SKILLS
INSTRUCT
INSTRUMENTS
CONSTRUCTION

# Deploy and adapt the tools for facilitating energy skills registers

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## Glossary

| Acronym | Full name |
|---|---|
| CA | Consortium Agreement |
| EC | European Commission |
| EASME | The Executive Agency for Small and Medium-sized Enterprises |
| GA | Grant Agreement |
| PC | Project Coordinator |
| WP | Work Package |
| TL | Task Leader |
| DoA | Description of Action |
| PSC | Project Steering Committee |
| SQM | Scientific and Quality Manager |
| DEC | Dissemination and Exploitation Committee |
| KOM | Kick-off meeting |
| ASM | ASM – Market Research and Analysis Centre |
| VTT | Technical Research Centre of Finland |
| LIST | Luxembourg Institute of Science and Technology |
| RIL | Finnish Association of Civil Engineers |
| CU | Cardiff University |
| R2M | Research to Market Solution France |
| DTTN | Distretto Tecnologico Trentino |
| ENEFFECT | Center for Energy Efficiency EnEffect |
| GER | General Exploitable Result |
| AB | Advisory Board |
| PM | Person month |
| M | Month |
| EE | Energy Efficiency |

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## Abstract

With the growing impact of the construction industry and the climate emergency upon us, the construction sector is looking to coordinate its efforts, with regards to energy efficiency. Training has been demonstrated to be a valuable tool in this direction. However, there are several barriers that contribute to the fragmentation of the sector. This report, within the context of the INSTRUCT project, draws on previous work and the collected data, to present digital solutions for the enhancement of the link between training and energy efficiency. It seeks to present concrete solutions and their development, as they will eventually be integrated in the web-based digital platform Energy-Education (https://www.energy-education.com/ ). Overall, the focus is placed on responding to the following requirements: 1. The elicitation of functional requirements. 2. The deployment and eventual adaptation of existing competency/skill matrices in the system, the update and continuous feeding of the database of energy-related training modules across EU. 3. The development of additional widgets that would be required to the portal 4. The development of a web interface adapted to mobile devices. 5. Information package for home and building owners. The proposed solutions include the extension of the https://www.energy-education.com platform, a development of a Blockchain based training platform concept, an Instruct User Interface to Blockchain training, and an NLP -based LO Matrix to facilitate measuring cross qualification scheme similarities among LOs.

## 1. Introduction

The construction industry is growing exponentially and there is a need to coordinate efforts, in order to overcome the currently fragmented landscape regarding energy efficiency (INSTRUCT, 2021). The aim of this report is to highlight the ways with which an ongoing, dynamic digital platform will integrate the needed tools to promote, continuously develop a basis for facilitating skills registers and training material.

This report is an intermediary stage within the context of the INSTRUCT project between previous and future work, by using as its basis previous work and the results from the consultations (interviews, questionnaires, use cases, workshop insights). By integrating the collected data, which connects energy efficiency and training, it looks to integrate them into a digital platform that will facilitate the use of tools developed for this purpose. The requirements for the digital platform translate into the following requirements:

“(a) Training organisations to register their training offers and associated learning outcomes, (b) Accreditation organisations to assess these and publish their accreditation outcomes, (c) White and blue workers to register their skills and trainings, and (d) Employers to search and recruit the skilled workers most suited to their job across Europe. It is interesting to note that the job market has been deregulated as a result of the ongoing pandemic and the restriction of movements of staff. The recruitment of skilled workers, therefore, transcends existing geographical boundaries while promoting a competitive landscape for skilled workers adapted to a wide range of country-specific organisational and cultural work practices across Europe” (INSTRUCT, 2021)

These requirements have been translated into specific solutions (INSTRUCT, 2021):

1. The elicitation of functional requirements. A survey will allow the team to fine tune the usage scenarios and required modules. A survey will allow the team to fine tune the usage scenarios and required modules.
2. The deployment and eventual adaptation of existing competency/skill matrices in the system, the update and continuous feeding of the database of energy-related training modules across EU.
3. The development of additional widgets that would be required to the portal, including skills register.
4. The development of a web interface adapted to mobile devices.
5. Information package for home and building owners. (INSTRUCT, 2021)

The proposed solutions include the extension of the INSTRUCT energy-education.com platform, the Blockchain based training platform, and the INSTRUCT User Interface, based on the needs that were identified in previous work, which incude the principles of: 1. Trust, 2. Self-Sovereingty, 3. Transparency, 4. Immutability, 5. Decentralisation, 7. Collaboration. Further to that, an NLP -based LO Matrix is proposed, to facilitate measuring cross qualification scheme similarities among LOs.

As mentioned in previous work (INSTRUCT, 2021), in the context of the INSTRUCT project, the following services have been developed:

a. **passports/registers for workers at regional/national level and support for their take up at EU level.**

b. **mobile applications facilitating the comparison of workers' skills and qualifications between countries**

   The digital platform is adaptable to being viewed on a mobile layout.

**c. new legislative frameworks or public procurement practices**

A number of solutions have been proposed, in previous work, which have been organised into subcategories. These include public certification support schemes for investors and building owners, Public certification mandatory schemes for people and companies, sustainable procurement practices for contractors and suppliers, and voluntary agreement between people/companies and authorities (INSTRUCT, 2021).

**d. initiatives for home and building owners**

The solutions that are proposed include: legal and fiscal frameworks, technical and performance requirements and an overview of possible energy efficiency interventions carried out in real cases (INSTRUCT, 2021).

**e. new partnerships with producers and retailers.**

The solutions proposed in previous work, include: procurement partnerships where companies can communicate with producer and retailers, and subcontracting partnerships, as a solution to aim at more efficient solutions (INSTRUCT, 2021).

To conclude, the present document addresses the above objectives and is structured into 7 chapters. Following this introduction, Chapter 2 provides a review of the related research and Chapter 3 analyses the methodological rationale that was followed. Chapter 4 explains how the digital tools were deployed and adapted into the https://www.energy-education.com platform, Chapter 5 presents the Blockchain based training platform concept, and Chapter 6 presents the Instruct User Interface to Blockchain training. Chapter 7 presents furthermore, an NLP-based LO Matrix tool. Lastly, Chapter 8 concludes this report.

## 2. Related Research

As the digital world evolves, technology has become an integral part of our daily life, opening possibilities in how we operate. Education is also growingly intertwined with digital strategies which offer alternatives and assist in keeping up with the continuous developments. As Collins et al. (2003) argue, there are several parametres to be taken into consideration as far as pedagogy is concerned, such as “opportunity for use, quality of knowledge gained, and student’s level of acceptance” (Collins et al., 2003). They also highlight the importance of making sure that the e-learning strategies are addressing the needs of all stakeholders in the field (Collins, 2003). There are exciting opportunities lying ahead with regards to the possibilities of education in a digital environment that can benefit both learners and educators (Mashau et al., 2021). However, it has also been argued that technology and any sense of change is not easily accepted and that there is a need to coordinate efforts between academia, the construction industry and authorities in order to evidence the benefits (Mashau et al., 2021).

**Table 3.1**
Information web sites summary.

| Name | Overview | Information access |
|---|---|---|
| AECB (the Sustainable Building Association) | Information and networking site. News, including free newsletter, free information factsheets, articles, FAQs, etc. Discussion forums | Full access to online forums, restricted 'members only' areas of the website, CarbonLite Programme, available on payment of annual membership fee |
| BRE | Research, consultancy, training, testing and certification services. Free news services; selected case studies | Services and publications available on fee-paying basis. Free access 'reduced experience' BREEAM extranet |
| Carbon trust | Practical information and resources for business and the public sector to move to a low carbon economy and develop commercial low carbon technologies for the future | Publications and case studies, searchable by category; full access available after registration (free). Multi-sectoral information but with advanced search capability |
| CIRIA | Industry briefings, guidance, CIRIA projects and research documents, including emerging technologies, regulatory and legislative changes, sustainability, etc. | Information can be accessed by theme, category, or via advanced full-text search mode accessible to all (after free registration) |
| CIS (Construction Information Service) | Expert knowledge tool delivering key technical information. Provides full-text access to regulations, standards, technical advice, news and briefings | Available on an annual subscription basis. Subscription allows fully searchable information delivery tailored to user's needs |
| Construction skills | Sector Skills Council for construction web site, in partnership with CITB-Construction Skills and the Construction Industry Council (CIC) | Strategic initiatives, research, news and Skills Update regular newsletter (requires free registration). Industry feedback surveys |
| DECC | Department of Energy and Climate Change web site. Information on consultation, legislation, statistics, etc. | Most publications are free. News distribution service, with filtering capabilities after free registration |
| Energy saving trust | Free advice for personal, business and public sector, and communities, on reducing $CO_2$ emissions. Case studies, publications, FAQs, etc. | Free registration for updates and support relevant to user/organisation. Searchable publications and reports library |
| Envirowise | Free, independent, practical advice for improving processes, profitability and competitiveness in Welsh businesses and public sector organisations | Events, key issues, sector services, and newsletters available on registration (free) |
| Green Spec | Directory of sustainable construction products, briefing notes, guides, white papers, research, CPD seminars | Free information access, including search capability. Opinion section inviting views from leading industry commentators |
| Zero Carbon Hub | Information to facilitate delivery of low and zero carbon homes. Examples of low carbon solutions, training, skills | Web site still under construction. Free information including library and small news centre with press releases |
| Sustainable Building wiki | Interactive web based information resource for anyone wishing to learn about sustainable building | Anyone can view, add to and edit the content. Requires account registration (free) |
| WRAP | Information to help individuals, businesses and local authorities to reduce waste, recycle, better use resources, and tackle climate change | Free access to tools and guidance including publications and searchable news section. Dedicated construction section |

*Figure 1. Information Web Sites Summary, ( Source: Petri et. Al, 2014)*

The construction sector specifically is characterised by fragmentation, with several barriers present such as economic barriers, awareness-related barriers, legal barriers, market barriers, and knowledge barriers (European Commission, 2018). Adequate educational strategies and training are a very helpful tool to coordinate efforts. So far, the INSTRUCT project, through a process of consultation which included 52 participants for a questionnaire, 15 participants from 8 European countries for a workshop, and 28 interviewees from 9 European countries for interviews, has identified five themes present, which hinder this process:

"1. Lack of access to useful information, knowledge, and best practice guides for energy-efficient interventions.

2. Lack of demand for skilled workforce in energy efficiency.

3. Lack of availability, or inadequate, training programs (in terms of scope, quality, content, cost, etc.).

4. Lack of shared vision and values for energy efficiency across the supply chain.

5. Inadequate policy landscape, including lack of government incentives" (INSTRUCT, 2020) Especially in the last decades, as argued by Tayeh et al. (2019), there has been a growing focus on means to resolve the multiple and complex landscape, in terms of content, data sharing and better communication across the whole value chain. As evidenced by Petri et. al (2014), there is a plethora of information web sites which aim at organising the construction industry (Figure 1), which however, often lack taking into account adequately the user experience (Petri et. Al, 2014). Some of the insights on these limitations stemming from an in-depth analysis, as presented by Petri et al (2014) are the limitations in construction-specific interfaces, in some cases unavailability of free training – as well as the availabinity for tools only for a fee, an unavailability of a clear picture about the sequence of training needed for training, as well as the prioritisation of information, lack of news services and

newsletters, need for more active engagement by members in discussion forums, and, lastly, the lack of in-depth analysis of best practices.

