Blockchain Applications in Education: A Case Study in Lifelong Learning

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Abstract—This paper presents a pilot case study of the QualiChain project, aiming at supporting lifelong learning through the combined use of Smart Badges and personalised recommendations. The pilot case study uses Blockchain technology as a means to decentralise lifelong learning and provide lifelong learners with transparent and immutable educational accreditation. At the same time, lifelong learners are provided with personalised recommendations that help them reach their personal and professional learning goals.

Keywords-lifelong learning; blockchain; decentralisation; smart badge; personalised recommendation.

I. INTRODUCTION

Education today is still controlled mostly by educational institutions, which offer quality, credibility, governance, and administrative functions. This model is not flexible enough and poses difficulties in recognising the achievements of a lifelong learner in informal and non-formal types of education. As a result, a lifelong learner's transition from formal to informal education and vice versa can be hindered, as the achievements acquired in one type of education are not easily transferable to another [1][2]. Generally, lifelong learners have limited control and ownership over their learning process and the data associated with their learning.

This indicates the need for a decentralised model across all types of education, offering learners a framework for fully controlling how they are learning, how they acquire qualifications and how they share their qualifications and other learning data with third parties, such as educational institutions or employers [3][4]. In this paper, we investigate how Blockchain technologies can help realise this vision via a pilot case study for offering support to lifelong learners in various stages of their learning journeys and of their career trajectories.

The remainder of this paper is organised as follows. In Section 2, we introduce the overall framework of the QualiChain project. We then proceed in Section 3 to present the pilot case study for supporting lifelong learning, its scope, the stakeholders involved, the main scenario, as well as the outcomes of a series of consultation workshops about this pilot. Finally, in Section 4 we conclude the paper and outline the next steps of this work.

II. THE QUALICHAIN PROJECT

The emergence of the Blockchain promises to revolutionise not only the financial world, but also education in various ways. Blockchain technology offers a decentralised peer-to-peer infrastructure, where privacy, secure archiving, consensual ownership, transparency, accountability, identity management and trust are built-in, both at the software and infrastructure levels. This technology offers opportunities to thoroughly rethink how we find educational content and tutoring services online, how we register and pay for them, as well as how we get accredited for what we have learned and how this accreditation affects our career trajectory.

The QualiChain research and innovation project focuses on the assessment of the technical, political, socio-economic, legal and cultural impact of decentralisation solutions on education. As shown in Figure 1, QualiChain is targeting four key areas for exploring the impact of decentralisation: (i) lifelong learning; (ii) smart curriculum design; (iii) staffing the public sector; (iv) providing HR consultancy and competency management services.
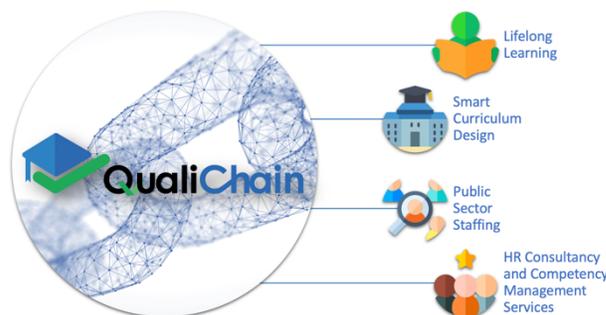

Figure 1. The key areas targeted by the QualiChain project.

QualiChain investigates the creation, piloting and evaluation of decentralisation solutions for storing, sharing and verifying education and employment qualifications and focuses on the assessment of the potential of Blockchain technology, algorithmic techniques and computational intelligence for disrupting the domain of public education, as well as its interfaces with private education, the labour market, public sector administrative procedures and the wider socio-economic developments.

