“Solving the Puzzle of Secure Digital Certification with Blockchain”

The My Skills project is investigating how to move the certification of vocational education forwards from its current paper-based model to a system that also uses official digital certificates in a reliable, trusted and verifiable manner, operating at a national scale over the long-term.

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Design Decision 7 – Use identity verification services and biometric data to verify individual identity

Users tend to identify with their learning provider

Verification of User Identity is the Key

Design Decision 6 – Using the Existing Paper Certificate Replacement Processes as the basis for a Digital Certificate Service

Verification of User Identity is the Key

Users tend to identify with their learning provider

Design decision 7 – Use identity verification services and biometric data to verify individual identity

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Introduction to the White Paper
This ‘White Paper’ discusses and describes how the transition to using digital certificates in education might be achieved. This will provide the basis for the creation a shorter generic model that provides a roadmap for organisations contemplating adopting digital certificates.

These notes in the form of a document / website are intended to record and show the development of our thinking as we work towards a final version of the White Paper and model. We think it is important to show our background ‘workings’ in developing any proposed model and hope this might be as useful as the model itself. The final generic model itself is intended to be capable of working with any combination of technology platforms or service providers. In this project we are working with two different technology platforms and service providers (APPII & Google), whose assistance we gratefully acknowledge.

The broad aims of the My Skills project are to identify, analyse and evaluate the issues involved in these two areas

1. Adopting digital certificates of learning (especially vocational learning) and how they might help employers and workers.

2. How the use of a digital e-portfolio system that is learner owned and contains the actual evidence of the learning and skills might be combined with digital certificates and what benefits that may provide.

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To fulfil these aims the project is been creating two outputs that are intended to act as a catalyst for generating interest, policy discussion and provide a co-development model for the adoption of digital certificates (aka credentialing). These outputs are:

1. A ‘White Paper’ (this document) that identifies, discusses and evaluates some of the issues involved, possible solutions and the types of services and benefits for learners and employers that may be developed. The White Paper is intended as a kind of ‘visualisation prototype’.

2. A generic model of digital certification to be used and adapted by other awarding bodies throughout the rest of the UK. The generic model will be a simple framework for adopters to consider when devising their own solutions.

**Approach to Creating the White Paper**

You can find out more about our approach to this work in Appendix 1. Broadly speaking, this project is a form of [action research][1] where the partners have come together to solve a particular problem. As the tagline of the project states, we are involved in:

“Solving the Puzzle of Secure Digital Certification with Blockchain”

It is worth stating at the start that we do not regard this project task as being primarily a technical problem, although we are using two advanced technical platforms. The really tricky and difficult work is in understanding and facilitating the cultural and organisational change involved to make good use of the technology. The head of Google puts it nicely:

"Technology alone will not improve education, but it can be a powerful part of the solution."  
Sundar Pichai, CEO, Google

The style of writing in this White Paper is not intended as an academic text, although our work and approach is informed by academic research, it is more informal and direct in style. We make extensive use of web links in the text to provide sources of further information for the reader. The web links are listed under their section headings in the References section at the end of the White Paper. We use a referencing system based (very loosely) on that of the [IEEE][2].

**Audience for the White Paper**

Our audience is anyone who is interested in the topic of using digital certificates to recognise learning achievements and outcomes, no prior technical or educational knowledge is assumed. Inevitably there are some specialist terms used and we provide a glossary to explain the main ones, we also make use of web links in the text to provide further information for the reader. We believe by providing an explanation of the issues involved and the potential solutions to a general audience we will make the work of the project more widely useful. The reader is strongly advised to read through the glossary where important terms are explained to provide orientation for what we discuss later.

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[1]: action research
[2]: IEEE

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White Paper Creation Process
Borrowed from the world of Art and Design, our process has been an iterative series of ‘working sketches’ of the White Paper as it proceeds, it is similar to the idea of rapid prototypes in agile software design. This is our first public ‘sketch’.

What is the White Paper?
When we started out on this journey into digital certification and verification of learning we knew that we needed to produce something that would explain what this was and how it could work. We also knew that this was going to be tricky because (unlike paper certificates) a lot more things have to work smoothly together to issue, manage and maintain digital certificates in the long term. In a way this represents the wider challenges to the adoption of technology in education – to get the benefits, more work has to be put in at the early stages.

What will the White Paper Cover?
It will certainly cover technical issues like blockchain technology. But it will also be covering the legal and privacy issues and the ‘soft’ issues like personal attitudes and organisational working cultures.

Our task has been to identify and map the relevant issues and to see how they interact. To do this the project partners have been organising a series of workshops and online discussions. As we proceeded, the second task was to try and imagine solutions to how potential problems can be solved and ‘talk them through’ until we think we had agreement and then include them in the White Paper as ‘Design Decisions’.

Executive Summary
The My Skills project has been exploring how to move the certification of vocational education from its current paper-based model to a system that also uses official digital certificates in a reliable, trusted and verifiable manner, and at scale. The current system causes a great deal of friction in the modern vocational employment sector, with paper certificates being repeatedly required for inspection, with little accompanying information about the actual learning involved. This document (The White Paper) discusses the issues involved in making the transition from paper to digital and presents a rationale for the Key Findings and Recommendations that are presented here. We propose a service that uses blockchain technologies and discuss how this might be implemented. For those new to blockchain we refer the reader to an excellent American report on the subject [1] from the National Institute of Standards and Technology. For our purposes we can regard it as an online shared database that uses encryption technology that makes alteration of the content extremely difficult, if not impossible. Thus, promoting trust in the content of the database.

We believe that enabling learners to possess official digital certificates of their own educational qualifications and linking them to their own personal digital evidence of learning can help transform vocational education, employment processes and individual career opportunities.

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Key Findings

Current Situation
Given the fact that the UK is one of the most intensely digital economies in the world, it is at first sight surprising that education and training still relies so heavily on paper certificates. This does make the process of applying for jobs and assessing prospective employees more arduous, time consuming and expensive than it ought to be. This problem is magnified in the modern workplace with increasing regulatory requirements on employers to undertake right to work and background checks as well as checking candidates claims about their qualifications. Another challenge is the increased mobility of labour and the rise of contract working with people working in multiple organisations every year.

Yet it is still common at job interviews to have to bring paper copies of educational certificates and a passport or driving licence to an interview and have them copied by the HR department to be kept on file. Then if you are offered a job you may be required to provide a background check certificate (basic) or the employer will have to obtain their own detailed check certificate in certain jobs.

Hype
In the process of reviewing the potential of a service based on Blockchain technology to help address the issues noted above the project has encountered the phenomenon of ‘hype’. Two government reports (USA & Scottish [1]) into the potential uses of blockchain cite the intense levels of hype [2] surrounding the subject as a factor in making it difficult to find useful information on which to make rational analysis and decisions. In the White Paper we discuss the phenomenon of hype in this context and that of the IT and EdTech industry in general. The hype surrounding both sectors make it doubly difficult when discussing the educational applications of blockchain. The IT industry itself acknowledges the use of hype as a competitive marketing and disinformation tool - Gartner Hype Cycle [3]. At the moment (early 2019) there is a growing negativity about using blockchain amongst some commentators as they head from the peak of early excitement to the so called 'Trough of Disillusionment' in the Hype Cycle. See the illustration below:

Fig. 1 Gartner Research’s Hype Cycle diagram
Image Credits: Jeremykemp at English Wikipedia. License CC BY-SA 3.0

Technical: Blockchain
Blockchain is not absolutely essential to issuing and managing digital certificates, but we think it has distinct advantages that are worth investigating. Our project is on 'The Slope of
Enlightenment’ in the Gartner Hype Cycle and we discuss blockchain throughout the White Paper. The kind of data and operations that we are envisaging are relatively simple and security is critical. So, the kind of blockchain we are looking at is private and permissioned – not distributed and public, as in cryptocurrencies like bitcoin, which has dominated thinking in this area. Also, there is no mining or minting of coins involved in writing to our blockchain.