As far as educational digital tools and digital platforms for educational purposes, there has been a variety of approaches developing. For example, the INES (INtelligent Educational System) is an online learning platform which combines Learning Management Systems, Learning Content Management Systems, and Intelligent Tutoring Systems. (Fonte et. Al, 2009). Other examples include Blackboard which is an international learning platform, as well as the online platform Coursera, which collaborates with universities around the world, to provide training.

With regards to energy efficiency and training, specifically in the construction sector, there are relevant examples of initiatives. Such examples are presented in Table 1. For example, CraftEdu is a database developing qualifications and training for craftsmen, and optimized from a user perspective. Another example, in the Bulgarian context, the Build in Green platform aims at providing theoretical content to trainees, on several subjects. The driving concept behind the platform is also providing a correspondence between the training courses a set of desired learning outcomes.

| | **Platforms for energy efficiency training in the construction sector** | **URL** | **Description** |
|---|---|---|---|
| 1 | CraftEdu | https://www.craftedu.eu/ | "A database developing qualifications and training for craftsmen, and optimized from a user perspective." (CraftEdu. 2021) |
| 2 | Build in Green (Bulgaria) | | Platform aims at providing theoretical content to trainees, on several subjects. The driving concept behind the platform is also providing a correspondence between the training courses a set of desired learning outcomes. |
| 3 | Construction Blueprint | https://constructionblueprint.eu/ | "Construction Blueprint is a European project, belonging to the Erasmus+ Programme, for implementing a new strategic approach to sectoral cooperation on skills. Construction Blueprint is a European project, belonging to the Erasmus+ Programme, for implementing a new strategic approach to sectoral cooperation on skills". (Construction Blueprint, 2021) |
| 4 | PassivHaus | https://passiv.de/ | "Independent institute for maximum energy efficiency in buildings". (PassivHaus, 2021) |
| 5 | BIMCERT | https://platform.energybimcert.eu/ | "BIMCERT provides an easily accessible portal for training the vast middle tier of construction industry supply chain professionals of all profiles". (BIMCERT, 2021) |

| | | | |
|---|---|---|---|
| 6 | CIET Sustainable Energy Training | https://cietcanada.com/ | "The Canadian Institute for Energy Training (CIET) is the most active energy training centre in Canada, both in person and virtually, as well as a leading international training center. We specialise in high-quality energy management and energy efficiency training, ensuring participants are ready to lead the energy transition." (CIET Sustainable Energy Training, 2021) |
| 7 | The Passivhaus Trust (PHT) | https://www.passivhaustrust.org.uk/ | "The Passivhaus Trust (PHT) is an independent industry leading organisation that promotes the adoption of Passivhaus in the UK. PHT is part of the global Passivhaus movement and the UK affiliate of the International Passive House Association (iPHA)". (The Passivhaus Trust, 2021) |
| 8 | Quidos | https://quidos.co.uk/ | "Energy assessor accreditation scheme and training centre for professionals in a built environment". (Quidos, 2021) |
| 9 | Chartered Institution of Building Services Engineers (CIBSE) | https://www.cibse.org/ | "Promotes the career of building services engineers by accrediting courses of study in further and higher education, by approving workbased training programmes and providing routes to full professional Registration and Membership, including Chartered Engineer, Incorporated Engineer and Engineering Technician". (CISBE, 2021) |
| 10 | Building Services Research and Information Association (BSRIA) | https://www.bsria.com/uk/ | "Non-profit distributing, member-based association promoting knowledge and providing specialist services for construction and building services stakeholders. Its mission is to make buildings better by improving their environmental, operational and occupational values, and by supporting the industry by providing guidance and solutions". (BSRIA, 2021) . |
| 11 | Online database of the Ministry of Education and Science (Bulgaria) | | Electronic training aids (PPTs and textbooks) for the new discipline for professional high schools "Ecologic and energy efficient construction". Two sets were developed: "Basic principles of energy efficient buildings" and "Airtightness and ventilation". |
| 12 | React Project | https://reactproject.eu/ | "The REACT project aims the creation of a European Energy Efficiency in Buildings Technician Qualification. This qualification on energy efficiency will be built with a view on its potential harmonization among all European Union countries and developed for a b-learning approach. The target groups are workers currently in the energy efficiency field who want to update or upgrade their qualification, workers in need to reskill and unemployed people". (React Project, 2021) |
| 13 | Train-to-nZEB mobile app | https://www.train-to-nzeb-app.com/ | Mostly been used for reference purposes (e.g. a builder wants to check something on the site), and not for training or education. |
| 14 | The Green Register of | https://www.greenregister.org.uk/ | "The Green Register trains construction professionals from all disciplines of the industry to build better, more |

| | | | |
|---|---|---|---|
| | Construction Professionals | | sustainable buildings". (The Green Register of Construction Professionals, 2021) |
| 15 | Association for Energy Affordability | https://aea.us.org | "The Association for Energy Affordability, Inc. is dedicated to achieving energy efficiency in new and existing buildings in order to foster and maintain affordable and healthy housing and communities, especially those of low-income". (Association for Energy Affordability, 2021) |
| 16 | Energy-Bim Platform | www.energy-bim.com/ | Digital platform aming at documenting, organising and identifying needs in the field of BiM training for energy efficiency. |
| 17 | Energy-Education Platform | www.energy-education.com | INSTRUCT project web based platform for training for energy efficiency – currently developing (focus of this report) |
| 18 | Better Buildings U.S Department of Energy | https://betterbuildingssolutioncenter.energy.gov/ | "Better Buildings is an initiative of the U.S. Department of Energy (DOE) designed to improve the lives of the American people by driving leadership in energy innovation. Through Better Buildings, DOE partners with leaders in the public and private sectors to make the nation's homes, commercial buildings, and industrial plants more energy-efficient by accelerating investment and sharing successful best practices". (Better Buildings U.S Department of Energy, 2021) |
| 19 | The Tywi Centre | https://www.tywicentre.org.uk / | "Promotion of the care and repair of the old buildings of West Wales through providing information, training and support to homeowners, builders, agents and building professionals". (The Tywi Centre, 2021) |
| 20 | House of Training | https://www.houseoftraining.lu/training/domain/architecture-ingenierie-urbanisme-167 | "The House of Training's vocation and principal mission is to offer continuing vocational training programmes designed to meet the needs of the Luxembourgish economy". (House of Training, 2022) |

*Table 1. Overview of platforms for energy efficiency training in the construction sector*

The BIM4VET platform and the BIMEET applications are closely aligned to the scope of this study and the report. The BIM4VET project, which was funded by the EC ERASMUS+ program, was focused on developing a European skills matrix for BIM stakeholders (INSTRUCT, 2021). The application included an SQL database, a recommender engine, and Tulip-CPS (INSTRUCT, 2021). Similarly, and as a direct predecessor of the current digital platform, the BIMEET project released Energy-BIM platform (www.energy-bim.com ) fed into the current web solution (www.energy-education.com), which acts as a comprehensive training repository for energy training requirements.

## 3. Methodology

The report draws on previous work in order to propose solutions that are grounded in the outcomes from the insights of the study. From a theoretical point of view, the study follows a pragmatic approach. Pragmatism focuses on offering practical solutions to the research, by taking into consideration any potential new valuable information that can inform the course of the study (Denscombe, 2014). Moreover, and aligned with the pragmatic framework, a mixed methods approach is being followed, where both qualitative and quantitative methods are being used, for better outcomes (Denscombe, 2014). The data analysis includes a collation of data from the consultations in the context of the INSTRUCT project (interviews, questionnaires, and workshop insights), regarding training programs for energy efficiency in the construction sector, in the EU context. The study has been relying on an EU- wide network of experts from the INSTRUCT consortium and beyond. The consultation integrated insights from 52 participants for the questionnaire, 15 participants from 8 European countries for the workshop, and 28 interviewees from 9 European countries for the interviews. The study also includes insights from previous work with regards to the value of Learning Outcomes, and concerning the elicitation of requirements for the digital platform. The development of the INSTRUCT platform, the Blockchain proposed technology and the INSTRUCT User interface that are presented were based on the needs that were presented and analysed previous work, which are: (1) Trust, (2) Self-Sovereignty, (3) Transparency, (4) Immutability, (5) Decentralisation, (6) Collaboration (INSTRUCT, 2021). Semantic web and Blockchain technology are proposed as a solution to these requirements, for the enhancement of the digital INSTRUCT platform, energy-education.com. To address the above requirements, the following services have been developed :

a. passports/registers for workers at regional/national level and support for their take up at EU level.
b. mobile applications facilitating the comparison of workers' skills and qualifications between countries,
c. new legislative frameworks or public procurement practices,
d. initiatives for home and building owners, and,
e. new partnerships with producers and retailers.

# 4. Demonstration of the https://www.energy-education.com/

We present below the architecture of the platform alongside dedicated services that were adapted and deployed as tools to support energy skills registers.

## 4.1. Context

The consultations previously conducted in the context of the INSTRUCT project have resulted in some useful requirements that have been implemented in the platform. It was documented how the field of training for energy efficiency lacks coordination when it comes to the several stakeholders in the construction industry in the EU, but also that there is an issue of awareness as well as adequate training being disseminated. Furthermore, inadequate legislations and supporting policies, were found to be one of the most critical barriers that weaken the link between training and energy efficiency.

In addition to that, in the context of the INSTRUCT project it was argued how the digital tools used for the coordination of collective efforts concerning training for energy efficiency would need to satisfy key requirements for such technology, including: trust, self-sovereignty, transparency, immutability, decentralisation, collaboration (INSTRUCT, 2021). This was translated into the following practical solutions, which the digital platform is looking to integrate and develop: "(a) training organisations to register their training offers and associated learning outcomes, (b) accreditation organisations to assess these and publish their accreditation outcomes, (c) white and blue workers to register their skills and trainings, and (d) employers to search and recruit the skilled workers most suited to their job across Europe" (INSTRUCT, 2021).

### 4.2. Energy-education.com platform

The Energy-Education platform (www.energy-education.com ) is formed by a number of services that support training management and authenticity for a community of users. The web-based platform works as a dynamic, user-oriented platform for educational purposes in the construction sector. The architecture of the platform as seen in Figure 2
, includes several functions and was develop by consulting partners of the consortium within the context of the project.


*Figure 2. The energy-education.com platform*

The platform, as described as "open, scalable and polymorphic context-based solution with modules that enable serendipitous BIM information and knowledge discovery using a symbiosis of technologies such as semantic web, social networking. The platform aims at supporting the understanding of the landscape concerning BIM training requirements for energy efficiency. The functions that it aimed at addressing are: Functionality / Services, Smart search facilities, Build and enforce sustainable training ontology, User profiles, Bi-networks for information exchange and enrichment, Interface for Shared Resources /Training/ Services, CPD facilities*.

In this context, the platform features a search service that helps document and energy-related data from an energy-knowledgebase database (Figure 3).

