

Using Blockchain, Semantics and Data Analytics to Optimise Qualification Certification, Recruitment and Competency Management: a Landscape Review

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Abstract—In the era of digitisation, innovative technologies and Information & Communication Technology (ICT) systems have transformed many areas and domains. The same cannot be said for Higher Education, especially as this concerns the certification of degrees, qualifications and other accreditations of students and job seekers that are still largely in paper form and require manual and time-consuming processes. Given that such documents are pertinent not only for education purposes but also for the job market and Human Resources-related (HR) processes of private and public organisations, there is a growing need for automatic and trustworthy systems that can handle qualification certification while at the same time providing added value for the job market. This paper is written under the context of the European Union (EU)-funded project QualiChain that aspires to investigate the impact of disruptive technologies, such as blockchain, semantics, data analytics and gamification in the domain of public education, as well as the interfaces of the latter with the fields of private education, the labour market, and public sector administrative procedures.. The scope of this publication is to perform a landscape analysis on commercial tools and frameworks that operate in the aforementioned domains and compare them to the projected functionality of the QualiChain platform.

Keywords-*blockchain; semantics; data analytics; state-of-the-art; qualification certification; human resources management.*

I. INTRODUCTION

When referring to qualification certification, the most common thought is a higher education diploma, a piece of paper that states the knowledge that has been acquired in a certain scientific field, or the skill to develop a task. The

certification body is the entity that provides a certification for this diploma and is the legal recogniser of the knowledge. A typical, paper-based education certificate is a document that states that a person has received specific education and/or evidence of achievement of expected learning outcomes. Education certificates are used for a variety of purposes, such as the recognition of the completion of a specific learning experience by a student; or the achievement of a defined amount of knowledge achieved in a specified area; the acquisition of skills or the attainment of a particular excellence criterion.

Despite the fact that education certificates find use in various educational and work related processes (individuals' further admission in other educational and training programmes, personnel recruitment, etc.), they are largely resisting the pull of technology, as they are still held in diverse formats in siloed databases, often involving paper documentation and extremely time-consuming manual processes for their verification [1]. Additionally, most higher education institutions operate in isolated environments with no connection to the respective labour market that their graduates are projected to follow. As such, in most cases there are no tools that can ease the transition of a person from being a student to a job seeker and the connection between academia and the labour market is in most cases non-existent. Consequently, there is a clear lack of a trustworthy and automatic solutions when it comes to archiving, managing and verifying educational qualifications that can operate in various settings and provide added value to its users.

The slow digitisation of the education sector [2] coupled with the lack of suitable ICT solutions for education

credentials' verification, means that holders of such titles are dependent from issuing/accrediting authorities every time they want to verify their degrees. This fact does not only affect academic institutions but also private and public organisations in their HR-related tasks. For example, recruitment in an organisation requires combing through hundreds of candidates' résumés, weeding out the unqualified ones and narrowing down the rest into a group of potential recruits', whose qualifications and academic degrees have to be checked and validated on a case-by-case basis. However, difficulties in the public and private sector do not limit to the actual task of recruiting but extend to a wider set of processes that follow contracting activities, indicatively encompassing personnel allocation and re-allocation, staff mobility, and skills' development and evaluation.

Solutions to these difficulties require fundamental changes in work practices and processes that extend beyond the transformation of the recruitment procedure itself and trace back to the way education and employment credentials and qualifications themselves are archived, managed and used and thereby to the way the educational and other accrediting organisations operate. Disruptive technologies, such as blockchain, algorithmic techniques, data analytics and semantics and innovative concepts like gamification may offer solutions to these challenges. Particularly, blockchain, as a decentralised, permanent, unalterable store of information can help with the archiving and trust issues, as well as provide a frictionless method for transacting with others, whereas computational intelligence found in the technological domains of algorithmic techniques, data analytics and semantic analysis may facilitate decision making and optimise work practices and procedures.

To assess the added value that this combination of technologies might provide to the aforementioned challenges, it is imperative to assess and evaluate similar frameworks and tools that operate in the domains of education and the labour market and provide solutions for qualification certification, recruitment and competency management. Under these circumstances, this paper presents a state-of-play analysis on 19 tools and frameworks that were identified in these domains. This analysis was performed under the context of the EU funded project QualiChain that aims to combine blockchain, semantics and other innovative technologies to provide a holistic, trustworthy and automatic solution in the challenges presented above.