### Proposed System: Diagram

![Diagram](https://myskills.org.uk/)

**Fig. 2 Proposed Digital Certificate System**

Fig. 2 shows the proposed system in action combining a digital certificate service provider and a portfolio service to empower learners and transform the vocational employment landscape.

### Technical: Simple Data

From a technical point of view the essential data contained in a typical paper certificate is very simple:

<table>
<thead>
<tr>
<th>Name*</th>
<th>Subject Qualification*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Only the first three data fields appear on all certificates.</td>
<td></td>
</tr>
<tr>
<td>Awarding Body*</td>
<td></td>
</tr>
<tr>
<td>Unique reference number</td>
<td></td>
</tr>
<tr>
<td>Date of Birth</td>
<td></td>
</tr>
<tr>
<td>Other Information...</td>
<td></td>
</tr>
</tbody>
</table>

**Table 1 Typical Paper Certificate Data**

Note: The potential to include ‘other’ information in a digital certificate is considerable an example of this being developed in digital form is the EU Europass system see [https://europass.cedefop.europa.eu/about-europass](https://europass.cedefop.europa.eu/about-europass)

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Cultural: The Role of Certificates
From a socio-economic point of view the possession of a paper certificate by a learner is a tangible piece of evidence that allows the owner to assert that they have attained and ‘own’ the qualification named on the certificate. In this sense, it is like a paper currency bank note or an aircraft boarding pass – it is a token of trust that allows the user to do something. In both cases (paper currency and boarding passes) the user’s assertion is backed up by an organisation that will validate their claim if required, although that rarely happens in practice.

Cultural: Users
In our view the rationale for adopting digital certificates is not a pressing lack of trust in the existing paper certificate system, although that is a factor for some commentators. We discuss the constituent components of the educational trust relationship in the White Paper. Rather, the motivation for adopting digital certificates is in the benefits and convenience that this may bring to users and organisations. Again, the comparison with paper bank notes and boarding passes is useful – in both cases we see their gradual replacement with digital versions and acceptance by users in shops and airports for the convenience and benefits they bring.

Technical: Awarding Bodies
So, on the face of it, the technical barriers to implementing digital certificates are small, given that the awarding bodies already have the data required in their possession. But a digital certificate requires a very different user infrastructure to a paper certificate system, paper is much simpler to maintain. A digital certificate is of no use unless it can be managed by a user who can choose who they share it with and how it is presented in connection with job seeking, networking and career progression. It also needs to be able to be verified digitally by the awarding body in a trustworthy way that gains acceptance by users and employers.

Organisational: Use of Third-Party Digital Certificate Suppliers
So, awarding bodies have the data but not the means (at the moment) to publish and support their own digital certificates. To supply this facility a third-party supplier is required. An early example of an awarding body experimenting with this approach is City and Guilds [4], whose DigitalMe [5] service is working with Credly [6] an Open Badge [7] service provider. In our project we are collaborating with a blockchain digital certificate service provider, APPII [8]. Open badges technology solutions have been around for a while, originally backed by the Silicon Valley non-profit Mozilla [9] foundation, their main use has been for certifying ‘informal learning’ in community settings, not mainstream qualifications, and to date there has been a resistance to using them for such purposes. We discuss the differences between badges and blockchain certificates in the White Paper Appendix 2.

Cultural Change: Awarding Bodies
Moving to digital certificates presents a business and cultural change challenge for the awarding bodies. This operates in a number of related dimensions:

- Current processes are paper-based; needs a clear business rationale for change
The paying customers of awarding bodies are learning providers not learners

- Internal process and data management may need to change
- Replacement paper certificates represents an income stream
- Core business data needs to be shared with third-party service providers
- Regulatory and policy concerns
- Fear of reputational damage (blockchain hype and misinformation, GDPR, negative media reports, etc.), possibly leading to a risk averse environment

Note: We are not proposing to replace paper certificates, although that may happen in the longer term. There is a cultural significance to the paper version that is important to learners. We would advocate an ultimate situation where digital certificates are issued automatically to complement the paper system.

Sustainability
Existing paper certificate systems have to exist over periods of several decades and support the verification of user’s qualifications and the replacement of certificates in the long-term. A digital system might reasonably be expected to replicate these characteristics. This represents a challenge in terms of governance and continuity of service if using a third-party digital certificate supplier. However, as long as the awarding body controls its own data and has the right governance arrangements in place it should be able switch suppliers and maintain a service to users.

Policy & Regulatory Environment
The policy environment has become more positive lately, the American and Scottish government reports cited earlier acknowledge that blockchain technologies are mature and should be investigated and pilot projects initiated. The UK government is currently conducting trials in several areas to evaluate the technology. The main regulatory and legal concern is privacy and the related EU GDPR regulations, we discuss this in the White Paper.

Feasibility
For some awarding bodies, providing digital certificates to learners may represent a big conceptual and process change from their current practice. It is not an overly complex technical challenge. The real difficulties lie in the cultural change across the education system with all its various regulatory and process links and finding a business rationale and motivation for making the change and offering something new to users. A fundamental business issue is that (in general) the paying customers of an awarding body are the learning providers not the learners. However, providing digital certificates may be an opportunity to redraw the relationship between learners, learning providers and awarding bodies.
Digital Certificate Process Model

In our workshops and discussions, we have come to the conclusion that the process of issuing a digital certificate can be effectively based on existing procedures for issuing a replacement paper certificate – see the diagrams below. In both cases, the key issue is the user needs to be able to effectively verify their personal identity and provide enough information about the qualification they are claiming for the awarding body to make a match with its records.

![Fig. 3a Paper Certificate Process](image)

![Fig 3b Digital Certificate Process](image)

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Fig. 3a & 3b: Comparing the process for issuing a replacement paper certificate to a request for a digital certificate.

**A Blockchain based T Level?**

T Levels are a new UK vocational qualification. A blockchain based certificate could easily contain this information. By its nature (being digital) it also lends itself to being extensible and can accommodate data at different levels – so supporting micro credentials (describing the component parts of a qualification). In addition, the user (learner) could also control what elements of their T Level they would like to share via an online platform like APPII that provides granular control over what the user chooses to share and a customisable CV builder. However, it does not stop there. In addition to the trust and flexibility that a blockchain T Level digital certificate would provide there are two further potential advantages:

1. The ability to include evidence of learning (images, reports, videos) in the blockchain that are certified as true by the learning provider
2. The ability for the learner to maintain their own personal digital portfolio of learning

With these two features (Digital Certificates and Evidence from a Portfolio) the T Levels could be given a rich and powerful platform to benefit learners and employers. See Appendix 5 for a more information and discussion about T Levels and blockchain.

**Unexpected Outcomes**

**Assessment Evidence in the Blockchain:** Any digital artefact can be put in a blockchain, it is just an encryption technology after all. It is quite possible to include the evidence of learning and assessment in a blockchain. This may or may not be available to the users but could be accessed by those involved in quality control and monitoring functions. This is important as all the awarding bodies have quality control measures in place to monitor the standards of delivery and assessment by their learning providers. This usually involves external inspections and verification of the evidence and assessment records held by the learning providers. Being able to collect this information would enable the comparison of standards and procedures between learning providers. This would also be useful as a source of primary research data by educational researchers and for regulatory agencies enquiries. Please see the White Paper section below called ‘Unexpected Outcomes and Possibilities’ where we discuss these issues further in a sub-section called ‘Assessment Evidence Recorded in Blockchain – Some Implications’.

**Administrative information in the Blockchain – Some Implications:** Our discussions about storing assessment evidence in the blockchain also led onto other uses for this technology. Blockchain could be used to remove internal data silos and duplication within learning providers by providing a single shared database and could result in major efficiency gains - making access to verified secure information far easier than at present. Such a service might provide part of a future business model for the deployment of blockchain technologies in education that support certification. This would be worth investigating in future pilot projects.

**Micro Credentials in the Blockchain:** There is unlimited space in the blockchain to record the finer details about a qualification to give employers and others a more detailed picture.
of what skills and knowledge the learners have acquired. So, each component of a course can have its own mini certificate. In addition, it would be possible for the learner to link each micro credential to their own personal portfolio of learning evidence; all under the granular sharing control of the user. This could be useful to part-time learners to present to employers even before they have completed the overall course.