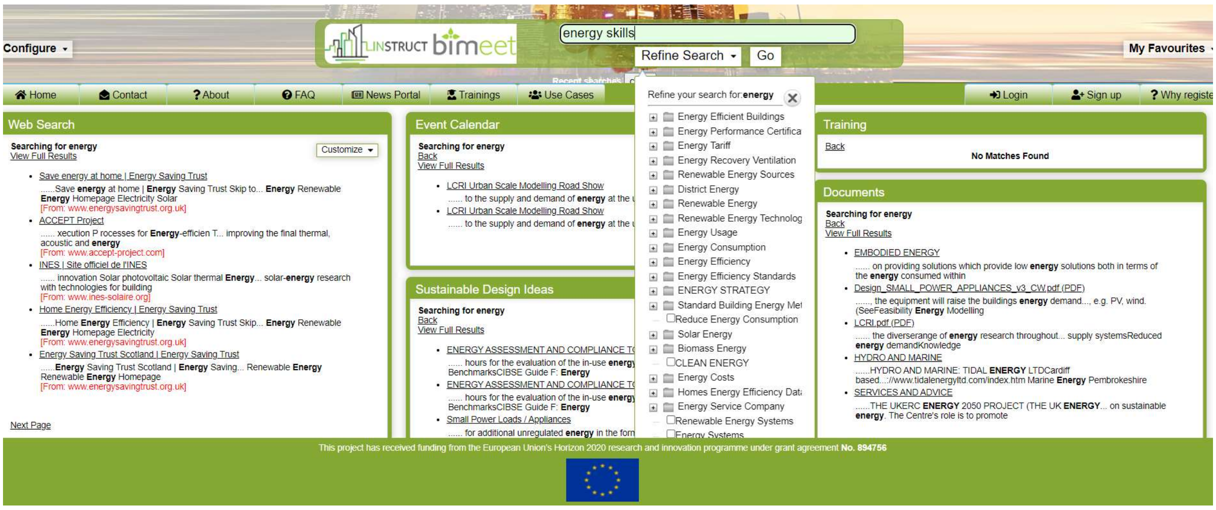



*Figure 3. The energy-education.com platform search system*

Furthermore, widges were developed, such as a Professional Networking Service (Figure 4), and Events Calendar Service (Figure 5), a Sustainable Energy Tools widget (Figure 6) and a Use Cases Widget (Figure 7).

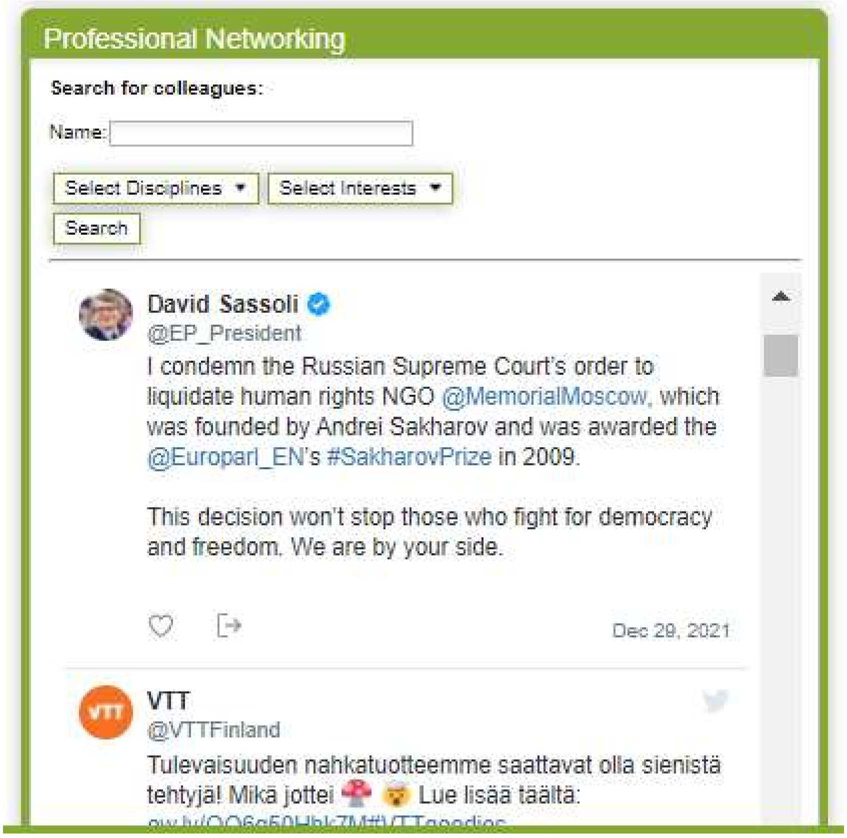



*Figure 4. Professional networking widget*

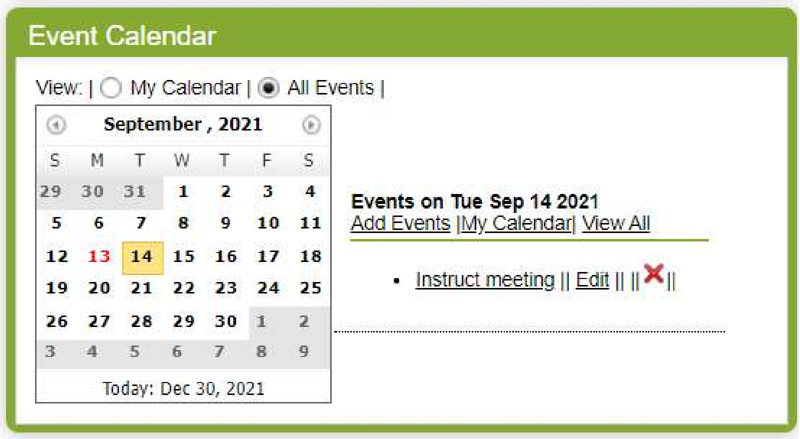



*Figure 5. The Event Calendar widget*

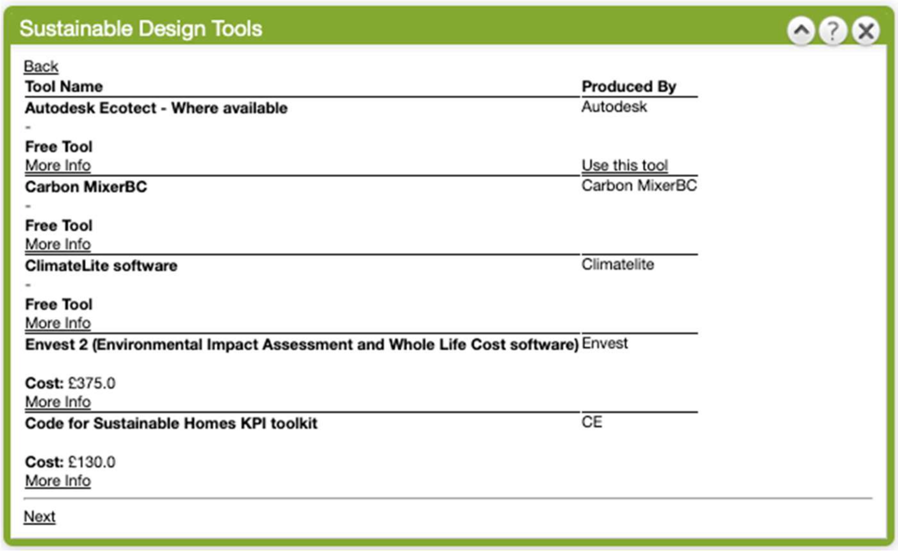



*Figure 6. The Sustainable Energy Tools widget*

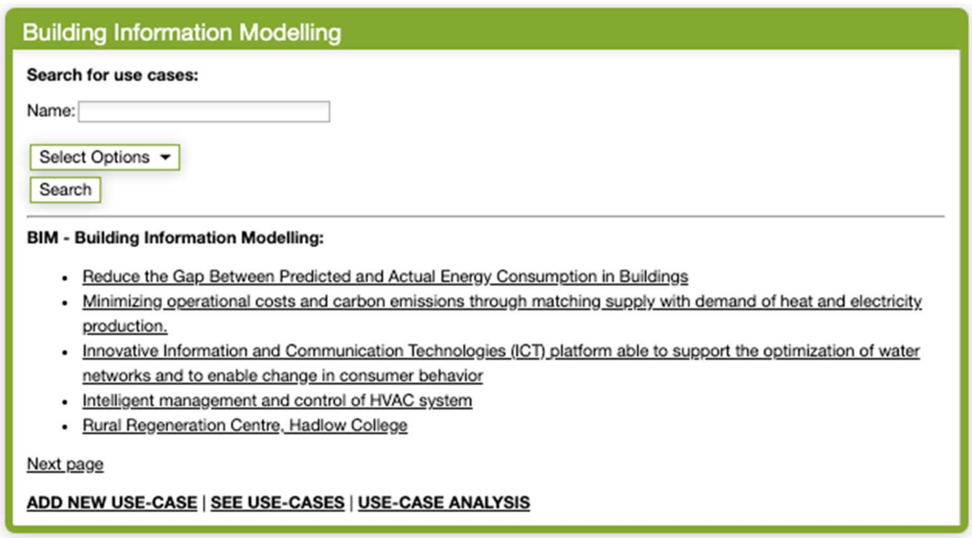



*Figure 7. The use cases widget*

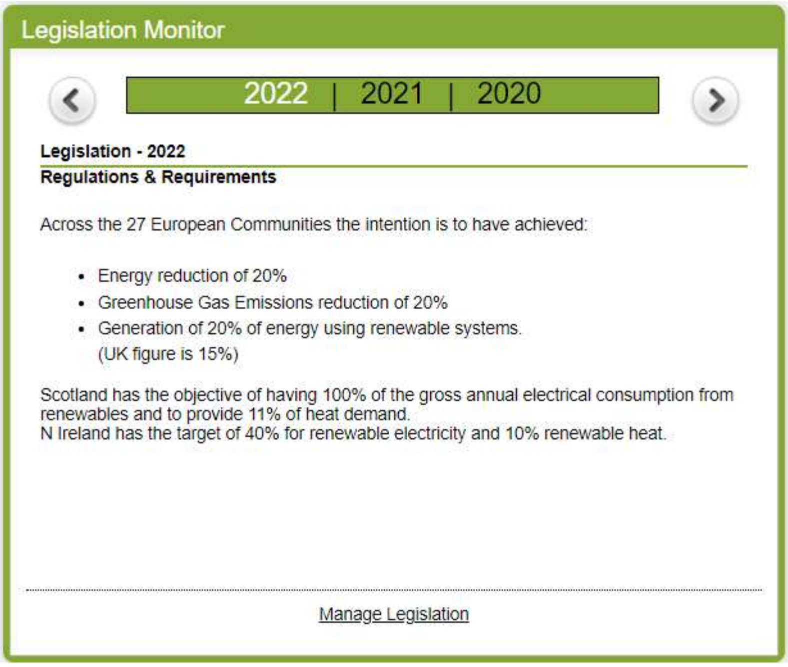



*Figure 8. Legislation for energy training and policies*

The INSTRUCT project builds on energy-education.com and looks to further develop its potentials (Figure 9). As explained in previous work "The INSTRUCT platform, a web-based system which relies on energy-education.com platform, and will host specifically for INSTRUCT the following services:
Support functions for the design of new trainings, including a training database with add and search functions, as well as an innovative mapping module for considering multiple LO matrices, a training management system, which considers the use of smart Blockchain contracts for the management of training processes.


