affordability.

CONTEXT AND SYSTEMS CHALLENGES

Features of the regulated education sector, and in particular the way in which the assessment market works within it, are not conducive to the introduction of technologies at the more transformative end of the spectrum.

Education as a whole has been characterised as a 'super-stable system' in respect of the challenges of introducing technological innovation and moving beyond prototypes. (Scanlon, 2013) A co-founder of the EdTech-focused conference EdTechXGlobal has been quoted as saying: "We estimate that the speed of digitisation in education will be up to five times slower than has been seen in other sectors, due primarily to the increased number of gatekeepers involved in digital transition decisions." (Spaven, 2016)

The centrally-regulated market for technical qualifications in England as described earlier in this report illustrates many of the issues. It is very complex with a large number of players and multiple regulatory authorities. Although there are numerous AOs in most segments of the market, competition between AOs at the level of individual qualifications is often limited. A research report commissioned by DfE to analyse the market for vocational qualifications in England concluded that insufficient head-to-head competition on qualifications between AOs is potentially leading to lower levels of innovation in response to changing technologies. (Frontier Economics, 2017) At the same time, the large number of AOs and individual qualifications makes it more difficult to achieve the scale needed to justify significant investment in technology. A further issue is the lack of a research base. It is difficult to make the case for technological innovation in an environment where there is limited evidence for what effective practice looks like. And finally it is widely recognised that there is a risk-adverse culture. This is understandable given how problems with assessment affect individuals and hit national headlines, and although

the greatest sensitivity is around exams like A-levels, the impact of high-profile crises appears to permeate the system more widely. One example is the need felt to pause the pilot competition exploring the use of AI to support marking.

LEGAL AND ETHICAL CONSIDERATIONS

The use of technology for assessment in education raises a range of legal and ethical considerations which need to be managed carefully. Where large volumes of data about individual learners are collected and processed, this can be intrusive and raise legal issues about privacy and confidentiality. Where AI is used to analyse such data and support assessment decisions, there are potential issues about bias being imported into the assessment as well as being able to explain how decisions are made in an open and accountable way. (JISC, 2021) There are also underlying issues of data ownership with growing role of big tech companies in education (Iqbal, 2021) and the acquisition by private equity funds of specialist providers of education management information systems (Capita, 2020).

It is widely recognised that addressing these issues is crucial to maintain confidence going forward. One response has been to develop an ethical framework for the use of AI in education under the auspices of 'The Institute for Ethical AI in Education' (2021), which operated as a 'task and finish' initiative funded by commercial and charitable organisations. Continuing to address these issues and maintain confidence will be an ongoing challenge.

BARRIERS TO BREAKING OUT

All of the above suggests that while technological capabilities and the digitalisation of working life move on apace, it remains very challenging in practical terms for more transformative uses of technology for assessment to be introduced, particularly within the sphere of publicly-funded and regulated technical education. Within the current system, the main impetus would be expected to come from AOs. They are doubtless aware of many of the possibilities. However, for individual AOs operating within the current regulatory and funding framework, it is difficult to see clearly the circumstances in which the rewards for them would outweigh the costs and risks. Individual training providers, who are the purchasers of accreditation and bear many of the costs of the associated assessment requirements, can only innovate to a limited extent in how they meet AO specifications and are not in a position to transform how assessment is undertaken.

Ofqual as the overall regulator of qualifications in England has in the past taken a position that it is supportive in principle of technological innovation, but it is not its role to proactively promote developments or favour technological solutions. As regulator, it sets out broad requirements, and it is down to AOs how they fulfil those requirements.

Overall, it appears that none of the main players in the system has the incentive or authority needed on their own. This contrasts with industry and large employers where a single set of decision-makers can look at what they want to achieve, the cost-effectiveness of their current arrangements and whether there is a case for investing in technology to enable things to be done differently. That said, COVID-19 has brought a disruptive shock to the 'super-stable system', as recognised in the statement quoted earlier from Simon Lebus, the Ofqual Chief Regulator, referencing a potential washback into assessment.

POSSIBLE APPROACHES TO MAKING PROGRESS

This raises the question of what more might be done to open up opportunities to at least test out more transformative applications of technology for assessing technical education. The following are some initial ideas.