III. SUPPORTING LIFELONG LEARNING

As outlined in the previous section, lifelong learning is a key area targeted by the QualiChain project. We are, therefore, aiming to provide support to lifelong learners in various stages of their learning journeys and of their career trajectories. In the context of this pilot case study, we investigate how Blockchain technologies can support lifelong learners in their learning journey and in advancing their career. Figure 2 illustrates the main goals of this pilot, which are the following:

- Awarding lifelong learners with **transparent and immutable educational accreditation.**
- Offering lifelong learners **personalised recommendations** based on their learning achievements.
- Supporting lifelong learners in reaching **their personal and professional learning goals.**

The next sections describe the scope, stakeholders and main scenario of this pilot, as well as the outcomes of a series of consultation workshops about this pilot.

Figure 2. The overall goals of the pilot on supporting lifelong learning.

A. Scope

The scope of this pilot case study spans across the following:

- We are targeting both **formal and informal learning**. While formal learning typically happens inside the classroom, for example in a traditional university lecture, informal learning happens outside of the classroom, for example by studying free online courses.
- We are targeting both **academic degrees and other forms of educational accreditation**. For example, open badges have emerged as a new form of certifying that someone has acquired certain skills and has gained specific knowledge upon fulfilling certain criteria, e.g. by completing an online course.
- We are supporting the **learning journey and career trajectory of learners**. We are aiming to support the whole learning journey of learners by offering them recommendations on what to study next. We are also

offering recommendations about their next career steps, based on the educational credentials they have acquired.

B. Stakeholders

The two main categories of stakeholders involved in this pilot are the following:

Lifelong learners. The concept of "lifelong learning" is based on the fact that learning is not confined to childhood or the classroom, but can take place throughout life and in a range of situations. Lifelong learners pursue learning throughout their lifetime, for either personal or professional reasons. They may study to develop new skills that they need in their professional life, for example to advance their career by finding a new job or by being promoted in their current job. They may also study to acquire skills and knowledge for personal reasons, for example as a hobby of theirs. Lifelong learners may engage in either formal or informal education, or both, depending on their current learning goals and personal or professional circumstances.

Lifelong learners face various challenges associated with the recognition of their learning achievements, for example when transitioning from formal to informal education or vice versa. In this pilot, we seek to support them in various ways, for example by verifying their learning achievements on the Blockchain, or by offering them personalised recommendations about what to study next or which job position might be suitable for them. In this way, we aim to help lifelong learners reach their personal or professional learning goals.

Educational institutions. These are institutions that provide education or training services, either paid ones or free. The offerings of educational institutions can vary from conventional offline degrees to online free or paid courses, such as Massive Open Online Courses (MOOCs) or Open Educational Resources (OERs) [5].

In the context of this pilot, we seek to make the awarding of accreditation by educational institutions transparent and immutable with the use of Smart Badges [6]. Smart Badges are dynamic records of accreditation that follow the same principles as Open Badges [7] and offer the same benefits in recording accreditation. However, Smart Badges are immutable and easily verifiable as they are stored on the Blockchain. The other novelty of Smart Badges lies in their dynamic features. For example, apart from just recording a learning achievement, a Smart Badge can also offer job or course recommendations, as described in the next section.

C. Scenario

In this section, we present the interactions between stakeholders in the context of the main scenario of this pilot, as illustrated in Figure 3. Let us consider a lifelong learner, Michelle, who is looking to expand her knowledge and skills on data science, and has thus enrolled in a number of courses offered online, including MOOCs and OERs. Each time she completes a course, she is awarded a Smart Badge by the educational institution that offers the course. This Smart Badge includes data about the skills that Michelle has acquired upon completion of the course. Each Smart Badge

Michelle earns is verified and stored on the Blockchain as part of her personal ePortfolio.

After studying for several months, Michelle has mastered some basic data science skills, including various computer science topics such as databases. Based on these skills, the Smart Badges generate recommendations about jobs that may be suitable for Michelle. Michelle receives personalised recommendations about jobs that fully match her skills, as well as about jobs that match her skills partially. Michelle may also further personalise these recommendations and filter them according to her specific criteria, such as the location of the job, salary, employer, etc.