*Figure 9. Homepage for the energy-education.com platform*

As argued in previous work, the platform includes 1. A comprehensive search service, 2. A Professional Networking Service, 3. Other services, such as an Events Calendar Service, and an Energy training Service. 4. Use cases collections, 5. A Training Database, 6. Legislation service, etc. (INSTRUCT, 2021).
With regards to tool for facilitating energy skills registers, as already analysed in previous work (INSTRUCT, 2021), there are several digital solutions which have been put forth via the energy-education.com to support energy efficiency training and education with tools for energy skills registers:

a. A Blockchain training network integrated into the energy-education.com platform to support passports/registers for workers at regional/national level and support for their take up at EU level.
b. A mobile interface using QR codes integrated into the energy-education.com platform for facilitating the comparison of workers' skills and qualifications between countries,
c. A dedicated legislation service exposed the energy-education.com to presented and inform about new legislative frameworks or public procurement practices,
d. A dedicated training service complemented with energy sustainability services to support and incentivise initiatives for home and building owners, and,
e. A professional network service and a comunity of 200+ registerd users from the field of energy efficiency aimed to facilitate new partnerships with producers and retailers.

The architecture of the INSTRUCT platform is presented in Figure 10.

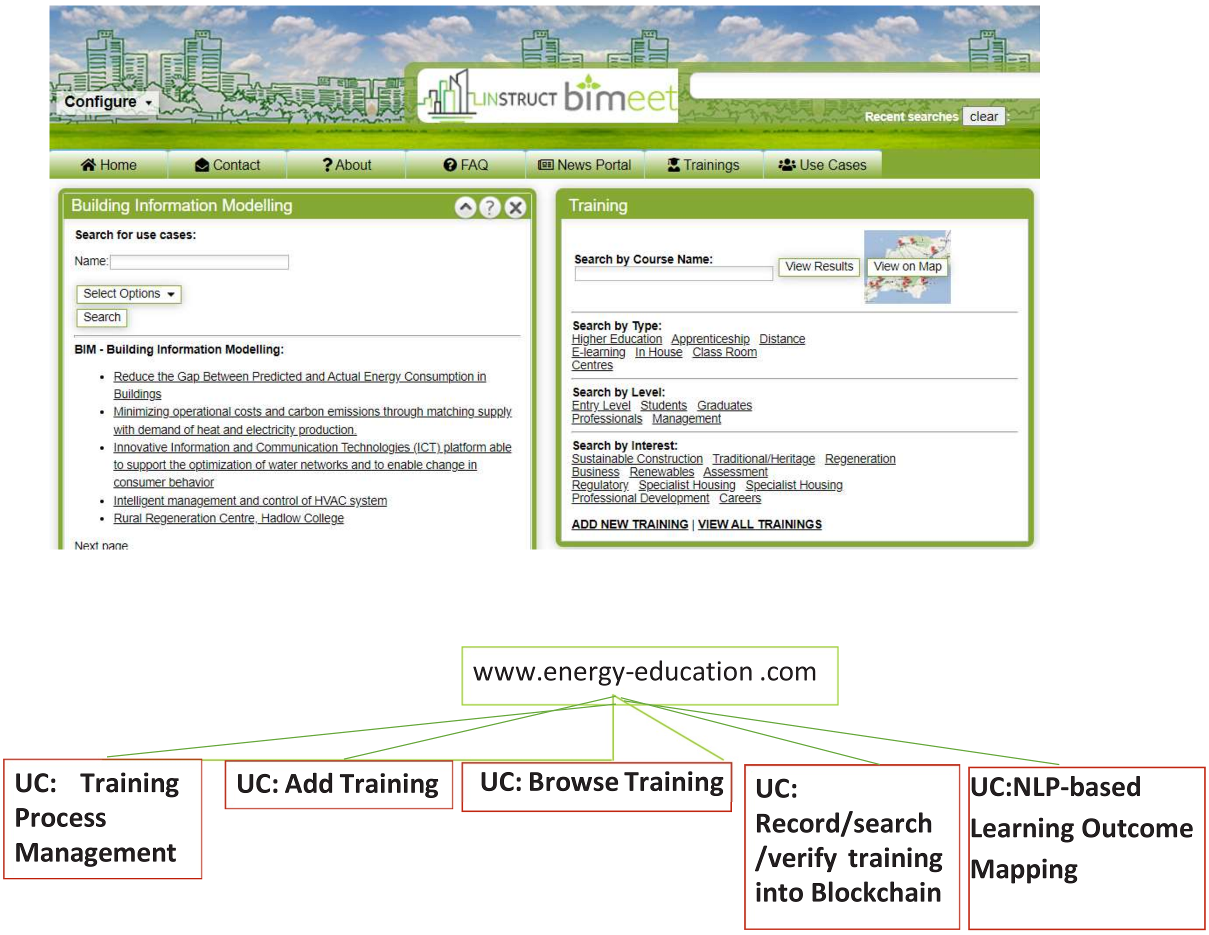



*Figure 10: Overview of INSTRUCT platform*

### 4.3 Blockchain

Blockchain is a developing technology, which has been argued to potentially be a strong solution for educational purposes. Blockchain technology offers a strong web-based solution when it comes to offering secure solutions for educational purposes (INSTRUCT, 2021). There have been several Blockchain based projects, which integrate solutions for certification and verification such as the Blockcerts project ,'CredenceLedger' , "TrueRec", Finema ," Open Certs", "BitDegree", "BCertificateD", "KRYPTED", "BLOCKCERTS", "EDGECOIN", "BIMcert", "Stampery", "Gradbase Bulgarian Open Source University", "CertiK", "Woolf, Proof Of Existence","Open Badges" (INSTRUCT, 2021).

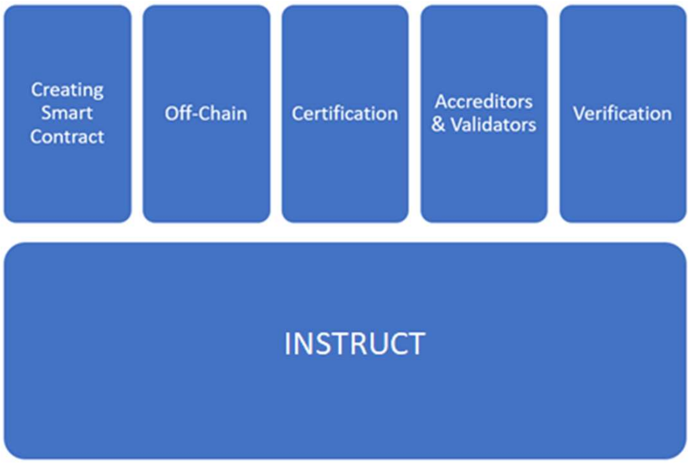



*Figure 11. Steps in a training labelling illustration for INSTRUCT*

The study in INSTRUCT is looking to integrate Blockchain as a technological solution which would enhance the functionality of the energy-education platform. Stemming from the requirements that were identified 1. Trust, 2. Self-Sovereignty, 3. Transparency, 4. Immutability, 5. Decentralisation, 6. Collaboration (INSTRUCT,2021), several solutions were proposed and developed within the energy-education.com platform:"passports/registers for workers at regional/national level and support for their take up at EU level, mobile applications facilitating the comparison of workers' skills and qualifications between countries, new legislative frameworks or public procurement practices, initiatives for home and building owners, and, new partnerships with producers and retailers." (INSTRUCT, 2021).

In this spirit, the following diagrams are proposed, as solutions for the technological architecture that would ensure such results, by using Blockchain for the INSTRUCT project. More will be analysed in Chapter 5.

# Chapter 5. Blockchain-enhanced training platform

The requirements elicited earlier in the methodology section have been addressed through a Blockchain based technology as described in the following subsections.

## 5.1. Blockchain in Education

Blockchain is a widely used technology that can provide capabilities for energy training labelling and authenticity. It works by maintaining immutable distributed ledgers across thousands of nodes, as Satoshi Nakamoto proposed in 2008 (Nakamoto 2008). Since the introduction of steam engines, electricity, and information technology, it has been regarded a component of the fourth industrial revolution. In the twenty-first century, this disruptive technology would have a profound influence on national politics, institutional activities, commercial operations, education, and people real lives. It has the ability to turn the present Internet from a "Network of Information Sharing" into a "Network of Value Exchange." Blockchain technology is predicted to transform the way business, industry, and education operate, as well as accelerate the worldwide growth of knowledge-based economies. Due to the immutability, transparency, and reliability of all transactions conducted inside a blockchain network, this cutting-edge technology provides a wide range of possible applications (Underwood 2016). At the beginning of it, blockchain technology struggled to provide widespread notification. However, as applications expanded has continued to operate securely and consistently over the years, society has grown aware of the great possibilities of the underlying technology in its application to not just cryptocurrencies but also to a variety of different of other industries (Collins 2016).

Swan (2015) outlined three stages of blockchain application development: Blockchain 1.0, 2.0, and 3.0. Blockchain 1.0 is the use of cryptocurrency to purchase products and services. Blockchain 2.0 includes more than just currency transactions, such as stocks, bonds, lending, smart property, and smart contacts. Blockchain 3.0 is creating blockchain applications for government, health, science, education, culture, and art.

Although researchers discussed the potential use of blockchain technology (Swan 2015), a number of studies examined how blockchain technology may be utilised in education (Devine 2015).

Some universities and institutions already employ blockchain technology to facilitate academic degree administration and summative assessment of learning outcomes (Skiba 2017). Blockchain can actually generate and formulate the transcript. In formal education, this includes learning outcomes, student accomplishments, and academic certifications. Also included in the informal learning environment are information regarding research, skills and online learning as well as personal hobbies. These data may be securely stored and accessible through a blockchain network. The University of Nicosia is the first institution to employ blockchain technology to maintain MOOC certificates (Sharples and Domingue 2016). Sony Worldwide Education created a global assessment platform to store and manage degree information using blockchain technology (Hoy 2017). MIT and Learning Machine also collaborated on a blockchain-based digital credential for online learning. Students who visited MIT Media Lab projects and completed the test will obtain a certificate recorded on a decentralized network (Skiba 2017). Example of blockchain-enabled digital certificates can be seen in Figure 12. Furthermore, Holberton School is the first institution to use blockchain technology to record degrees. The blockchain may connect any educational data to a user's unique ID. It incorporates classroom instruction, micro-project experience, and macro-educational foundation. Blockchain technology can minimize degree fraud. As there have been several incidents of degree fraud. The data associated with users' ID and kept in blockchain are examined, confirmed, and maintained by miners from anywhere in the world. Blockchain is a trustworthy distributed ledger whereby reliability and authenticity are guaranteed, reducing degree fraud.