**Identity Verification Services:** Another unexpected outcome from the project for College participants is a new awareness of the central importance of the existence of identity verification services that commercial bodies and the UK government both use and contribute to and rely on in order to provide an important part of the ‘back office’ to the digital economy. They help prove an individual really is who they claim to be.

This was unexpected / unknown by our participants and understanding that these services exist and how they function can allay concerns about being asked to provide personal and biometric data to identify a user in the APPII system. As the whole digital certificate proposition revolves around the verification of an individual’s identity, it is important for these aspects of the system to be explained to users. You can find more information about this topic in the White Paper glossary. Below is a diagram and text box representing the relationship between the Digital Certificate Service provider (APPII) and the Identity Verification Service that it uses. We used this to explain the process to lecturers and students in the project:

**APPII User Sign Up Process: Digital identity & Security Details:**

- User takes picture of their Photo ID: Photo ID text is scanned and ‘read’ and entered into APPII database. Photo ID Facial image is scanned and stored in APPII database
- User takes ‘Selfie’, this is scanned and stored in the APPII database
- All this data is then used by an Identity Verification (IV) Service to check if the user data provided matches official records
- APPII Account Created

*Identity Verification (IV) Services* are used all the time by online shopping and banking services – but are invisible to most users

The UK Government also uses selected identity verification services to share its own data with – see this [GOV.UK link](https://www.gov.uk)

Your personal data is safe with APPII it is fully compliant with the strictest data and privacy protection law such as the [GDPR](https://gdpr.eu)
Digital Certificates as Change Agents: Educational systems are resistant to change in general and expectations of technology-led change have not met expectations. There are two sensitive areas in education that can influence the rest of the system, these are summative assessment and certification; these provide a reason for the existence of the system in many ways. Making changes here by adopting technology has the potential to influence change in the rest of the educational system.

Unique Identifiers: Each awarding body uses its own internal system of unique identifiers to manage learners. In addition, there are also a number of national identifier schemes that are used to gather information about learners. The possession of a unique identifier by a user is not enough on its own to verify the individual’s identity but can be a very useful part of the process in matching the individual to the certificate. It is worth considering including the use of the learners National Insurance Number in such systems (they are issued to users at 16) or some other genuinely common national identifier scheme.

Digital Certificates Exist in More than One Location: Unlike paper, digital certificates can exist in different location at the same time. This simple fact may lead to unanticipated benefits and should be explored in projects.

Recommendations
The adoption of digital certificates for educational qualifications seems inevitable, it is a case of when, how and - of course - why? Combined with personal digital portfolios of learning evidence and experience they could provide a better way of matching candidates with jobs and lead to other benefits in terms of lifelong learning. It will involve change for both awarding bodies, learning providers and learners from existing paper-based practices and the development of new business models that rely on leveraging the minimal cost of providing modern cloud-based information services to create a useful product. In our project we are working with two technical platforms that do this to provide innovative and useful services to their end users but charges them nothing – monetization comes elsewhere:

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Google G Suite provides an educational platform for education. They gain future customers for the consumer version of its products when the learners graduate.

APPII does not charge awarding bodies, learning providers or learners for its service. It generates a revenue stream by providing services to employment agencies and employee checks.

A Scottish government report makes the observation that smaller countries can be more nimble in adopting digital technologies in their public services and recommends the development of pilot projects to explore the benefits in real practical settings.

In Scotland The SQA [1] is an awarding body and also a regulator for other awarding bodies operating in Scotland, in England, the awarding bodies need to meet regulatory requirements of OfQual. In addition, for their awards to attract public funding (which many awarding bodies see as desirable) the awarding bodies will have to meet the funding requirements of the relevant funding agency in terms of qualifications design and reporting. Clearly, a push from the qualifications regulators or the funding agencies, but ideally both, on digital certification, could unlock the bottleneck – so pilot projects that involved all parties would be ideal / essential.

The independent nature of awarding bodies and competition between them means each are likely to follow their own path in this area. One motivation for change is working with a service provider like APPII as a marketing tool to make its qualifications more relevant and useful to prospective learners and employers. For a discussion of the implications of doing this please see the section ‘Design Decision 5’ below. This in turn implies a changing (closer) relationship between awarding bodies and learners than the current one. Another factor in this future scenario is how the learning provider fits into this picture. We know that many learners tend to identify with their learning provider (FE) rather than their awarding body. A digital certificate service that includes the name of the learning provider can also be an important publicity and branding tool for the provider with industry and potentially a communication channel with its own alumni.

A new technology may disrupt existing roles, relationships and ways of working if it is used in a way that really adds value. As that is true here too, the potential for any new approach to be successful will in part depend on the willingness of each player in the education/certification system to engage in work in this space aware of this fact and willing in principle to redraw existing lines if that proves necessary. To this end, a set of pilot projects would be very useful and should involve learning providers and industry and employer representatives as well. It would also make a great deal of sense to have collaborative pilot projects including different awarding bodies who could learn from each other and mutually benefit.

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My Skills Project Overview

The My Skills project (https://myskills.org.uk/) has been funded by the Ufi charitable trust to investigate how to move the certification of vocational education forwards from its current paper-based model to a system that can also use official digital certificates in a reliable, trusted and verifiable manner, operating at a national scale over the long-term.

The project has two complementary parts:

- The technical ‘head’ of the project is about investigating how organisations can use blockchain technologies to administer official digital certificates that recognise learning achievements. You can find more information about blockchain in the Glossary and Appendix 2.
- The social ‘heart’ of the project seeks to understand how the individuals, groups and organisations involved in the current paper certificate process use and relate to paper certificates and how this might work in the digital space.

Aims

The project aims are to identify, analyse and evaluate the issues involved in two areas:

1. Adopting digital certificates of learning (especially vocational learning) and how they might help employers and workers.

2. How the use of a digital e-portfolio system that is learner owned and contains the actual evidence of the learning and skills might be combined with digital certificates and what benefits that may provide.

Objectives

To fulfil these aims the project has been creating two outputs that are intended to act as a catalyst for generating interest, policy discussion and provide a co-development model for the adoption of digital certificates (aka credentialing). These outputs are:

1. A ‘White Paper’ (this document) that identifies, discusses and evaluates some of the issues involved, possible solutions and the types of services and benefits for learners and employers that may be developed. The White Paper is intended as a kind of ‘visualisation prototype’.

2. Create a generic model of digital certification to be used and adapted by other awarding bodies throughout the rest of the UK. The generic model will be a simple framework for adopters to consider when devising their own solutions.

Educational Terminology and Glossary

Before we go any further it will be useful to provide and define a list of terms commonly used in relation to the certification of learning to provide a common baseline for our discussions. It also illustrates the complex web of relationships involved in the delivery and governance of education in the UK.
Awarding Body
An organisation that develops qualifications and maintains the quality of those qualifications and issues certificates to learners as proof that their learning has achieved certain standards. Here is a more detailed definition of an Awarding Body:

“an organisation that designs, develops, delivers and awards the recognition of learning outcomes (knowledge, skills and/or competences) of an individual following an assessment and quality assurance process that is valued by employers, learners or stakeholders.”

http://www.awarding.org.uk/about-us/about-awarding-bodies

There are many awarding bodies in the UK providing a wide range of vocational qualifications and the FAB (Federation of Awarding Bodies) [1] provides a useful listing, http://www.awarding.org.uk/about-us/full-members, note; sometimes the term ‘Awarding Organisation’ (AO) is also used.

Learning Provider
An organisation that provides learning or training services to individuals or organisations. Many providers, such as FE (Further Education) colleges and training companies provide courses of learning specifically to help learners gain a qualification issued by an awarding body. Some providers are also awarding bodies in their own right and design, develop and deliver their own qualifications – universities are an example.

Regulatory Agency
Awarding bodies for vocational education are overseen by government regulatory agencies to maintain quality and their compliance with legal obligations, e.g. Ofqual [2] in England.

Learning providers are also overseen by a range of government regulatory agencies including:

- Universities are regulated by the Quality Assurance Agency for Higher Education (QAA) [6] and UK national funding councils, such as the English Office for Students [7] and the Scottish Funding Council [8].