Section I introduces the scope of this paper by presenting the current situation and challenges arising from the lack of technical solutions for qualification certification. Section II introduces the QualiChain project and the platform's functionalities. Section III outlines the criteria used for the analysis and provides a short description of each tool and framework that was analysed. Finally, Section IV presents the conclusions of the analysis.

II. THE QUALICHAIN CONCEPT

QualiChain is a project that aspires to investigate the impact of disruptive technologies, such as blockchain, semantics, data analytics and gamification in the domain of

public education, as well as the interfaces of the latter with the fields of private education, the labour market, and public sector administrative procedures. The project concept lies in applying the aforementioned technologies for the design, implementation, piloting and thorough evaluation of the QualiChain technological solution, a distributed platform targeting the storage, service, and verification of academic and employment qualifications [3]. Apart from educational and professional certificates verification, QualiChain aims to develop various added-value tools that can provide solutions to major challenges in the domains of education and the labour market. In fact, QualiChain services are structured along two main pillars, i.e., baseline and value adding services. The first pillar is grounded upon QualiChain main technological foundations, namely blockchain and semantics, enabling educational awards' and other qualifications' archiving and storing, awards' verification, the latter incorporating, if needed, certificates' translation and equivalence verification, as well as qualifications' portfolio management. The second pillar will build upon QualiChain baseline services to offer with the help of the computational intelligence, embodied in data analytics and decision support algorithms, as well as gamification techniques, a set of more advanced services, including career counselling, intelligent profiling, and competency management and within the context of the latter recruitment and evaluation support, and consulting.

III. RELATED TOOLS AND FRAMEWORKS

A. Comparison Criteria

The comparative analysis in the following sections pertains to the current state of practices regarding tools, methods and frameworks, similar to QualiChain that are used in education and public administration, as well as commercial applications, and that all the tools presented therein are released for use and are not under development. In addition, the tools and frameworks described are not expected to include every projected function of QualiChain given that their scope is much more specific. What is useful though, is to perform a comparison on the state-of-play of functionalities and technical capabilities included in such systems to identify innovative ideas or potential shortcomings of existing solutions. Consequently, for this comparison the criteria for the analysis largely represent the high-level technical capabilities of the various modules of the QualiChain platform and are the following:

1. Target users: This part of the analysis will help assess if the list of stakeholders identified for the projected QualiChain platform is as complete as possible.
2. Blockchain usage/Data security: Identify the solutions that employ blockchain or other data security methods
3. Personalisation approach: This criterion will help compare the various approaches that make the tools more user-centric
4. Use of Semantics/data interoperability: Distil the tools that provide the capability for data analytics and in less innovative solutions other searchable interfaces as well as the available pool of data.

5. Gamification approach: Identify approaches that increase user engagement
6. Qualification certification and Multilinguality: This criterion pertains to the tools that certify qualifications. Two important sub-criteria here further divide the tools into automatic and non-automatic as well as the capability to translate degrees in multiple languages
7. Recruitment & Competency Management: This criterion pertains to the solutions that offer to organisations the ability to perform various HR related tasks.
8. Open source/APIs: This criterion will help identify the openness of each tool and the potential to create synergies with QualiChain.

B. Selected Tools & Indicative Analysis Tables

The tools and frameworks analysed under the context of this publication were the following:

1. Qualification Check [4] (tool): Qualification Check offer a global solution for qualification verifications, supported by a team of multilingual education experts. Qualification Check provides qualification validation to help stop the damaging and costly effect credentials fraud has on organisations.
2. Recognition Finder [5] (tool and framework): Recognition Finder is a tool for the recognition of foreign professional qualifications in Germany. It presents important information about the legal foundations, the recognition procedures for individual occupations and the available counselling services in a concise form. The tool is not automatic but rather finds the competent authority that the user needs to contact for the respective occupation.
3. European Credit Transfer & Accumulation System [6] (credit and grading system): ECTS is a credit system designed to make it easier for students to move between different countries. Since credits are based on the learning achievements and workload of a course, a student can transfer their European Credit Transfer System (ECTS) credits from one university to another, so they are added up to contribute to an individual's degree programme or training.
4. UHR Recognition of foreign qualifications [7] (tool and framework): The Swedish Council for Higher Education evaluates foreign qualifications to provide support for people looking for work in Sweden, people who wish to continue studying, or for employers who wish to employ someone with foreign qualifications. The tool includes an online application to apply for an evaluation and recognition of qualifications; however, the validation is not performed automatically.
5. ServiceNow [8] (tool): The ServiceNow module offers an expansive portfolio of training offerings across IT, HR, Customer Service and other departments that cover the Now Platform (HR and workflow organisation platform for enterprises). Moreover, it provides certifications upon mastering new features offered in the latest release of the platform, micro-certification on

a variety of subjects as well as verification of certifications received through the ServiceNow platform.