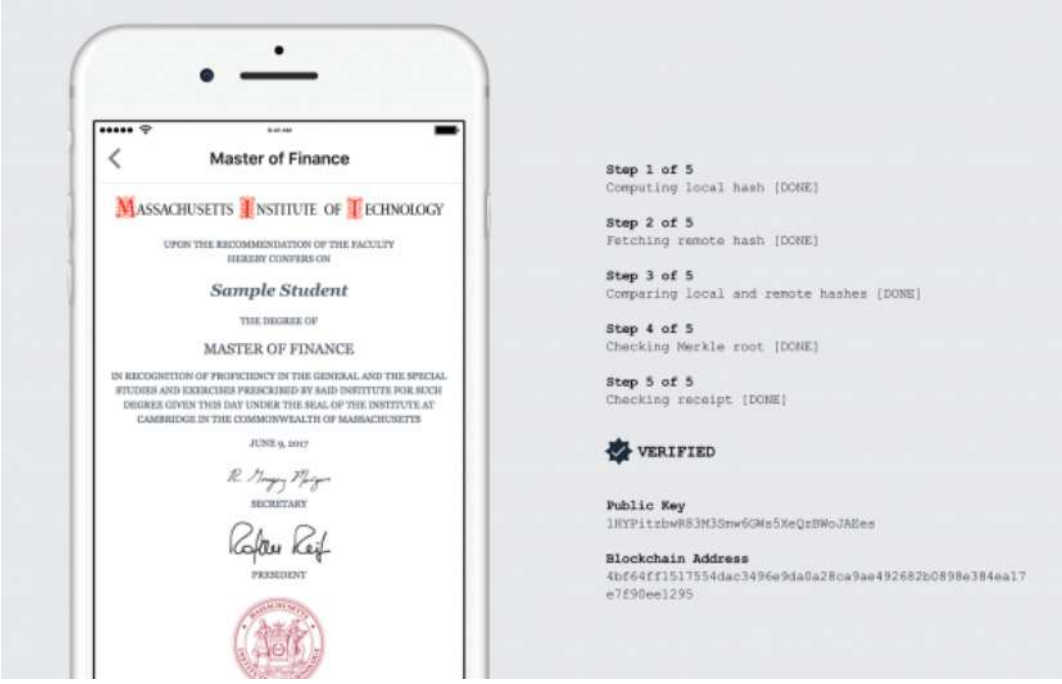



*Figure 12: Example of blockchain-enabled digital certificates, source: www.news.mit.edu*

## 5.2 Smart Contract

A smart contract is a self-verifying, self-executing, and tamper-resistant computer programme.The first proposed concept of smart contracts was in 1994. It enables code execution without the involvement of external parties. A smart contract is composed of the following elements: value, address, function, and state. It approves a transaction as an input, executes the associated code, and initiates the output activities. States of the conceptual implementation change according to the function. Since 2008, when the cryptocurrency trend was introduced using the blockchain technology. The integration of smart contracts into blockchain technology has become a priority topic for development since it enables peer-to-peer transactions and allows for the public management of databases in a transparent and reliable environment. Smart contracts are tamper-evident and immutable. Moreover, a smart contract contains all transaction information and executes automatically. The smart contract is also implemented on several blockchain platforms using the computer language Solidity.
Solidity is a high-level programming language that is used to create smart contracts. Ethereum which is a decentralized, open-source blockchain with smart contract functionality is a developing solidity-based blockchain platform. Remix is a browser-based compiler and integrated development environment (IDE) that allows users to create Ethereum contracts using the Solidity programming language and debug transactions.

## 5.3 Blockchain-based training platform concept

To address the passport and registers for energy training, Blockchain technology is used based on the Solidity programming language and the Remix compiler and integrated within the energy-education.com platform. For the delivery of the Blockchain training a blockchain account is created for each user to join the training platform. With this account, it can be used to sign transactions and pay for a range of services, obtain certificates and authenticate as a participant in these services.

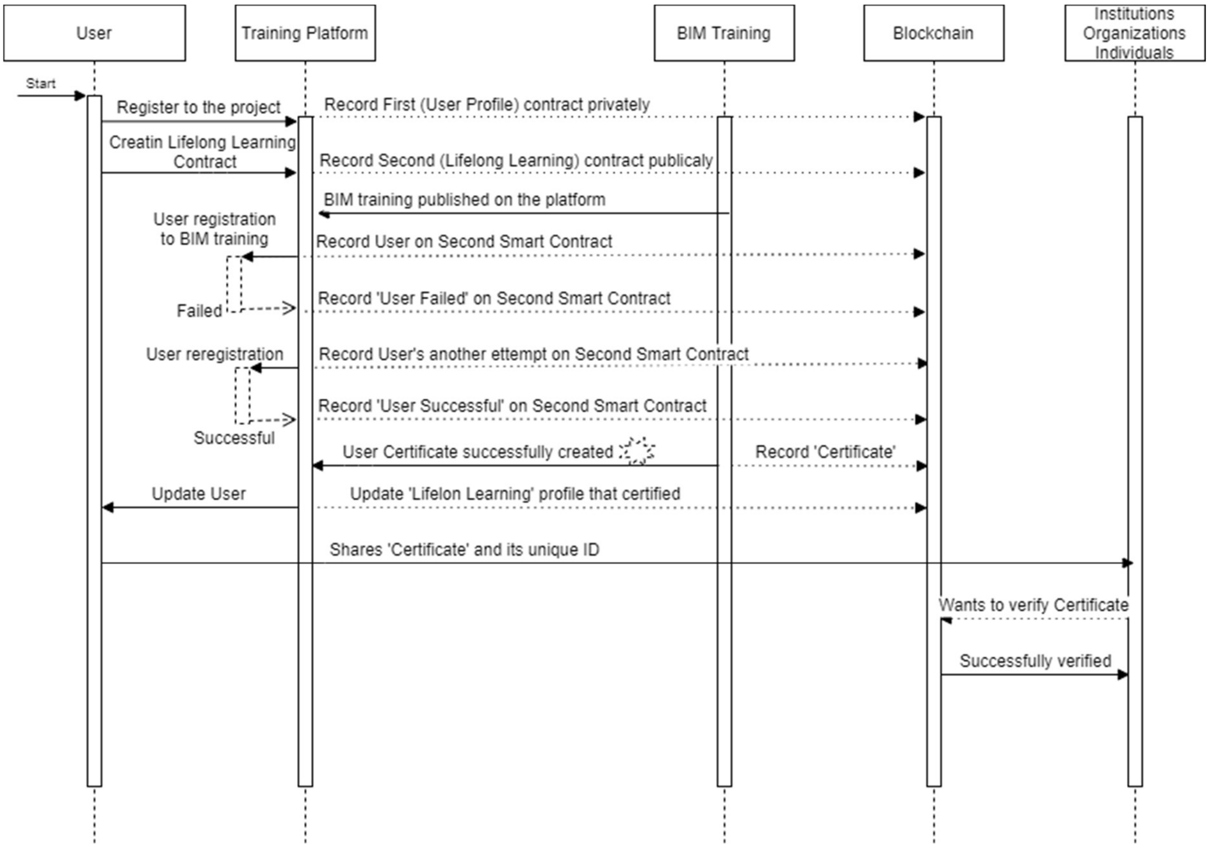



*Figure 13: Workflow of the blockchain-based training platform*

There are two types of blockchain modes of operation to consider: public blockchain and private blockchain. The main difference between them is in the level of access and control over the authorized reading/writing rights.

In the training platform, we have created two smart contracts that may be used to conduct transactions on training assets. One is a private smart contract which requires to have trusted entities for validating new users and issuing new blocks on the blockchain. This will be the main profile of users in the network.

Other one is a public permissioned deployment to manage new users' training registration and validation of smart contracts. Users will be able to read data from the chain prior to training registration verification but will not be able to write new training transactions or extract/verify chain blocks. It is considered to use as a Lifelong learning Smart contract.

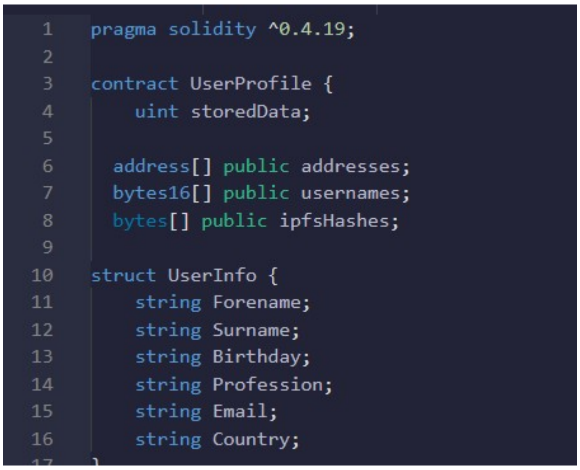
A smart contract for a new user can be developed at any time and enrolled in the training network in anywhere of the world. This network is private, and it is not accessible to the public. Following that, a second smart contract is made for the user who has already enrolled in the system, and it is assured that they can get the trainings via this account. This account is a public account, which means that any public member can see the transactions on the network.

Every user activity such as training session and billing transactions on the training platform recorded to Blockchain by using the Smart Contract. Therefore, the system can monitor when, what training has been taken, and the grade of the training, its validity, the due date if there is, and potential outcomes.

## 5.4 Remix Ethereum Implementation

We develop our Solidity programmes using the Remix Browser platform. Initially, the first smart contract is created as a User Profile that included user forename, surname, birthday, profession, email and country. Using this Smart contract, the username and address will be visible to all users, however the date of birth, email address, and other personal details will be recorded as private information. Being private ensures that this person's information is secured, while leaving the username and address as public makes it easier to find when searching an index. Figure 14 shows the codes and features for the private contract, User Profile.

Lifelong Learning is a separate contract that is publicly accessible and will be published to the Blockchain network via the training data associated with the user's personal account. On the Blockchain Network, it will be possible to see the title and score of a training, as well as the validity, link, and outcomes of the training program. As a result, any company or institution will have access to all of the relevant information on what training has been received and completed, as well as the outcomes, score and link of the training program. Figure 14 provides a general representation  of the smart contracts including the codes and attributes for the public contract, Lifelong Learning contract.

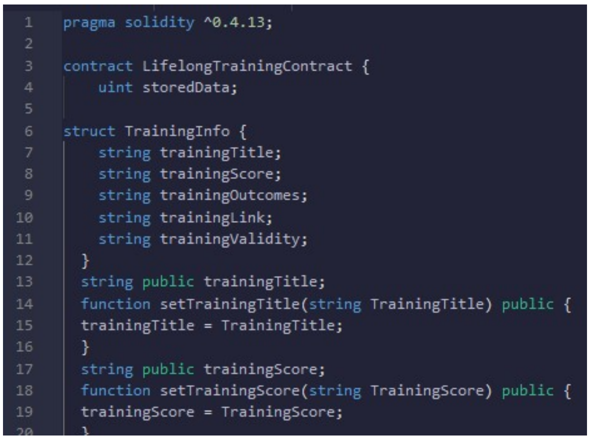


```
pragma solidity ^0.4.19;

contract UserProfile {
    uint storedData;

  address[] public addresses;
  bytes16[] public usernames;
  bytes[] public ipfsHashes;

struct UserInfo {
    string Forename;
    string Surname;
    string Birthday;
    string Profession;
    string Email;
    string Country;
```



```
pragma solidity ^0.4.13;

contract LifelongTrainingContract {
    uint storedData;

struct TrainingInfo {
    string trainingTitle;
    string trainingScore;
    string trainingOutcomes;
    string trainingLink;
    string trainingValidity;
  }
  string public trainingTitle;
  function setTrainingTitle(string TrainingTitle) public {
  trainingTitle = TrainingTitle;
  }
  string public trainingScore;
  function setTrainingScore(string TrainingScore) public {
  trainingScore = TrainingScore;
```

*Figure 14: A sample smart contract code to create for a) User Profile and b) Lifelong Learning Contract*

### 5.5 Remix Ethereum Deployment

A smart contract has been deployed to the Ethereum Remix platform using the deploy button, then the transaction is completed, and the address of the smart contract becomes visible. This means that all information associated with an energy training will be recorded to Blockchain, and this will be costed as a gas value. For both contracts, the deployment phase can be seen in Figure 15.