Evidence
The evidence used to prove that a learner has reached intended learning outcomes such as knowledge, skills, and competence. This may take many forms: Sitting an exam and completing exam ‘papers’ is still very common. Observation and practical tests are often used in vocational education. Online tests and exams are increasingly being used. All these produce data that constitute evidence of learning.

Assessment
Assessment is used to analyse, inform, grade and certify learning. Different criteria, methods and instruments of assessment are used according to the subject being studied and the context of learning and assessment. In relation to this project, we are primarily interested in
a certain kind of assessment called ‘summative assessment’, this summarises the overall learning that has been achieved in order to award a qualification

**Qualification**
An official record showing that a learner has achieved a defined level of learning. The qualification is given to an individual by an awarding body. The awarding body maintains records of who has gained what qualifications, when the qualification was awarded and with what learning provider the learner studied with to gain the qualification. This information forms the basis for granting an individual a certificate that certifies they have reached a certain standard of learning that is recorded in the qualification.

**Certificate**
A certificate is an official document (usually paper) that signifies that the person named as the holder of the certificate has gained a qualification. There is considerable social and cultural importance attached to physical tangible certificates of learning, for instance some people like to display them on their office walls. Interestingly, MOOCs [9] such as the UK’s FutureLearn [10] also offer optional paper certificates [11] of achievement in addition to digital versions.

**Verification (of individuals and their qualifications)**
In general terms verification means the process or act that proves that an assertion about someone or something, is true or correct. In our project context we are interested in two particular types of verification of an assertion:

- That an individual is really who they say they are
- That the same individual has a right to say they have a certain qualification

**Credential**
This term is sometimes used instead of qualification or certificate. It is also used by technical specialists in the context of verifying personal identity in IT systems, especially in the use of blockchain. It is not a term that is commonly used by our target users, so we use the term ‘certificate’ to indicate the certification of learning and possession of a related qualification.

**Technical Terminology and Glossary**

**Blockchain**
The Wikipedia entry on blockchain provides a good explanation. A recent US government report from the National Institute of Standards and Technology entitled ‘Blockchain Technology Overview’ is also very clear – important considering the amount of hype surrounding the subject. For our purposes we can regard it as an online shared database that uses encryption technology that makes alteration of the content extremely difficult, if not impossible. Thus, promoting trust in the content of the database. Some blockchains are public and some are private. In this project we are investigating the use of a private blockchain where an awarding body can record the qualifications it has issued. Each learner controls access to their personal qualification record in the blockchain by the use of public and private ‘digital keys’ [1]. In this way a learner can choose whom to share their digital certificate of learning with and a recipient of a digital certificate can trust the authenticity of
the assertion by the learner of their qualification because the certificate links back to an official online record. See the section called ‘Design Decision 2’ for more information about our use of blockchain.

**Public Key / Private Key**
These ‘digital keys’ are way of encrypting and controlling access to information so that the user has a form of digital signature [2] they can use when sending their blockchain information to third parties that proves that the information came from them. In this way the information about a user’s qualification that a third party gets access to in the blockchain is trusted because:

- The identity of the sender is verified
- It is officially connected to the awarding body of the qualification
- It provides details that match the senders ID
- The qualification content is known to be difficult / impossible to falsify

**Biometric ID**
This is a way of measuring and recording the physical features of an individual, facial scans, fingerprints etc. to help identify an individual. An example is the facial image on a driving licence.

**Identity Verification Service**
This statement [3] from Wikipedia describes what these services are:

> “An identity verification service is used by businesses to ensure that users or customers provide information that is associated with the identity of a real person. The service may verify the authenticity of physical identity documents such as a driver license or passport, called documentary verification, or may verify identity information against authoritative sources such as a credit bureau or government data, called non-documentary verification.”

These services are already extensively used as ‘back office’ functions of the digital economy – think of the facial / fingerprint scans as you go through an airport security system, these are connected to these kinds of service. This UK government web page [4] gives a good overview off what these services do, and what kind of private sector organisations are involved and how they interact with government and private sector personal information records.

**The Current Situation: Paper Certificates in a Digital Economy**
Currently the great majority of all education and training provision in the UK certifies the achievement of learning outcomes using paper certificates. There has also been rapid increase in the need to scrutinise and verify the documentation of job applicants for a number of reasons. So, if you apply for a job in the UK in 2019 there is a high probability that you will be asked to provide documentary proof of your qualifications - in paper form – where they will be examined and even copied by the HR Dept of your prospective employer. You will also be asked to produce proof of your right to work in the UK – for instance by presenting your birth certificate or passport. In some jobs you will also be asked to present a
background and criminal records check document that proves you are not barred from working in certain kinds of jobs.

This whole process slows things down, can cost a lot of money and create a lot of stress for both employers and job seekers. This can be particularly problematic for contract workers and the self-employed who need to work with multiple organisations in a single year. It has been, correctly, described as a source of great friction in the UK labour market.

At first sight, the current situation is rather odd given that the UK is one the most digital economies in the world [1]. In fact, The UK spends more per household online than any other country [2] and online banking [3] has been with us for more than 2 decades. With so much of our daily lives being conducted online and digitally it seems strange at first sight that education is so wedded to paper. But if we look into this a bit further, we begin to see why this might be so. Education, like healthcare, is a complex ‘people business’ where issues of trust are critical, and ways of working have very deep roots.

But if we now return to our example of online shopping and banking with ‘new eyes’ we can see that these are relatively simple transactions (literally) between individuals and organisations where both parties have a clear reason and benefit for engaging in the transaction e.g. convenience and price for the customer and cost reduction for the supplier. In contrast, both education and health are much longer-term ‘transactions’ that are more complex and involve a range of different parties in a variety of relationships over time. To introduce technology solutions successfully into these kinds of environments needs an approach that takes account of these factors. In the past, expensive tech projects in both these sectors have come badly unstuck by not taking this approach. Please see the section entitled Design Decision 5 and Appendix 1 for more information and a discussion of these issues. Design intensive disciplines (such as software engineering) are increasingly aware of these factors, which are more social, economic and political in nature than technical. A growing movement is to use participatory design methods to deliver solutions that work for all affected stakeholders – please see Appendix 1 for more information about this.

**Solution: What If…Technical**

If we look at the current situation, we can conduct a thought experiment. What if we had quick, easy and trusted ways of digitally certifying our personal:

- Qualifications
- Right to work in the UK
- Background and criminal records checks

We can go a little further and also imagine what if in addition to these digital certificate services each learner / job applicant had access to their own personal digital portfolio of evidence of their learning achievements that they could use to back up their job applications and embed this information in their use of online platforms to support their professional identities and network with colleagues.

To help explore these potential solutions we are working with two technology platform providers:

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APPII [https://appii.io/] A project partner and company specialising in providing verification services for qualifications and background checks for individuals and employers, using a secure blockchain technology. A growing list of services includes biometric identity confirmation. Access to trusted third party identity verification services and a ‘CV Builder’ that enables a user to easily construct a customised CV featuring digital certificates that verify qualifications and background checks.

Google G Suite for Education [https://edu.google.com] A service provided to educational institutions by Google. This contains a wide range of productivity tools; the basic version is free to use and features unlimited storage to users while in education. It also enables a learner to easily transfer their content into a private Google Account when they leave college. Thus, providing the basis of a flexible lifelong personal portfolio of learning achievements.

Solution: What If...Educational
In parallel to exploring the technical options the project is working with 3 educational partners to understand the policy, administrative and cultural aspects of adopting digital certificates, in tandem with using digital portfolios of learning.

The City of Glasgow College (the lead partner) is trialling the use of APPII and Google G Suite for Education with its staff and students. It is using this experience to feed into the creation of the White Paper. It is also using the project to develop its strategy for making better use of digital technologies to support quality learning experiences for its students.

The Scottish Qualifications Authority is an awarding body that provides many of the vocational qualifications studied in FE Colleges in Scotland. It is keen to update its systems to operate in the digital age and is providing the project access to how its current administrative processes operate in order to understand the kind of changes needed to adopt digital certificates.