Michelle is interested in one of the jobs that matches her skills partially. She then receives recommendations about courses that will give her the additional skills required for this job. Michelle enrols for these courses, in order to acquire the needed skills. When she has acquired them, she proceeds to apply for her desired job and allows the prospect employer to access the relevant Smart Badges from her ePortfolio. By using this Blockchain-based infrastructure to support her in her studies, Michelle has adopted a more efficient and targeted approach to learning, towards achieving her desired career trajectory.
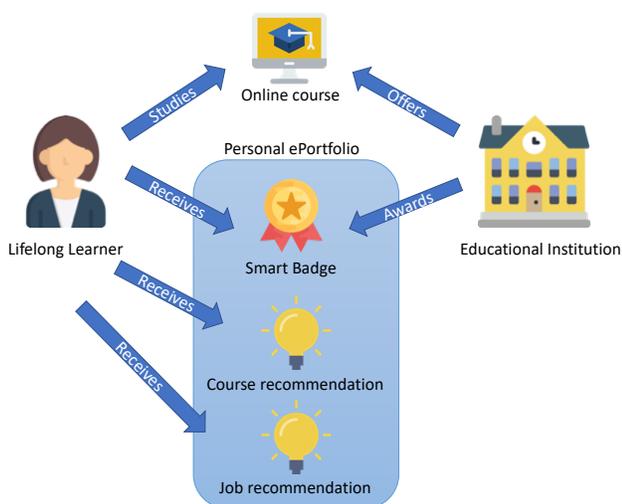

Figure 3.   Stakeholder interactions in the main scenario of the lifelong learning pilot.

Our early work on implementing this scenario can be found in [6]. This implementation has been based on the use of Smart Contracts for the Ethereum Blockchain platform [8]. Smart Contracts are defined as "automatable and enforceable agreements" [9] and they constitute one of the main features of current Blockchain platforms, including Ethereum. In order to collect job market data, we are harvesting datasets of current job offers and their associated skills from a job aggregator that has been developed by the European Data Science Academy (EDSA) project [10]. These datasets are placed in Smart Contracts on the Ethereum Blockchain and are then used for matching jobs with a learner's badge-based skills. In this way, the awarded badges are smart, in the sense that they are being used to offer recommendations to learners.

D. Consultation workshops

In order to further develop our pilot case study and to better understand the current needs of our stakeholders, we have performed a series of consultation workshops (Figure 4). These workshops have targeted different audiences in the context of renowned international conferences on open education and educational technology. So far, the workshop series has been delivered in the context of the following events:

- The EATEL Summer School on Technology Enhanced Learning (JTELSS 2019), 3-7 June 2019, Bari, Italy.
- The Association for Learning Technology Conference (ALTC 2019), 3-5 September 2019, Edinburgh, UK.
- The Online, Open and Flexible Higher Education Conference (OOFHEC2019), 16-18 October 2019, Madrid, Spain.
- The Open Education Global Conference (OE Global 2019), 26-28 November 2019, Milan, Italy.

Figure 4.   Snapshots from the consultation workshop series.

Participants in these workshops have been early and late career researchers, lecturers, technologists and professionals from the educational sector. During the workshops, participants were introduced to the overall framework of the QualiChain project, as well as the scenarios that apply Blockchain technologies in education. In particular, participants explored the ways that ePortfolios, accreditation, tutoring, as well as other aspects of teaching and learning can evolve within a decentralised ecosystem based on the Blockchain.

E. Findings

In order to document requirements for the further development of our pilot case study, we asked participants of

our consultation workshops to produce learning scenarios that make use of Blockchain technologies in the context of lifelong learning. More specifically, participants were asked to work in small groups in order to brainstorm the following aspects of learning scenarios:

- *Persona(s):* Who are the typical users in this scenario and what do they wish to accomplish?
- *Requirements:* Documented in the following format: As Persona "X", I want to do "Y", so that I achieve "Z".
- *Use of Blockchain:* How can the Blockchain be used in this scenario?
- *Related resources:* Any links/publications/other resources that are relevant to this scenario.