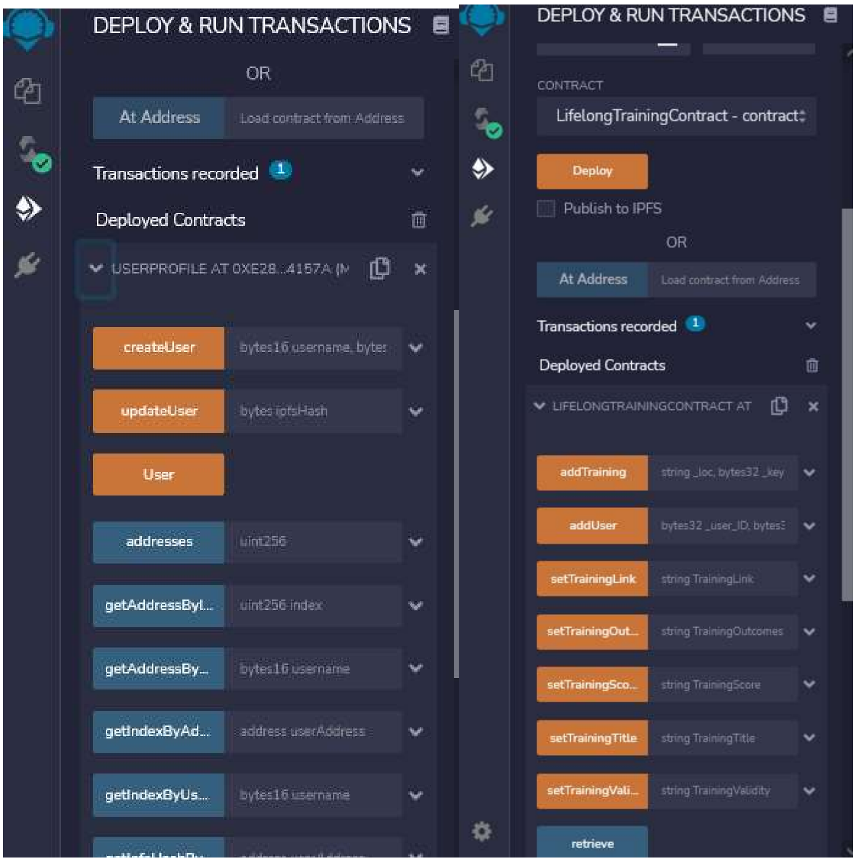


*Figure 15: Deployment of Smart contracts for both User Profile and Lifelong Learning Contract*

The gas value price is a value determined by the transaction's author, who must pay (gas price * gas amount) from the sending account. The gas price for one of our transactions can be seen in Figure 16 for the User Profile and for the Lifelong Learning contract.

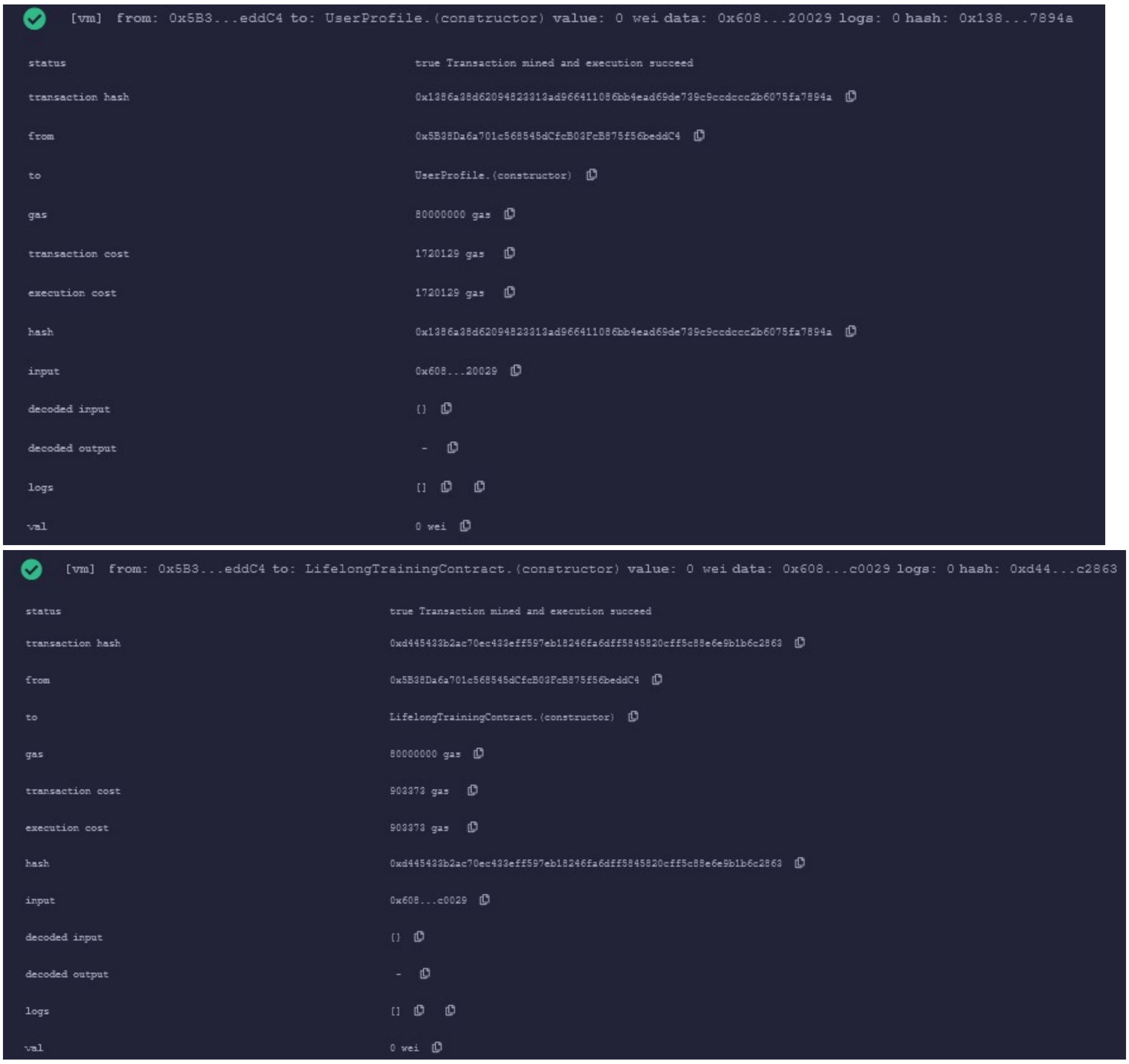



*Figure 16: Gas price for a) User Profile and b) Lifelong Learning contract*

Variable costs in Ethereum affects all organisations, since the cost of executing a smart contract varies from low to high. Ethereum promises to improve scalability and reduce the amount of computing power necessity to verify transactions. As a result, it is anticipated that these transactions would be inexpensive.

The following is a simplified process that demonstrates how a smart contract may be utilised in education:

- By enrolling in the system, the user creates a private contract as a User Profile ;
- The person accesses a Blockchain API to digitally sign the contract and creates a unique cryptographic hash for the recording to Blockchain.
- With this unique password, a lifelong learning smart contract is then constructed publicly. All of the user's training records are stored in this newly formed Lifelong learning contract.
- While the first User Profile contract is used to verify personal information of the user. The second contract, lifelong learning, is used to record and verify educational trainings of the user.

In general, including a technology such as blockchain into the training platform will provide a considerable measure of speed and efficiency. Some of the main benefits of Blockchain in the training network includes trust, self-sovereignty, transparency, immutability, decentralisation, collaboration but also the following practical advantages:

- Excessive file and document processing will be eliminated, and certifications will be available from any location in the world.
- All user activities will be recorded and monitored on the blockchain
- Due to the fact that it would serve as no middleman, procedures such as permission and verification will be accelerated. Businesses, institutions, or individuals may verify and validate a certificate on a Blockchain network without the need of intermediaries.
- Due to the blockchain network's security, no unauthorised registration or modification are permitted.
- With the use of a worldwide network of locations and time periods, blockchain allows companies, institutions, and trainees from various locations to work together.
- Blockchain offers a good opportunity to secure user information in the digital environment.
- Educators and users may use it regularly to prevent authority bias.
- Digital certificates, transcripts, and user records will be immutable and may be confirmed and reviewed by anyone with blockchain access.

On a blockchain network, everyone has the same rights and opportunities. Its open, unregulated, and permissionless nature ensures equitable access to the technology and the network built around it. Anyone may request a blockchain electronic wallet. Blockchain technology does not restrict users. With a shared distributed ledger, the certificate may be verified even if the issuing entity no longer exists. Blockchain will replace paper by storing digital documents, transcripts, degrees, and certifications even if losing all the records. Employers, institutions, students, and others may seek access to certain documents, which are more reliable due to their immutability. No need to certify copies. The blockchain will verify and consolidate everything. Cryptographic training certificates will be maintained on blockchain and may be recovered at any moment from a digital wallet.

# Chapter 6. User Interface using Blockchain training network via energy-education.com

A "smart contract" can be created using the blockchain technology, which automates and tracks particular state transitions (such as a change in viewership rights, or the birth of a new record in the system). This section presents the integration of the Blokchain training system within the energy-education.com platform and associated operations that users may perform on the blockchain network.

## 6.1 General background information

We use smart contracts on the Ethereum blockchain to track training client - training provider interactions and correlate a training record with viewing permissions and data retrieval instructions (essentially data pointers) that can be executed in other databases. On the blockchain, we include a cryptographic hash of the record to ensure that it cannot be manipulated. New records can be created for a single training facility, and training providers can allow administrators to create and share their training records. In both cases, the recipient of new information is automatically notified and given the option to verify the proposed record before accepting or rejecting it. This approach keeps people informed and involved in the status of their records.

The deployment of smart contracts via browser-based User Interfaces via the WEB3 protocol and interaction with smart contracts via the WEB3.js library has been widely cited and experimented with, especially since the wide adoption of the Ethereum blockchain and the ERC20 blockchain standard. A plethora of notable real-world utilisations of WEB3 user interfaces include decentralised sharing applications (Bonger et al., 2016), IoT data marketplaces (Park et al., 2018), smart home security (Qashlan et al., 2020), and identity management (Benedict et al., 2021).

## 6.2 User Interface purpose

The INSTRUCT Blockchain User Interface is primarily designed to serve two purposes:

1. Interacting with the main smart contract functionality to facilitate operations -Add, Retrieve, Verify;
2. Visualising the data present on the blockchain in an intuitive format, as in Figure 17, that provides a fair and accurate representation of:
    a. the transaction volume taking place on the blockchain, correlated with the functionality mentioned in point 1.
    b. an evolution of the blockchain transaction volume / utilisation over time
    c. Summary statistics concerning the training types created, alongside with their delivery outcomes and provider institution
    d. A ledger of the historical transactions of the types mentioned in point 1. Above, together with their approval seal / independent verification status.