EdTech Horizons Ltd. is an EdTech consultancy that is advising the project, it specialises in digital assessment techniques with a long experience in this field and has useful previous involvement in projects involving blockchain.

Developing the Design
These design notes are derived from our discussions, workshop sessions and feedback from users, this is an iterative process and not necessarily linear i.e. we will jump around a bit. Design Decisions [1] (in our case a mixture of requirements and constraints), Scenarios [2], User Stories [3], Personas [4] and Use Cases [5] are all techniques used to help the process of designing systems where people interact with technology to achieve their objectives. What follows here is a record of our developing understanding of what a generic system would need to be able to do to support users. We start the process by stating some basic design decisions, these in turn may be revised as we work through the issues.
Design Decision 1 – Individual Learners / Users as the focus of system design

The system has to work for and meet the needs of individual users - not just the awarding bodies and learning providers etc. So, the system has to be designed around the needs / perspectives of individual users – in relation to digital certificates of learning and their use in job seeking and online personal identity management. But we also need to consider the other parts of the system involved in producing and using data about the user.

User characteristics – top level

- Users will be learners (while they study) and earn qualifications
- Users will be job seekers who need to use their digital certificates as proof of learning
- Users will collect and share evidence of learning in their personal portfolios in the form of multiple media e.g. essays, reports, videos, images etc.
- Users may require verified information for purposes other than employment (e.g. purchasing goods and services)

System Consumers of User Data

The other parts of the (existing paper system) that consume the data about and produced by the user are:

- Awarding body (e.g. SQA)
- Learning provider
- Employer
- Other learning providers
- Government and public sector organisations

The digital system would also need to include these consumers of user data.

Design Decision 2 – Use Blockchain for storing and managing access to Certificates

For a description of blockchain please see the technical glossary and Appendix 2. The project has decided that this technology is mature enough to support this task because of these features:

- The blockchain is highly secure and cannot (easily) be falsified (important for trust)
- Data can be encrypted – good for protecting the personal data contained in educational qualifications
- Suitable for managed shared access – useful for an awarding body using a blockchain service provider
- Access can be controlled (private blockchain and digital keys)

The particular type of blockchain we are using is sometimes described as a private blockchain [6], meaning it is not publicly accessible – unlike many blockchains associated with cryptocurrencies. In addition it is also described as a permissioned blockchain [7] because the owners control who has access to the blockchain to read and write its data. The blockchain being used in the project is based on the open source Ethereum [8] system. In this application (digital certificates) it is not involved in minting a digital currency it is just
being used to record and encrypt data. So, there is no massive computational resources or electrical energy expenditure involved, as in the bitcoin blockchain.

In our White Paper the actors who have access to the data are:

- Awarding body (owner and read / write access)
- Blockchain service provider (read access)
- User (read access – only their own data)
- Employer and Colleagues and Friends etc. (read access to data chosen by users)

It is worth stressing here that use of blockchain technology is already well established (over 10 years) and what we are proposing is a very simple (almost basic) use of the technology. However, because of the association of the term blockchain with cryptocurrencies such as Bitcoin and the associated intense industry hype many people, including the technically informed, tend to assume every blockchain application has to be like that used in Bitcoin:

- Distributed
- Public
- Requires the ‘minting’ of a digital coin to write to the blockchain that in turn needs a lot of computation effort and consumes a lot of electrical energy

This is not the type of blockchain application the My Skills project is envisaging. In fact, it is almost the reverse of the Bitcoin blockchain:

- Distributed – but only to vetted participants
- Private
- No ‘minting’ of a digital coin to write to the blockchain is needed – so not much computational power needed

This IBM article[9] gives a nice overview of what a private blockchain is and its possible uses. So, a My Skills style blockchain application would be pretty simple record keeping exercise that uses the characteristics of the technology listed above to support issuing digital certificates.

**Do we have to use blockchain?**

No, is the short answer. It would be quite possible to do this with other existing database and web technologies. The attraction to using blockchain are those reasons described here and in the other parts of these notes. A blockchain is designed from the start for sharing information as opposed to existing systems that have to be combined together achieve the same outcome. It is also designed for long term storage and access – very important for qualification records over decades, and the data can be encrypted, and access controlled at a granular level.

**The importance of systemic issues in adopting Blockchain**

2019 is the tenth Anniversary of the birth of Bitcoin and its accompanying blockchain technology and the publishing of the Bitcoin white paper[10] by the mysterious Satoshi Nakamoto. To mark this anniversary a commentary to the White Paper has been published...
by Ignota Books [11], who have produced an interesting SoundCloud [12] discussion about blockchain that is worth listening to get an idea of the background to this innovation. In connection with the application of technologies like blockchain the commentary author Jaya Klara Brekke makes this insightful comment:

“If there’s one thing we should have learned by now,” Brekke says, it’s the importance of looking at “the relationships between pre-existing systems and what you’re introducing into the world.”

This chimes closely with the approach we are taking in this White Paper.

**Design Decision 3 – Awarding Bodies will need to use an external service provider for digital certificates**

This is a large sweeping generalisation, granted, but based on our experience so far this seems the most likely scenario. Apart from some of the very largest awarding bodies and perhaps a few large universities, it is unlikely in our opinion that most will have the internal capabilities to do so. In the larger Universities and some Colleges management may consider a DIY approach. Here, the role of central IT departments is central to these kinds of decisions. The introduction of such a service may require careful negotiation with the relevant internal stakeholders. There is a discussion of these factors in the section entitled Design Decision 5.

**Design Decision 4 – Identify the other actors / services / organisations in the system**

There are, of course, other actors [13], services and organisations in the system that need to be involved to make it work, some of these will be combined and offered by one service provider, as is the case with the APPII platform and service. However, it makes sense to list these separately here as they do not all have to be combined together. For instance, the criminal and background check, right to work and are not essential for a digital certification service. We see the minimum combination (in addition to an awarding body) being:

- Identity verification
- Blockchain service
- Personal Information Management and Presentation Service

For a discussion of this minimum combination (and hence the foundation of a digital certificate service) please see Design Decision 6 – Using Existing Paper Certificate Replacement Processes as the basis for a Digital Certificate Service

**Identity verification service**

See the Glossary entry

**Blockchain Service**

See the Glossary entry, Design decision 2 and Appendix 2
Personal Information Management and Presentation Service
This rather cumbersome title is intended to describe what the user can do with their data that is in the awarding body blockchain. Without this the system has no useful functionality for users, other than to view their own certificates and qualification information, i.e. they cannot share it or present it. This might be described as a presentation ‘layer’ in the technical system that allows a user to:

- View their official digital certificates and related information held by the awarding body
- Present the digital certificates (and related information) online in a variety of ways
- Select and share which digital certificates and personal information they want to share

The user needs to be able to present their information in a number of different ways and this service should be able to support this, such as embedding in web and social media platforms and of course creating customised CVs, that can be online or in the form of a PDF that can be printed.

Optional Services
Criminal and Background Check Service
See the Glossary entry

Right to Work Service
See the Glossary entry

Design Decision 5 – Identify the other factors influencing the system design
Legal
The main legal factor is likely to be data protection, privacy and compliance with the General Data Protection Regulation (EU) 2016/679 (GDPR)\[14\]. One area that requires investigation is the new ‘right of erasure’ in this law that means a data subject (user) can request their data be destroyed on a number of grounds. As a blockchain is specifically created to preserve and safeguard data and prevent it being deleted or altered this is an issue. However, the ability of the user to withdraw their digital key at any time should render their data to be inaccessible to anybody else. This might satisfy the legal requirements of the GDPR and shall probably be clarified through case law.

However, the use of blockchain may also help organisations to meet the other requirements of the GDPR such as the right of access to personal data and the right to be able to transfer data between systems using commonly accessible formats – the new right of ‘data portability’ [15].

Other legal factors may well be involved, for instance we refer to trademarks later in the context of trust issues.
Regulatory
The national and supra national (e.g. the EU) regulatory bodies and agencies affecting awarding bodies and learning providers may well have an effect on implementation.