6. Teacher Certification [9] (framework): The Teacher Certification framework of the British Columbia is a framework that provides a number of services to UK Ministry-certified educators. Among them are certification services, criminal record checks and fee information. The framework includes complete instructions regarding certification offices, pertinent e-mail addresses and the complete methodological steps that a teacher should follow to complete a certain task.
7. DegreeVerify [10] (tool): DegreeVerify provides immediate online verifications of college degrees and attendance. It provides prompt access to many degree and attendance records and eliminates the complications and delays associated with manual processing through individual schools. It can also reduce the risk and cost of making bad hiring decisions as well as ensure only verified eligible student customers are eligible for receiving offers from prospective employers.
8. WES Degree Equivalency Tool [11] (tool): The WES Degree Equivalency Tool compares a user's education credentials to Canadian standards. It allows a user to select the country he/she studied in, enter his/her credentials and the tool shows the degree equivalency. The Degree Equivalency tool doesn't replace an official evaluation, but rather estimates the degree equivalency.
9. Higher Education Degree Datacheck [12] (tool): HEDD is UK's official degree verification hub, used by organisations, institutions and universities to verify degrees. HEDD cannot be used by students or graduates to verify their own rewards, which means that the organisation using the tool's services will have to request a proof of consent from the individual.
10. NOKUT Recognition of foreign education in Norway [13] (framework): NOKUT is a framework that helps institutions, organisations and universities to validate foreign higher education degrees, vocational education and training certifications. It includes an exhaustive list of regulated professions and industries and a pertinent list of recognition authorities that users of the system will have to contact to get recognised in Norway.
11. Vitnemalsportalen Diploma registry [14] (tool): The Diploma registry is a Norwegian service that helps users automatically collect results from higher education institutions in Norway and share them with potential employers, educational institutions and other relevant recipients. Moreover, all transmissions are encrypted and only the sender can decide who he/she wants to share the data with.
12. e-CF 2.0 Profiling tool [15] (tool): The objective of the tool is to bring to life the content of e-CF version 3.0 and provide linkage to the EU ICT Professional profiles. It helps users build their profiles based on their

- preferred orientation (e.g., job profile or education profile) and provides comparisons between user created profiles and established ICT professional profiles to support skill gap identification. The tool also supports multiple languages.
13. CEPIS e-Competence Benchmark [16] (tool): CEPIS is a free online tool that helps assess ICT professionals' skills, based on the e-CF. This tool provides ICT professionals with a personal competence gap analysis that compares their competences against those required for a range of European ICT professional profiles. This enables individuals to plan their career development and make informed decisions about further education.
 14. e-Competences assessment and certification assessment [17] (tool): This tool lets users compose their own professional profile, find the best matching ICT profiles and choose the certificates that could help them meet their aspirations. It provides users with three distinct functionalities: a self-assessment tool, comparison of e-competence related certificates and an e-competence demand and supply calculator.
 15. IT Staffing Nederland [18] (tool): IT Staffing is embedding the European Competence Framework in their recruiting and matching systems, for the sake of better transparency and quality on this process. The tool takes advantage of semantics for translation of ICT texts into digital e-competences and provides transparency to better interpret job descriptions, vacancy texts, incoming CVs and training materials.
 16. Blockcerts [19] (tool): Blockcerts is an open standard for creating, issuing, viewing, and verifying blockchain-based certificates. These digital records are registered on a blockchain, cryptographically signed, tamper-proof, and shareable. The goal is to give to individuals the capacity to possess and share their own official records.
 17. Diplome [20] (tool): Diplome is a blockchain-powered credential evaluation service that generates a "certificate wallet", in which it is possible to upload one's qualifications, making it easier for a student, graduate or professional to enrol in a foreign university or enter the labour market in a foreign country. Diplome is a global ecosystem, which can be used by authorities and institutions to securely and unchangeably register education/training documents, guaranteeing their transferability and authenticity.
 18. LinkChain [21] (tool): LinkChain is a Blockchain-enabled Linked Data Platform catered to data publishers and consumers that provides certificate equivalence verification, credential auditing & verification while supporting multi-lingual capabilities as well.