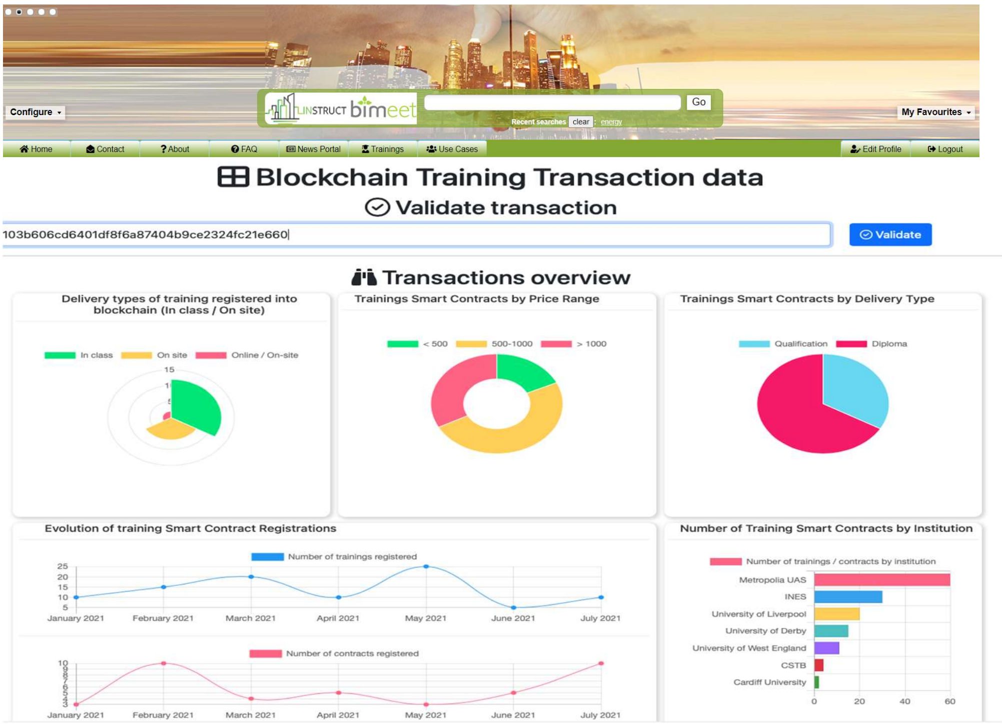



*Figure 17. An overview of the Blockchain Transaction Data Dashboard: A historical overview of the smart contract deployment transaction data and the proportions by Institution, Price range, Delivery types and Outcome Types*

For all the purposes mentioned above, we implement a number of data visualisation and analytics design patterns: line charts, pie charts, bar charts and data-rich tables, for the transaction ledgers. The elements corresponding to these design patterns are further grouped into widgets. It is a widely established principle in visual analytics that interactive exploration and iterative view refining must be supported. A single static visualisation is rarely sufficient, unless in the most basic of investigation activities. There are several opportunities for the user to interact with their data, allowing them to refine their inquiries as well as their visualisation style. For visual analytics, we are exploring the use of natural language interaction in addition to standard mouse and touch-based input. Direct manipulation is a useful interaction method when one can readily point to the things of interest (e.g., lassoing a cluster of points).
A summary of the logical sequence of the steps followed by the user across the different views of the INSTRUCT Blockchain UI is presented in Figure 18 below.

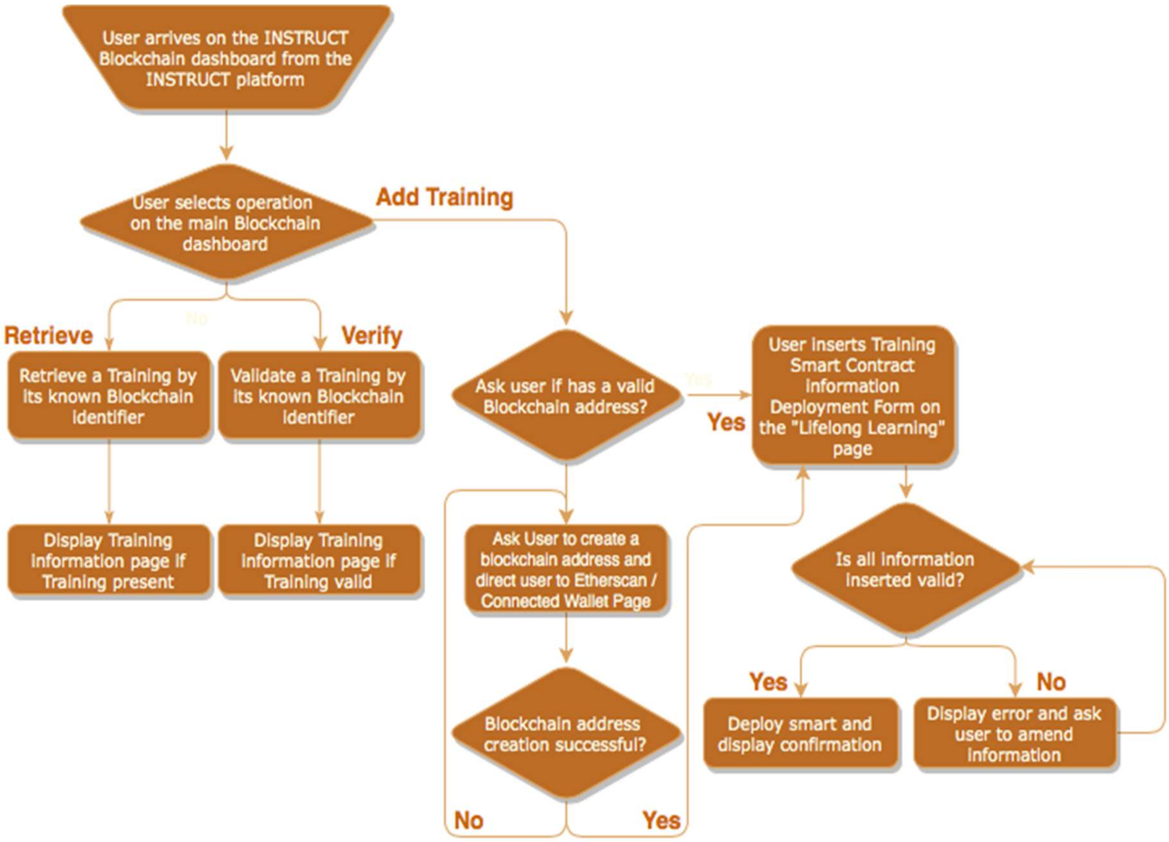



*Figure 18: User Flow Diagram of the INSTRUCT Blockchain UI (The logical sequence of the user journey).*

Once presented with the dashboard landing page, the user is presented with a number of options / actions which can be taken:

- Visualise the transaction overview - various actions could be performed, such as toggling the display of the presented widgets on / off and filtering the data on the charts
- Retrieve / Validate a training: the user is asked to enter the transaction ID of the respective training in the large horizontal bar / input field, and subsequently click on one of the two buttons (Retrieve / Verify). If the training is present in the blockchain and valid, the associated transactions will be

displayed (as per Figure 19 below), alongside with their metadata: transaction ID, block, timestamp, action, originating wallet ID

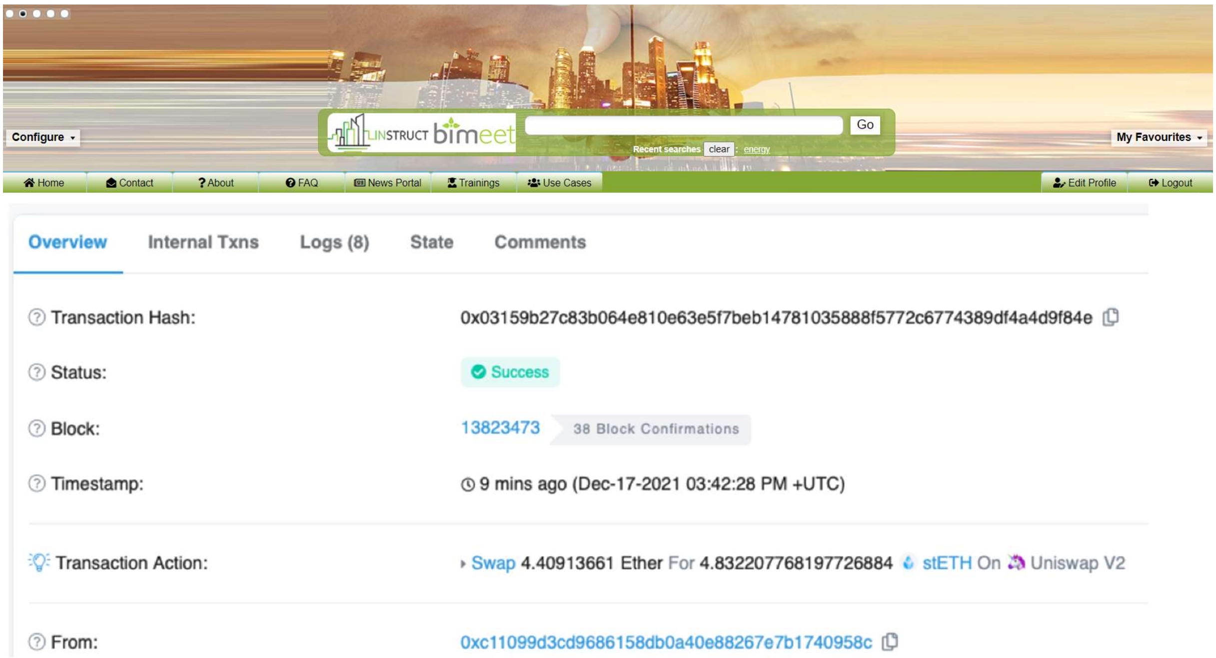
- Create / Edit profile: the user is invited to authenticate with a WEB3 compatible Ethereum / ERC20 wallet, or, alternatively, is taken to Etherscan or the utilised wallet page to authenticate
- Add New Training: once the user is successfully authenticated, the facility to deploy a smart contract associated with a new training is enabled
- 


*Figure 19: Successful transaction example*

### 6.3 Mobile compatibility and design principles

The INSTRUCT Blockchain UI is compatible with mobile devices (Figure 20) and provides QR codes to certify when an user has been recorded into the Blockchain. This facilitates skills registers and mobile passports fuctionality for users within a twofold functionality (i) recording training specifications into a Blockchain network and (ii) training authenticity and recognition in the form of a mobile application with QR capability facilitated via the energy-education.com.