Hype and F.U.D.

**Hype** (a form of advertising and promotion) is well known as a means to sell IT and communications technology to organisations and individuals. Both the American and Scottish government reports on blockchain technologies observe that this is a strong factor that makes it difficult to undertake reasoned assessment of possible uses, due to the ‘background noise’ coming from the industry hype machines. **F.U.D.** (Fear, Uncertainty and Doubt) [16] is used intensively in the IT industry to instil a fear of being left behind one’s competitors in order to persuade managers (or consumers) to buy a particular product. The use of hype and FUD is already intense, pervasive and well-funded in relation to technology in education. It takes the form of what Martin Weller [17] of the Open University has described as the ‘Silicon Valley narrative for education’. Over the years, as Norm Friesen [18] has observed, this has led to massive amounts of money being spent in both deploying and researching educational technology to little effect, other than to support this dominant narrative. It is important to be aware that IT Corporate interests have long seen education as a huge global prize. The CEO of CISCO states it plainly in a *New York Times* article [19]:

"The next big killer application for the Internet is going to be education. Education over the Internet is going to be so big it is going to make e-mail usage look like a rounding error"

For these reasons, it is important to be as clear as possible about the rationale for using any chosen technology and be critically aware of any hype and FUD surrounding it.

How the networks of power, finance and influence work to control the direction of EdTech in our education systems are not well studied or reported, the investigative work of Audrey Watters [20] in this area is an exception and highly recommended. In this connection, Casey and Greller [21] have begun a series of discussion about the wider societal issues involved in this area, in the process of developing an EdTech design handbook.

Policy
Education is particularly sensitive to policy developments. This is an important factor in the Scottish context where the SQA as an awarding body is a part of the public sector and answerable to the Scottish Government as “a non-departmental public body established under the Education (Scotland) Act 1996”. The other UK awarding bodies are also subject to oversight and policy developments from the UK and national governments (see the glossary).

In this connection, an important recent development is that the Scottish Government has recently commissioned a report into the use of blockchain to support public services and recommends pilot projects. In addition, in the UK public sector the Land Registry [22] is investigating the use of blockchain as is the UK Food Standards Agency [23]. These recent developments help to give confidence to those investigating the use of blockchain to support digital certificates in education.
Central IT Depts & Service Units
These are some of the most powerful stakeholders involved in making digital certification possible. They are usually the gatekeepers to organisational data and as such are at the start of the digital supply chain to deliver digital certificates. They may not be used to sharing their data with third parties in this manner, so this can represent a considerable cultural challenge. Data will have to be organised and formatted in different ways to their normal business processes in order to deliver digital certificates to users.

This aspect of cultural and organisational change for central IT Depts is likely to be much more of a challenge to Learning providers who are also awarding bodies (e.g. Universities and some Colleges). These IT Depts are likely to have a more diverse set of service requirements and can have a tendency to try and do everything and resist using outside services. This is part of a wider public sector characteristic in relation to IT use.

The Scottish government McLennan report in 2011 [24] examined the potential of using cloud services to improve efficiency and reduce costs in the public sector. It identified a lack of oversight and governance of IT functions as a major obstacle to progress, as was acknowledged in the Scottish government reply to the report [25]. This is slowly changing as the economics of running and maintaining internal data centres becomes less economically viable in the face of cloud / networked solutions. Interestingly, a recent survey [26] by UCISA (Universities and Colleges Information Systems Association) noted that none of the institutions who had outsourced an IT function to cloud providers would consider returning those services in-house. In 2017 the Scottish government published its Digital Strategy For Scotland report [27], which again reiterated the need to move to cloud based solutions in the public sector.

Trust and Cultural Acceptance
This is an intangible and extremely important feature of any educational system. Once lost it can be hard to rebuild and this is particularly relevant to awarding bodies. So negative media reports need to be avoided if possible and responses need to be prepared in advance. This is particularly important for the use of blockchain technologies and their links to cryptocurrencies in the popular media, as acknowledged in the recent American and Scottish Government reports on the subject (see above). People and employers trust awarding bodies and their learning providers to deliver and maintain the quality of their training and qualifications. So, the introduction of digital certificates needs to be carefully managed to maintain trust.

Paradoxically, although it is easy to falsify paper certificates, they have a strong level of cultural significance and trust (see the glossary entry). That is why we are not proposing the total replacement of paper certificates but the development of a parallel digital service that speeds up the search and recruitment process and delivers new services and capabilities to users and employers. It is important to take these kinds of factors into account when introducing this kind of digital change in a complex system like education. You can find out more about the rationale behind our approach in Appendix 1.
The design of the digital certificates and the user experience will be important in gaining acceptance. People are used to seeing QR codes on air and rail tickets for instance. Knowing that this is a means of verifying a qualification all the way back to an awarding body’s records is reassuring. The registered trademarks of awarding bodies can be useful in providing reassurance to users because they are a sign of authenticity. For an awarding body it may be easier in some cases to successfully prosecute for misuse of a trademark in creating false certificates, by claiming trademark violation. Other legal remedies are also available.

**Design Decision 6 – Using the Existing Paper Certificate Replacement Processes as the basis for a Digital Certificate Service**

At one of our workshops we examined the existing processes used by the SQA and other awarding bodies to enable users to obtain replacement paper certificates, where the original had been lost. It became clear that this might provide the basic mechanics for the design of a digital system for issuing digital certificates. The two schematic diagrams below illustrate how the existing system works and how a potential digital system could work.

![Fig. 5 Replacement Paper Certificate Process](image_url)
Verification of User Identity is the Key

As we discussed these ideas it became clear that the key issue in the process of issuing a replacement paper certificate is for the awarding body to be sure that the request is coming from an individual who matches the information, they hold about them on their records.

You can find examples of the information required to issue a replacement paper certificate at these web links for awarding bodies

- SQA [30]
- NCFE [31]
- CNAA (via the OU) [32]
- City and Guilds [33]

There is a degree of human judgement involved in making these decisions about identity in the existing paper system and in our envisaged digital system there would always be a human channel for enquiries. One observation is that some awarding bodies ask a user for a unique user identifier that the awarding body used for its own internal administration of the learner’s records. However, it is unlikely that most learners will know their awarding body user identifier, the same applies to other identifier systems in use by government agencies.

We think it is worth considering incorporating the users National Insurance number into the awarding body record systems to aid searching and identity verification. If the problem of verifying an individual’s identity can be solved satisfactorily this would provide the basis of a digital certification system. This forms the basis of Design decision 6.
Users tend to identify with their learning provider

All the awarding bodies ask a user requesting a replacement paper certificate what learning provider they studied at for their qualification. In a system that issues digital certificates to users on request (as we envisage) it will be important for the awarding body to maintain historical lists of learning providers and their change of names. This is important where mergers of colleges have occurred for instance. This will help in the verification process.

Design decision 7 – Use identity verification services and biometric data to verify individual identity

During one of our workshop sessions we went through how the APPII service verifies an individual’s identity using a smartphone. This is a mixture of users entering their personal data and taking a photo of their photographic ID document (driver licence, passport, student card etc.) and taking a ‘selfie’ of themselves. The images of the selfie and photo ID are compared to confirm the user’s identity; the text from the photo ID documents is scanned into the APPII system and compared against official databases – as described in the technical glossary of this document. The data is verified with reference to information about the user held in in identity verification service provider records. Taken together, these measures provide a very strong proof of identity.

One of the workshop participants observed that if this process actually works then the APPII service would solve the identity problem in the proposed digital certificate system to the satisfaction of the awarding body. If this is the case, then the task of the awarding body in our proposed system is to supply the qualification data requested for the user to the blockchain record. From there it would be available to the user in the ‘presentation layer’ component of the system to use in their job seeking and networking activities.

Design decision 8 – The system has to be sustainable in the long term – digital curation

A digital certificate system needs to operate in the long term over decades (like the paper system). This is reinforced by the GDPR right to data portability that requires a data subject (our system user) must be able to transfer data between systems using commonly accessible formats – the new right of ‘data portability’. This means that if an external blockchain provider (like APPII) is involved in supporting the service there needs to be the means to export the data easily and in a format that can be reused. This legal right and requirement is a useful as a driver for sustainable system design, of course the same applies to an in-house provider. This means that there should be no proprietary formats or other forms of vendor lock-in. There would also need to be adequate disaster recovery plans in place.