These group brainstorming activities were followed by plenary discussion sessions, where participants presented and discussed their scenarios. Figure 5 summarises the main findings from the group activities and discussion sessions. These findings are presented in the form of requirements derived from the learning scenarios produced by participants of the workshops, as well as from the main takeaway points of the discussion sessions.

Figure 5.   Requirements collected from the participants of the consultation workshop series.

First of all, participants pointed out the need for ePortfolios to aggregate both formal and informal qualifications that will be easily validated by employers and educational institutions. This will help streamline the admission processes in universities and the hiring processes by employers, as well as eliminate falsified qualifications.

Participants also highlighted the need for learners to be guided on how to build lifelong learning pathways in order to achieve their learning goals. These learning goals can be aligned with job market needs for improving the learner's employability, or they can be associated with the learner's personal progression ambitions. Acquiring micro-credentials can help lifelong learners achieve these goals by studying short online courses and earning professional or academic credentials [11][12]. Micro-credentials are rapidly emerging and gaining popularity among lifelong learners, as they address their needs for granular certified learning. Renowned educational institutions from around the world are currently offering a continuously increasing range of micro-accredited courses, thus providing opportunities to pursue further study in a variety of specialised fields [13]-[16].

Career counselling was also featured in the learning scenarios and discussions of participants of the workshops. It was pointed out that job seekers are in need of acquiring a comprehensive overview of the job market and the latest market trends, so that they can make informed decisions about the next steps in their careers.

Finally, data ownership and privacy requirements were deemed quite important by participants of the workshops. It was highlighted that learners and job seekers should own their digital identity and the data in their ePortfolio. Additionally, they should be able to control who accesses their identity and their ePortfolio, which data are accessed and for how long.

These requirements largely validate the scope of the QualiChain lifelong learning pilot, while helping us further expand it. In particular, we will be addressing the validation of both formal and informal qualifications in the form of Smart Badges. We will also be facilitating the building of lifelong learning pathways via personalised course recommendations, which will help learners choose their next online or offline course, towards achieving their learning goals. Additionally, the personalised course recommendations will include micro-accredited courses, in order to facilitate the acquisition of micro-credentials by lifelong learners.

With regards to the career counselling requirement, personalised job recommendations will provide job seekers with advice on their next career steps. We are also contemplating offering detailed overviews of the job market and its latest trends via interactive dashboards, based on the ones we have developed in the context of the EDSA project [10].

We will be extending our pilot case study to address data ownership and privacy requirements by employing decentralisation solutions, such as the Solid platform [17] and the FAIR TRADE framework [18]. Solid is a decentralised platform for social web applications, where the data of users is managed independently of the applications that create and consume this data. This approach enables users to choose where their data resides and who is allowed to access it. The FAIR TRADE framework builds on top of the Solid approach by defining a set of dimensions relevant to data management in decentralised contexts. The framework can therefore be used for describing and evaluating the management of decentralised data solutions, as well as for the development of best practices in the developing field of decentralised data management.

Finally, we will be looking into ways of implementing Self-Sovereign Identity (SSI) for learners and jobs seekers. SSI is a technology that adds a layer of trust to digital interactions, thus allowing individuals to own and manage their digital identity [19]. There are several implementations of SSI in the literature, largely based on the use of Blockchain technology [20]-[22].

IV. CONCLUSIONS AND NEXT STEPS

This paper has presented a pilot case study for supporting lifelong learning via Smart Badges and personalised recommendations. The pilot case study employs Blockchain technology for providing lifelong learners with transparent and immutable educational accreditation. It also uses personalised recommendations for helping lifelong learners reach their personal and professional learning goals. This pilot is part of the QualiChain initiative for decentralising education and employment qualifications using Blockchain technologies.

Engaging the communities of stakeholders has provided us with a valuable insight into the lifelong learning challenges they face and their proposed solutions. This insight will help us further shape the requirements and the implementation of our pilot. We will continue consulting with the communities of stakeholders throughout the different implementation phases of our pilot, so as to better understand and address their needs.

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