19. Blockchain for Education [22] (tool): The available blockchain tool (part of a platform that is in development) enables learners to present their digital certificates while also supporting certification authorities in the management and archiving of digital certificates. The tool relies on blockchain to enable tamper-proof archiving of certificates and their correct and permanent allocation to the learners. The existing in-use tool relies on Open Badges and uses JSON/JSON-LD for metadata and as a basis for querying (verification purposes).

For the analysis of the tools and frameworks that are presented above, the following tables (see TABLE I) were used to describe the general functionality of each tool, the technologies implemented in it and the added value that they provide to users.

TABLE I. ANALYSIS TABLE

Tool/method name		Recognition Finder[5]	
Category (tool, product, framework)	Tool and framework	Current version	Released
Description			
Recognition Finder is a tool for the recognition of foreign professional qualifications in Germany. Moreover, those seeking advice only need a few clicks and this online tool will name the competent authority for their application. In addition, it presents important information about the legal foundations, the recognition procedures for individual occupations and available counselling services in a concise form. Recognition Finder does not automatically verify the user's qualifications but finds the competent authority that the user needs to contact for the respective occupation.			
Implemented technologies and functionalities			
<ul style="list-style-type: none"> • Recognition check allows users to see whether their professional qualifications are recognised in Germany • The portal is available in German and English, as well as Arabic, French, Greek, Italian, Polish, Romanian, Russian, Spanish and Turkish. • For mobile use, there is also the "Recognition in Germany" app, which offers the information in seven languages • The database currently contains more than 1,500 different contact addresses for the recognition procedures of occupations 			
Added Value			
<ul style="list-style-type: none"> • In the "Recognition Finder", the user can enter his or her profession and use the occupational profile displayed to determine the German vocational certificate that matches the qualifications acquired abroad. • Just a few clicks are sufficient to get the address where an application for an assessment of equivalence can be submitted. • All the information that is important for submitting an application is summarised – for example the documents required for an application. 			

Following that, a comparison table was created that analyses each tool based on the criteria described in Section III.A. An indicative section of the comparison table can be seen in TABLE II.

TABLE II. COMPARISON TABLE

Name	Version	Target users	Blockchain/ Transaction Records/	Personalisation	Semantics/ Interoperability/ Analytics/	Gamification	Qualification Certification/ Multilinguality	Recruitment/ Competency management	Open Source/ APIs
Qualification Check	Released	Businesses, public agencies, regulators, education providers, professional bodies, recruitment firms, HR teams,	No Blockchain Full audit trail and record for verification	No	No	No	Automated qualification verification, worldwide education verification, electronic transcripts/ degree certificates to outside bodies/ Multilinguality	No	QCheck API allows queries from integrated systems
Recognition Finder	Released	Students, job seekers	No	No	No	No	Allows users to see whether their professional qualifications can be recognised in Germany, not automatic, finds the competent authority/ 11 languages	No	No

The full table will not be presented in this body of work in its entirety, due to space limitations. However, the main purpose of the table was to help draw the conclusions that will be presented in the following section (Section IV).

IV. DISCUSSION

This section will conclude on the approaches that were analysed and the potential/projected position of QualiChain in the domains of Qualification Certification and Human Resource Management. The conclusions will be based on the eight criteria that were defined for the comparative matrix as well as the overall added value of the presented tools.

The target users constitute the only criterion where no significant differences among the various approaches can be noted. In fact, given that the tools presented are tailored for the stakeholders either in the domain of education, or that of the job market/HR management or a combination of both, it stands to reason that the target users are like those of QualiChain. Identified target users include students, job seekers, employers, private and public organisations, government agencies, education providers, regulators, HR teams and recruitment firms among others. This fact gives credence to QualiChain's approach for stakeholder identification and proves that the list of QualiChain stakeholders is as exhaustive and complete as it needs to be.

Moving on to other criteria, the analysis showed that only 4/19 (Blockcerts, Diplome, LinkChain, Blockchain for Education) tools take advantage of Blockchain ledgers and decentralised standards for the purposes of record keeping, issuing and verification of certifications. While, it is a fact that blockchains are harder to implement compared to more traditional databases, their capabilities for secure distribution of certificates, security, data privacy and immutability are considered to be of paramount importance for minimising fraud around educational and other certificates. Moreover, considering the approaches that did not use blockchain, only 2/19 (Qualification Check, DegreeVerify) keep any records of transactions and 1/19 (Vitnemalsportalen) provides any level of security by adding digital signatures on documents.