For this to work in practice there needs to be sufficient documentation from all parties to allow future owners of the system to be able to take the data in the blockchain and read it and convert it into usable formats. This is particularly important when the system is dependent on an external blockchain service provider – being able to demonstrate this in practice would greatly help adoption. These arrangements can be managed through existing industry methods like contract terms and escrow services.

This function needs to be overseen by a manager at an awarding body and be part of a long-term data management strategy. The work of the information retrieval research...
community is useful to help inform this kind of planning. In addition to the technical architecture for such systems it is important to remember that there need to be a continuing human and organisational input to look after this data and get the most benefit out of it (curation). Ingeborg Torvik Sølvberg [34] of the national library of Norway reminds us that the traditional skills of libraries and librarians in a digital context are still highly relevant in relation to effective data retrieval and curation because of these crucial qualities:

- Long Term
- Managed
- Quality controlled

Unexpected Outcomes and Possibilities
Sometimes in projects such as this the unexpected turns up and it is sensible to provide a placeholder to capture these insights and ideas.

Assessment Evidence Recorded in Blockchain – Some Implications
It became clear as the project progressed that any digital artefact can be placed in the blockchain. This means it is quite possible to store the data concerning a user’s qualification together with any evidence of learning that has been used by the learning provider to assess the learning. In the case of the SQA and other awarding bodies they already gather sample assessment evidence as part of their quality control process. As the move to digital assessment gathers pace it is quite feasible to record the sampled evidence produced by the learners in the blockchain.

This has a number of important implications:
- It will be possible to easily compare evidence and assessment marking across learning providers for quality purposes – useful for regulatory bodies and policy development but could prove contentious for learning providers.
- This could be very useful for educational research as a source of primary research data
- In some professions it is desirable to have proof of competence
- There are legal implications to this that need to be examined

The legal issues raised include GDPR and copyright. It is quite common for learning providers to have underdeveloped institutional policies on Intellectual Property Rights (IPR). For instance, some institutions believe (wrongly) that student work belongs to the institution. Jisc [1] funded a useful project that provided a development pack for institutional IPR policy development [2].

Administrative information in the Blockchain – Some Implications
Our discussions about storing assessment evidence in the blockchain also led onto other uses for this technology. It is quite common for learning providers to have many internal information silos to support their business processes that duplicate each other and involve the same information changing from paper to digital to paper again as the information passes between the various siloes. This is something that also affects many other business sectors beyond education. As a learner passes through these internal siloes it would be
possible to use blockchain as a common repository of information of that student’s information for use across the learning provider – removing the silos and duplication and making access to verified secure information far easier than at present. This would, of course, require business process change to make effective use of this type of a shared database, but could result in major efficiency gains. Such a service might provide part of a future business model for the deployment of blockchain technologies in education that support certification. This would be worth investigating in future pilot projects.

**Becoming Aware of Identity Verification Services**

In the course of the project many of the participants have become aware for the first time how online digital identity verification is undertaken by a mixture of commercial and government agencies collaborating. This has helped in understanding the requests for personal information involved in issuing a digital certificate.

**Digital Certification as an agent of change in Vocational Education**

Education is resistant to change, and the adoption of technology has been slow, much slower than earlier predictions. There are two areas where progress in adopting digital methods could have an effect on the entire educational system, these are assessment and certification. Change here could have a galvanising effect on the rest of the educational system.

**Learning Outcomes and Assessment Criteria Recorded in the Blockchain – for micro credentialing**

SQA has publicly available unit descriptors that provide considerable detail about the learning outcomes, assessment criteria and methods for the component units in a qualification. This would provide the basis for micro-certificates for the component parts of a qualification. This could be used to answer a common complaint from employers that they do not know what qualification means or covers, it would also enable users to create a richer customised CV in their job applications.

**Use of Unique Personal Identifiers – NI number as a candidate?**

Awarding bodies use their own internal identifiers for learners who are candidates for their qualifications. The SQA uses the Scottish Candidate Number (SCN). The UK Government uses a number of systems including the Individualised Learner Record (ILR) [3] for gathering data about learners in the FE sector and the Unique Learner Number [4], which is supposed to apply to every individual in the UK over 13 years of age. We have discussed whether it is worth using the personal National Insurance number [5] as an (additional) personal identifier in the blockchain system. The main reason being that it is much more widely known by users than these other identity schemes which many users are never aware of.

**Digital Certificates Can Exist in More Than One Location**

Paper Certificates can only exist in one place at a time for verification by employers and others, its physical rarity confers a value upon it. A digital certificate can exist in many places at once, so trust in its authenticity is important.
Appendix: 1 Our Approach and Influences

Our approach is influenced by well-known approaches to computing science and software engineering that are taught at undergraduate level which stress understanding the purpose of the development and the people who are going to use it and their context. In other words, to adopt a critical engineering approach. However, IT developments occur in the real world of politics, media, money and influence which can result in a technical development in the wrong place for the wrong people for the wrong reasons. The role of IT industry hype is designed to sell solutions that are often searching for a problem to solve. One of the (many) textbooks of case studies documenting and analysing software failures is Software Runaways [1], in almost most cases it is these social and human factors that are the root cause of failure. We know from recent UK history that attempts to use technology to engineer rapid change in both the health and education sectors have come badly unstuck due to a such a naive (or cynical) approach to using technology. The £10 billion failure [2] to implement a unified NHS IT system is just one example and the multimillion pound collapse of the UK e-university project [3] is another.

Systems Theory [4]. Quite simply the concept that things in a system are linked together and can affect each other. Remarkably useful in our context and equally remarkable in its lack of application in EdTech. The work of Peter Senge [5] in this connection is important and his concept of mental models.

Enid Mumford [5]. On the importance of understanding local working cultures when trying to introduce technology into any workplace – the socio technical approach.

Martin Weller Open University. Shows the damaging effects of what he calls the seductive ‘Silicon Valley Narrative’ message about EdTech and how it is accepted by some academic leaders and influencers.

The work of Norm Friesen. Identifies the effects of industry hype and political ideology combining to create persistent failings in academic research into using technology in education.

Participatory Design [6]. This is a further development of the concept of sociotechnical design, that seeks to understand the complex interactions between people and technology. Participatory Design is exemplified in the work of Ezio Manzini, Pelle Ehn, and others; the main principle is that those affected by a design should have a genuine say in shaping it. Anyone who has struggled with (the all too common) combinations of barely usable educational software systems will appreciate this idea.

Appendix: 2 Relationship to digital open badges and differences

If you have not already read the excellent American report on blockchain technologies from the National Institute of Standards and Technology, then now is the time before reading this Appendix

The openbadges.org [1] home page describes open badges as:
“Open Badges are visual tokens of achievement, affiliation, authorization, or other trust relationship shareable across the web. Open Badges represent a more detailed picture than a CV or résumé as they can be presented in ever-changing combinations, creating a constantly evolving picture of a person’s lifelong learning.”

They are also described as:

“Connected, verifiable credentials represented in portable image files”

Originally developed by the Mozilla foundation the rationale for their use is given by this web page [2] as:

“A digital badge is an online representation of a skill you’ve earned. Open Badges take that concept one step further, and allows you to verify your skills, interests and achievements through credible organizations and attaches that information to the badge image file, hard-coding the metadata for future access and review. Because the system is based on an open [technical] standard, earners can combine multiple badges from different issuers to tell the complete story of their achievements — both online and off. Badges can be displayed wherever earners want them on the web, and share them for employment, education or lifelong learning.”