Leadership

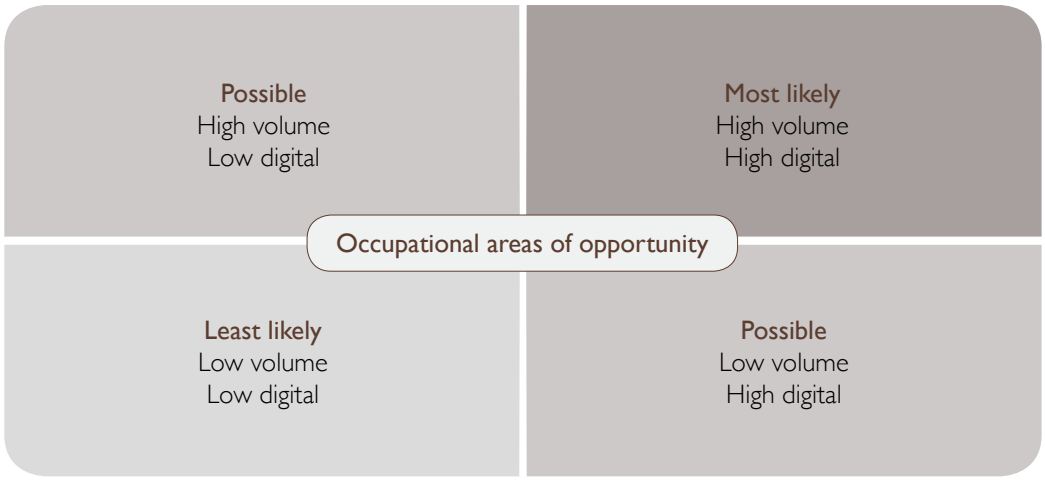
There needs to be more concerted system leadership. Leaving it to the market with individual Awarding Organisations responding to a hands-off regulatory framework is unlikely to work. The competition initiated by Ofqual on using AI to support marking, albeit now paused, is an example of what could be done.

Developments in Wales also offer an interesting point of comparison. Qualifications Wales combines a reform function with its regulatory remit, whereas in England that sits separately with DfE. Following their sector reviews of Digital Technology and of Construction and the Built Environment they have taken a lead on commissioning reformed qualifications which are to become available either from September 2021 or September 2022. These include mandatory on-screen assessments, and some of the practical tasks for Digital Technology will be assessed using raw product files in Adobe or Gamemaker Studio 2 format without any exams. This has involved WJEC, as the awarding body, with approval from Qualifications Wales, stipulating software to be used for comparable practical tasks. The Welsh Government and Qualifications Wales have negotiated licensing arrangements on a national basis with Adobe (for the Creative Cloud suite) and YoYo Games' Gamemaker to ensure the necessary access.

In England, DfE and Ofqual could consider where they might take a more proactive stance when reflecting on the longer-term implications of the pandemic for assessment.

Promising occupational areas for change

Occupational areas could be identified which are most promising for change. Two key considerations are likely to be the scale to justify investment and the extent to which the occupation is digitalised. Thus, as a starting point it would make sense to look at the top right-hand quadrant of the matrix below.



Further secondary considerations might include the following.

Specificity and uniformity of role
Technological approaches are likely to be more practical and cost-effective where the skills required are relatively narrow and specific, though these may require high levels of technical expertise – for example a sophisticated simulator can assess a wide range of what an aeroplane pilot or train driver does.

High stakes
With academic qualifications such as A-levels their perceived high stakes are often cited as an inhibitor of change and innovation with the concern to maintain standards over time and not risk disadvantaging individual young people. By contrast, in industry, it seems that it is where the stakes are high, whether financially or in terms of safety, that there is the greatest incentive to innovate with technology to ensure assessment is valid and reliable.

Cost differentials
Using industry-standard equipment for assessment can be prohibitively expensive, particularly if it needs to be accessible to all students. Areas could be focused on where there is a significant cost differential between using real equipment and what can be achieved through digitally simulated assessment.

Newness
It may be easier to design an assessment process from scratch where new qualifications and standards are being developed, particularly where technology is changing and creating new occupations.

Industry impetus
Employers need to be at the forefront, recognising where there are shortcomings in conventional assessment approaches for their industry and willing to contribute their expertise to exploring technological solutions.

Cross-cutting competencies
Another approach, particularly as an alternative way of achieving scale, could be to look at the assessment of cross-cutting competences which underpin multiple occupations. This might mean a technology-based assessment that could count towards a wide range of individual occupational qualifications or where the underlying technology could be adapted or 'skinned' for a variety of working environments.

Integration with training and practice
It is not necessarily helpful to think of technology for assessment separately from that which supports teaching, learning and purposeful practice. To do so risks replicating the inefficiencies of a conventional 'stop and test' model. If assessment capability can be built in as an integral part of technology used for training and practice (as for example is the case with an intelligent AI-based tutoring system like IBM's Watson Tutor which tracks topic mastery), there is likely to be a much stronger business case.