Concerning semantics and data interoperability approaches, of all the tools that were described, only 4/19 took it into account. Specifically, IT Staffing Nederland applies semantic software that translates ICT texts into digital e-competencies while Diplome applies other standards of interoperability on the data. On the other hand, Blockchain for Education, offers JSON-LD support which can therefore provide the required verification methodology. Furthermore, LinkChain is projected to be fully semantic and support public and private RDF. Moreover, 4/19 solutions had minor data analytics capabilities, mainly for the purpose of matching between a student's/ job seeker's profile and the skills required for a given position. Finally, 6/19 approaches provided some data structure coupled with searchable registries for the user's convenience. Such searches are only applied on static data and do not provide any automatic capabilities for analysis except for LinkChain that provides a federated searchable Linked Data Platform.

Another criterion studied, was the level of personalisation that each tool provides for a more user-centric experience. The results here are more encouraging given that 8/19 approaches provide some level of personalisation for a user's profile. For example, tools like ECTS make learning more user-centred via use of credits as currency. In addition, WES offers digital badges used to display verified credentials on social media sites like LinkedIn. Moreover, tools that are powered by the European e-Competence Framework, provide users with the capability to develop their profiles based on preferred orientation and competence gap analyses. Finally, the approaches that take advantage of Blockchain (Blockcerts, Diplome and LinkChain) provide each user with a valid and verified certificate/ qualifications wallet.

Concerning gamification, there are no tools that provide a clear solution. While there are some tools that provide some degree of informal gamification with credits and digital badges, the overall conclusion is that the community does not consider it to be that important for the developed tools. However, given that most of the tools are free of charge and offer solutions of low technical capabilities that are

realistically applied in Niche markets, it makes sense that gamification cannot be a priority in such systems.

The main criteria of the analysis revolve around the two main high-level functionalities that QualiChain will also provide, i.e., Qualification Certification and Recruitment/Competency Management. One clear division between the various tools, has to do with the level of automation that they provide. Only 4/19 solutions are non-automatic meaning that they do not automatically certify/validate users' qualifications but rather help them navigate through the various procedures that they will have to follow in order to get certified in a given country or domain.

The rest of the solutions provide various levels of automation and will be assessed based on the actual added value that they offer on the entire end-to-end procedure of either Qualification Certification or Recruitment/Competency Management. Starting from Recruitment/Competency Management, no tools were found that offer holistic solutions in a pan-European level. Specifically, while most solutions offer solid functionalities for organisations that can help their HR teams make staffing and strategic decisions, tools like NOKUT (Norway) mainly apply for their own country and other tools (e-CF 2.0 profiling tool, CEPIS e-Competence benchmark, e-Competences assessment and certification assessment and IT staffing Nederland) have application only for ICT positions and organisations. On the other hand, platforms like LinkChain do not directly offer such functionalities but support external analytics and can serve as a data backend for qualification analysis, opportunity identification, competency development & evaluation, etc.

On the contrary and concerning the domain of Qualification Certification, there are a number of solutions that provide added value in every step of the process. Tools like Qualification Check, ECTS, Blockcerts, Diplome, LinkChain and Blockchain for Education are holistic solutions that automatically handle every step of the process while some of them have been adopted by multiple countries. However, there are still solutions that are country specific (Vitnemalsportalen, DegreeVerify) that do not offer the full range of functionalities for every type of user (HEDD) and others like the ServiceNow module that offer micro-accreditations for expertise in specific platforms and tools. In addition, only five approaches support Multilinguality and only three of them (NOKUT, Diplome, LinkChain) offer functionalities for both Qualification Certification and Recruitment/Competency Management. One of the key suggestions of QualiChain is that having both services operate in a single platform seamlessly will further connect high-level education with the job market so that each domain can learn from the other and help students, job seekers and organisations make more informed decisions. Finally, the fact that 8/19 tools have APIs that allow them to connect with other systems can potentially help QualiChain synergise with them.

V. CONCLUSIONS

The scope of this paper was to perform a state-of-play analysis on tools, applications and frameworks used in the

domains of Qualification Certification or Recruitment/Competency Management. All in all, most of the tools that were analysed are either commercial applications or country/domain-specific and are usually focused on specific functionalities that are useful in some steps of the processes required by students, job seekers, educational institutions and organisations of all types. This gives credence to QualiChain's holistic approach and proves that there is a vacuum on the market of the domains tackled by the project. In fact, not only does QualiChain aim to fill a void in the market but also to advance the state-of-the-art by developing a holistic platform that provides open semantic interoperability and data privacy by extending the research in blockchain, semantics, data analytics and gamification.

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