The badge system is now certified and overseen by the IMS [3] educational standards organisations and used by a wide range of organisations including the City and Guilds awarding body in the UK through their subsidiary DigitalMe

On the face of it this is pretty close to what we might do in a blockchain based system. There are some important differences though. The badges system has tended to be used and experimented with by learning providers and awarding bodies but not used for ‘proper’ mainstream qualifications. Instead, they have tended to be used to recognise soft skills and informal learning or ‘enrich’ formal qualifications – not replace them. A recent literature review [4] observed that the terminology ‘badges’ and the visual design of the badges have put some people off as seeing them as childish – showing the importance of cultural acceptance. The accompanying hype has not helped either as this has often been billed as yet another ‘revolutionary change’ to education by a technology and its supporters.

Perhaps the biggest difference is the blockchain direct link into the awarding body system that is controlled by the awarding body. Whereas digital badges ‘float’ around the web with the information about the learning embedded within them. This has been recognised as a drawback as this online Medium magazine article [5] explains with the proposed addition of third party verification. To be fair, open badges were never intended to be tied into the type of closed system that this White Paper envisages, their whole point is to be open and mobile and ‘point’ to the organisation that awarded the badge and describe the learning involved, absolute verification was never a priority.

Perhaps the best way to think about the relation of open badges to a blockchain system of certification is that the blockchain system has more perceived and actual trust than an open badge system due to the explicit digital link back to the awarding body blockchain without

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which it cannot work or exist. In some ways what we are proposing is simpler in scope compared to the ambitions for open badges. Another way of looking at this is that blockchain based certificates are a development of open badge ideas that are more trustworthy and, in some ways, more flexible.

This article [6] discusses combining badges and blockchain. It is by Doug Belshaw an open badges expert and enthusiast who worked for the Mozilla Foundation. Here, Doug assumes an open distributed blockchain not a private closed one (as we do). Part of this confusion comes from the popular dominant view of blockchain being defined by reference to the Bitcoin blockchain – which is public and distributed. A useful and clear discussion of the differences and uses of open and closed blockchains is provided in this Medium magazine article by Demiro Massessi [7].
Appendix: 3 Digital Certificate System Diagrams

1 - Certification of Learning: The Big Picture

Fig. 7 Certification of Learning: The Big Picture
2 - Paper Certificate Replacement Process

Fig. 8 The Paper Certificate Replacement Process
3 - Digital Certificate Process

Fig. 9 The Digital Certificate Process

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4 – Layers of Trust in a Digital Certificate System


**Fig. 10 Layers of Trust in a Digital Certificate System**
5 – Envisaged Auto and Manual Certificate Issue

Digital Certificate Process Details:
1. Automatic – Awarding Body Database writes to APPII Blockchain in response to a successful request [ID and user info matches]. User receives digital certificate in their APPII account.
2. Manual (Traditional) – Not enough information for auto issue of certificate to user. Enquiry with Help Centre support resolves case

APPII user account request (green arrow) to Awarding Body for Digital Certificate.
Success, response data written to APPII Blockchain for user account. User gets access to digital certificate via APPII system to share with 3rd parties (dotted red arrow).

Fig. 11 Auto and Manual Issue of Digital Certificates
6 – APPII User Sign UP – Identity Verification Explanation

APPII User Sign Up Process: Digital Identity & Security Details:

- User takes picture of their Photo ID: Photo ID text is scanned and ‘read’ and entered into APPII database. Photo ID Facial image is scanned and stored in APPII database.
- User takes ‘Selfie’, this is scanned and stored in the APPII database.
- All this data is then used by an Identity Verification (IV) Service to check if the user data provided matches official records.
- APPII Account Created.

Identity Verification (IV) Services are used all the time by online shopping and banking services – but are invisible to most users.

The UK Government also uses selected identity verification services to share its own data with – see this GOV.UK link.

Your personal data is safe with APPII it is fully compliant with the strictest data and privacy protection law such as the GDPR.

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Fig 12. The APPII User Sign Up Process – Explaining the Identity Verification Process

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7 – Final System

Fig. 13 The Final Proposed System
Appendix 4: Digital Portfolio Using Google G Suite for Education

Portfolios of student work have been used in education from the beginning of human learning. By creating and compiling a collection of resources the learner is able to document their progress and share it with their peers and teachers for assessment and feedback. Modern digital e-Portfolio systems are very much oriented towards the needs of the learning providers (understandably) and access to them ceases when the learner leaves the College or University. We think a portfolio system that is learner centred and owned is needed. One that the learner can continue using throughout the rest of their career.

About ten years ago the project manager of My Skills was involved in a discussion at an African e-learning conference about the kind of digital portfolio system that would work well in Africa. The requirements and ideas that were discussed also applied increasingly to developed countries. You can see the original article and slides in the ‘The African Connection’ section below. Ten years later, Google G Suite for Education [1] fits the bill pretty well indeed. The project has enabled the City of Glasgow College to trial its use as a portfolio and teaching tool. The response has been overwhelmingly positive. We hope to have it integrated into the college systems permanently if we can get over the kind of issues to adopting cloud solutions we have discussed in the White Paper.

The African Connection

Lusaka in Africa is a long, long way from Glasgow and the UK but in 2010 at the annual eLearning Africa conference the My Skills project manager, John Casey, was involved in presenting a discussion paper together with African and Austrian colleagues entitled “e-Portfolios for Learning and Development: Without Constant Internet or Electric Grid Access” you can check out the academic repository summary at this link [2] and find a copy of the actual discussion paper at this link [3]. Back then, the ideas of having an electronic portfolio that would be wholly owned by an individual and would be able to ‘dock’ with different learning providers and work offline at times was futuristic. But, nine years on and with the breakneck speed of web and mobile technology development that dream seems close to reality.

This experience is what has inspired us in choosing Google G Suite for Education as the Portfolio system in the My Skills project. It fits most of the requirements we outlined. You can see our presentation slides here [4].

Appendix 5: T Levels

T Levels are a new vocational training qualification that are due to be introduced in 2020. They will be available to post-16 learners after they have studied for their GCSEs. They are intended as vocational alternatives to A-levels. Could blockchain based digital certificates support T Levels? Yes, is the simple answer. They could also do more, especially if combined with learner owned digital portfolios as we are doing in the My Skills project. We can illustrate this by looking at the structure and grading of a T level (taken from the UK Government web site [1]) shown below:
Structure of a T Level
T Level courses will include the following compulsory elements:
- a technical qualification, which will include
  - core theory, concepts and skills for an industry area
  - specialist skills and knowledge for an occupation or career
- an industry placement with an employer
- a minimum standard in maths and English if students have not already achieved them

Grading
Students who pass all the elements of their T Level will get a nationally recognised certificate showing an overall grade of pass, merit or distinction. It will also set out the details of what students have achieved on the course.
The T Level certificate will include:
- an overall pass grade for the T Level, shown as pass, merit or distinction
- a separate grade for the occupational specialism, shown as pass, merit or distinction
- a separate grade for the core component, using A* to E
- grades for maths and English qualifications
- details of the industry placement

A Blockchain based T Level?
A blockchain based certificate could easily contain this information. By its nature (being digital) it also lends itself to being extendable and can accommodate data at different levels – so supporting micro credentials (describing the component parts of a qualification). In addition, the user (learner) could also control what elements of their T Level they would like to share via an online blockchain platform like APPII that provides granular control over what the user chooses to share and a customisable CV builder this is a powerful tool.
However, it does not stop there. In addition to the trust and flexibility that a blockchain T Level digital certificate would provide there are two further potential advantages:

1. The ability to include evidence of learning (images, reports, videos) in the blockchain) that are certified as true by the learning provider
2. The ability for the learner to maintain their own personal digital portfolio of learning

With these two features (Digital Certificates and Evidence from a Portfolio) the T Levels could be given a rich and powerful platform to benefit learners and employers.
References

**Introduction to the White Paper**


**Executive Summary**


**Key Findings**


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**Recommendations**


**My Skills Project Overview**


**Educational Terminology and Glossary**


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The Current Situation: Paper Certificates in a Digital Economy


Developing the Design


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Unexpected Outcomes and Possibilities


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[4] The Unique Learner Number (ULN)

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Appendix 1 Our Approach and Influences

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Appendix: 2 Relationship to digital open badges and differences


Appendix 4: Digital Portfolio Using Google G Suite for Education


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Appendix 5: T Levels
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