Repurposing existing technology
Technology could be brought in from industry or gaming rather than developed from scratch. As industry itself becomes more digitalised, there may be opportunities to adapt digital assets and systems that have been developed primarily for production and service purposes so they can be used in an

assessment mode, whether in a training environment or the actual workplace. There are also likely to be opportunities to use and adapt games that have been developed primarily for entertainment purposes. So rather than attempting to develop new games to assess specific competencies, without having the huge budgets available to the entertainment games industry, it may be more practical to look at how existing games develop and assess competencies almost as a by-product, particularly cross-cutting competencies such as problem-solving and team-working. Developments like Minecraft Education and Enginuity's Skills Miner, which uses Minecraft to assess competencies for a career in engineering, give pointers for what could be possible.

Building a research base

Doing more to strengthen the evidence base for assessment of technical education is not an easy solution, but it could help create a more conducive context for technological innovation. As well as evaluating use of technology, this might include more research on the limitations of conventional methods, for example the extent to which approaches relying on documenting evidence may demotivate and disadvantage people who are more practical than academic.

SUMMARY

The challenges and barriers to introducing more transformative uses of technology are considerable, though not primarily about the technology itself. The disruption of COVID-19 has given rise to a renewed willingness to reflect on how things could be done differently. For more progress to made, it is suggested that more proactive system leadership and encouragement will be needed. It could also be helpful to identify the most likely areas where new approaches could be tested out, to bring across and adapt technology from industry, and to build a stronger research base.

CONCLUSION AND RECOMMENDATIONS

The potential exists for more transformative use of technology which could help address some of the fundamental challenges and issues associated with assessing technical education, particularly associated with practical skills and the application of knowledge and understanding. However, there has been limited progress so far and, particularly in the centrally-funded and regulated sphere of technical and vocational qualifications, there are significant barriers to be overcome. To move forward, there needs to be more proactive system leadership and encouragement, and more targeted development and experimentation working with employers in areas offering the greatest opportunity. The recent experience of the pandemic has amplified the case for change.

RECOMMENDATIONS

This report makes four recommendations, three of which are specific to e-assessment and one which could support the broader development of EdTech.

Specific to e-assessment in technical education

1 A clear and co-ordinated policy commitment should be made by the main bodies regulating the assessment of technical education in England – DfE, Ofqual, IfATE, OfS and AOs – to work with employers to encourage and explore greater and more transformative use of digital technology for assessment, reflecting the widespread digitalisation of the workplace. Given its leadership responsibility for the system as a whole in England, this should be led by DfE.

2 Further work should be undertaken to identify occupational areas of greatest opportunity to test out new and transformative approaches to using digital technology for assessment. This should build on the analysis presented in this report and could include developing case studies with employers where performance monitoring and data collection in the workplace could be adapted for assessment purposes. The Gatsby Foundation is ready to support such further work, in partnership with IfATE, employers and other key interests.

3 A competition should be run, focused on the occupational areas where greatest opportunity for digital transformation of assessment has been identified, seeking proposals that could be supported as demonstration projects. DfE, alongside other Government bodies, AOs and interested parties such as JISC and the University for Industry Trust (UfI) should consider how such a competition could be organised and evaluated.

Broader development of edtech

Discussions around this report have raised the question whether there is now a case for some form of Catapult or accelerator-type organisation focused on bringing together research and innovation in EdTech more broadly. It can be argued that the limited progress with use of technology for technical assessment is illustrative of a much wider issue, which the impact of the pandemic has brought into sharper focus.

4 Innovate UK should be asked by DfE and BEIS to review the research and innovation landscape around EdTech with a view to assessing the case for an EdTech Catapult or similar mechanism.

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KEY CONTACTS

Rob Arntsen – MyKnowledgeMap
Gavin Busuttil-Reynaud – E-Assessment Association/AlphaPlus Consultancy Ltd
Jeremy Carter – Advance EdTech
Rebecca Conway – Federation of Awarding Bodies
Paddy Craven – City & Guilds
Wendy Edie – eCom Scotland
Claire Gill – Ofqual
Jake Habgood – Sheffield Hallam University
Bob Harrison – University of Wolverhampton
Guido Helmerhorst – Warp VR
Jane Hickie - AELP
Graham Hudson – E-assessment Association
Rose Luckin – UCL Knowledge Lab
Rob Nitsch - IfATE
David Patterson – Learning Light
Neil Robertson – National Skills Academy for Rail
Venkat Sastry – Cranfield University/Conference Chair e-Assessment in Practice
Dean Seabrook – Qualifications Wales
Darren Shaw - IfATE
Linda Steedman – eCom Scotland
Nick Stephenson– xApiApps

The Gatsby Charitable Foundation
The Peak, 5 Wilton Road, London SW1V 1AP
T +44 (0)20 7410 0330 www.gatsby.org.uk
Registered Charity number 251988

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