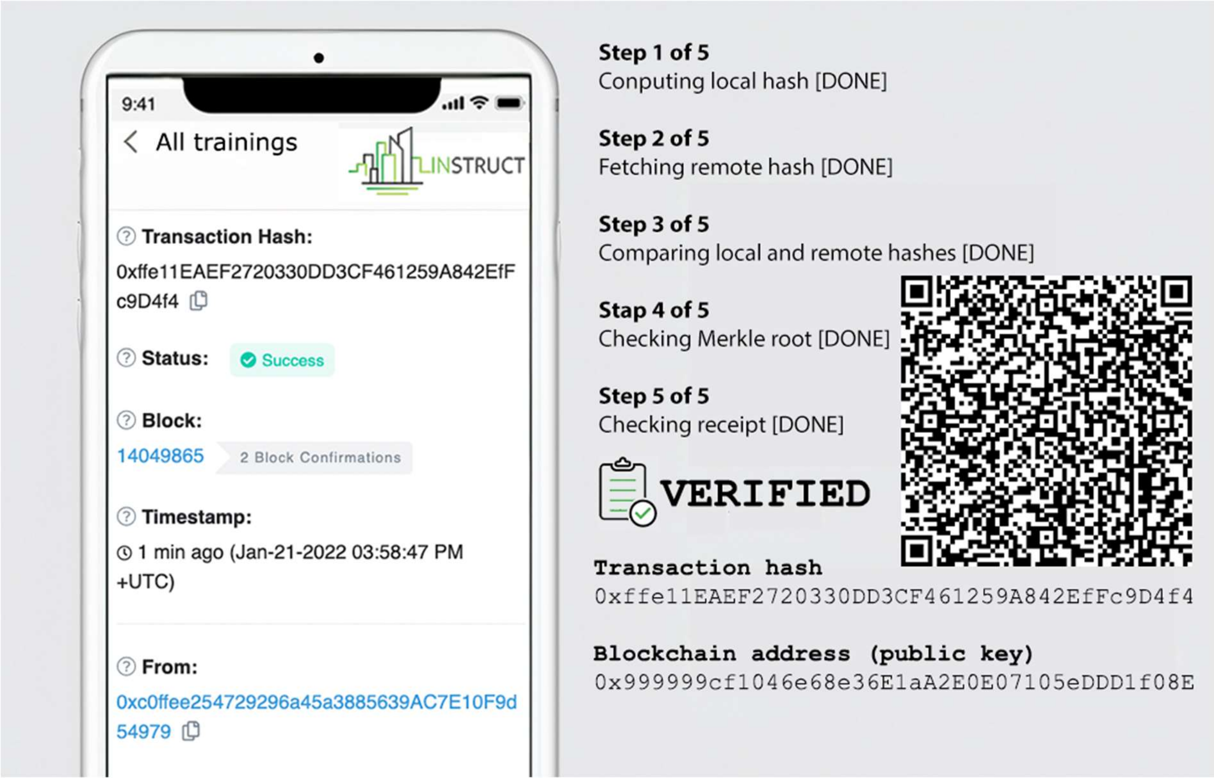



*Figure 20: Mobile application using Blockchain via energy-education.com*

In designing our User Interface, we did our best to pay close attention to the Everett principles of intuitiveness (Everett, 2014). These are briefly outlined below, along with examples from our implementation.

The UI has visual cues that show what it is about to perform. Users are not required to conduct experiments or make inferences about the encounter. The affordances are derived from real-world situations or from established user interface norms.

Functionally, the UI produces predictable, anticipated outputs with no surprises. Users are not required to conduct experiments or determine the impact. The expectations are established by the use of labels, real-world experiences, and common UI patterns. Considering defaults in anticipation of the goals users of the INSTRUCT Blockchain UI might have, we reduce the burden placed on the user to make decisions, by pre-populating fields where they are unlikely to be customised by the user. The user is kept informed at all stages of the User Interface utilisation. Various UI elements keep the user at bay with what occurs in the background once a task is triggered (loading circles, progress bars, error messages if appropriate, mock data replacing real data if not available). The UI provides fast, responsive feedback indicating if the activity was successful or not.

The user interface enables people to complete a task with minimal effort. If the goal is obvious, the UI will give the anticipated outcomes the first time, eliminating the need for users to repeat the action (possibly with slight differences) in order to obtain the desired result.

If users make a mistake, either the correct action occurs automatically or they may easily correct or reverse the action.  Users may explore the UI without worry of incurring penalties, unforeseen consequences, or becoming disoriented. If there is no cause for complaint, users are emotionally happy with the engagement.

The UI avoids unnecessary elements and are clear in the language they use on labels and in messaging. Consistency in the use of elements is achieved through the use of a uniform element layout across the different sections corresponding to the various smart contracts in the UI, which enables users to feel comfortable using the interface when migrating between sites, regardless of their level of expertise. Patterns in language, layout and design are created and deployed throughout the different INSTRUCT Blockchain sites to help facilitate efficiency and speed of conducting tasks. Once the usability methodology is evaluated, consistency enables the user to transfer their User Interface skills acquired to other sites / part of the platform.
Layout rules followed through the spatial relationships between items on the page and structure the page are based on importance (i.e., toggle buttons, separators). The careful placement of interface elements facilitate the attention of the user on the crucial components of the interface, while enabling easier page scanning and readability. Colouring rules are also followed through the appropriate use of colour, light, contrast, and texture, in order to redirect the attention of a user away from unimportant / less important elements of the interface. We conducted a careful selection of colours for contrast in the line charts.

### 6.4 Frontend fields correspondence to smart contract inputs

The main input fields in the New Training contract deployment form are displayed in Figure 21. To ensure data integrity and consistency, a one-to-one correspondence is established between the User Interface fields and the input data that is transmitted to the underlying smart contract.

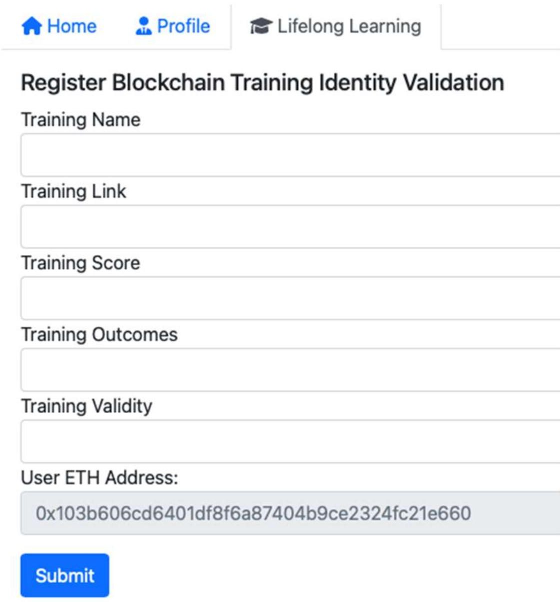



*Figure 21: New Training smart contract deployment form*

Upon a submission of the training addition form, the value of each text field in Figure 21 above is relayed to the corresponding parameters of the setter methods in the constructor of the LifeLongTraining contract: `trainingTitle`, `trainingLink`, `trainingScore`, `trainingOutcomes`, `trainingValidity`.

## 6.5 Frontend input validation

We apply a number of validation rules to the input fields in the “Profile” form.
Users can only select a “Title” from a predefined list (Mr., Mrs., Miss., Dr., Prof., etc.). This list is expandable by a user with administrator privileges in the INSTRUCT platform.
A valid alphabetical string of minimum 3 characters need to be entered for the “Name” and “Surname” input fields respectively. Numbers or special characters are not allowed.
A valid date needs to be selected in the “Birthday” field. This field is particularly important, since it can be used as an additional key to differentiate users, in addition to their blockchain Ethereum address. To facilitate the selection of a valid Date of Birth, a date picker is displayed, enabling the user to pick a date from a predefined calendar. If the user interacts with the platform from a mobile device, a group of three drop-down selection boxes is displayed:
A valid alphanumeric string of minimum 10 characters needs to be entered for the “Profession” field. Special characters are not allowed.
A valid email address needs to be entered in the “Email” field. This is validated using a comprehensive regular expression, which tests for the introduction of a text / character string pattern that is specific to email addresses (a lowercase, non-case-sensitive username, followed by the “@” sign, followed by the address of the email provider. The address of the email provider is composed, in turn, by a bespoke domain name, followed by a valid Top Level Domain (TLD). The format of a valid email address is outlined below:

```
(username)@(domainname).(top-leveldomain)
```

The Regular Expression for validating the user-readable format above is outlined below:

```
([A-Za-z0-9]+[.-_])*[A-Za-z0-9]+@[A-Za-z0-9-]+(\.[A-Z|a-z]{2,})+
```

Because a special character in the prefix cannot occur immediately before or after the @ symbol, and the prefix cannot begin with it, we ensured that there is at least one alphanumeric character preceding and following each special character. In terms of domains, an email can contain a number of top-level domains separated by a dot. This regular expression might seem complex, but it covers all of the email format rules that are defined in the RFC standard [Reference here].
The input value from the Country field can only be selected from a predefined list of countries. Anti-tampering validation is further implemented in the middleware and back-end of the application. The selection of a valid country is also checked by the middleware before the form submission.
The user can insert up to 1000 alphanumeric characters in the “short introduction” field, alongside with a limited number of special characters that are commonly used in biographies and descriptions. To enhance the readability of the short description inserted, the text is wrapped within the confines of the textarea field. To further strengthen the security of the platform, before passing its value to the smart contract, the contents of this field are also escaped and encoded. This prevents the user from attempting to exploit widely known web vulnerabilities, such as XSS (Cross-Site Scripting).
Before passing the user-defined Ethereum address to the smart contract, the format of this field is also validated through two mechanisms:

1. regular expressions

2. capital-based checksum validation, which is specific to the hexadecimal addresses present on the Ethereum network

The regular expression used to validate the Ethereum address is defined below:

```
/^0x[a-fA-F0-9]{40}$/
```

This regular expression checks for a leading 0x, followed by a random string of 40 hexadecimal characters (lowercase a-f, uppercase A-F, and numbers 0-9). These expressions are not case sensitive, although a capitalized checksum version exists that refers to the same account but provides an added layer of security.

### 6.6 User Interface Security

As with any interface exposing and enabling the alteration of potentially sensitive data, a number of security measures need to be implemented to ensure continued data integrity, while balancing these with usability. Given the sensitive nature of the data processed that is potentially confidential, it is important to guard against a number of risks:

- users being impersonated through having their passwords or cookies intercepted
- users being tricked into revealing their authentication details through the use of social engineering attacks that are disguised as help offers from the support team
- attackers with stolen user credentials or cookies, or malicious users themselves attempting to utilise the form input functionality for nefarious purposes, such as gaining access to data they are not authorised to access

The security measures were implemented across a number of areas, which are also detailed in the subsequent sections: *Authentication*, *Data Sanitisation*, *Social Engineering and Phishing Protection*.

### 6.7 Authentication

The INSTRUCT User Interface provides a two-tiered authentication methodology. Firstly, only users with a valid account and a validated and verified email address on the INSTRUCT platform can access the interface. Secondly, the users would need to authenticate with a valid Ethereum wallet supporting the WEB3 authentication protocol.

The following sanitisation measures are applied before relaying the user-defined input data to the smart contract, and displaying an error if the user attempts to circumvent them:

- Escaping content so HTML is rendered as text: <p>Hello <script>badStuff()</script> world!</p> becomes <p>Hello <script>hackingAttempt()</script> world!</p>. < and > are displayed as < and > instead of being parsed as HTML tags.
- Stripping content to not allow any HTML at all. <p>Hello <script>hackingAttempt()</script> world!</p> becomes Hello world!.
- Replacing content so users can enter non-HTML (typeset) tags that the system converts to HTML in the background. For example, content such as [b]bold[/b] becomes <p>some <span class="bold">bold</span> content</p>.

### 6.8 Social Engineering and Phishing Protection

Social Engineering is a common technique through which users are tricked into performing an action by a malicious attacker that pretends to be a trusted party, such as a support agent or a representative of the company the user is interacting with. It is very common for users of web applications to be tricked into entering code in their web browser console (displayed below), under the pretext that the code would enable a hidden feature or help them secure their account. Unfortunately, the only outcome of this operation, when initiated by an attacker, is that the user will inadvertently send their account password, which is stored in the browser's database, to the attacker. This is achieved through the XSS (Cross-Site Scripting) vulnerability, which enables remote Javascript to be executed in the browser of the user. We did our best to mitigate this vulnerability by displaying a clear warning message in the browser console of the user.

### 6.9 Cookie protection

In order not to expose the smart contract directly to the User Interface, we used the Spring Web Framework as a middleware between the User Interface and the WEB3 protocol. We imported the Spring Security module, which has the `SessionManagementFilter` enabled by default as a security filter configured in the security filter chain. This approach provides more control over user sessions and adds another layer of security. A user session is only created if required using `if_required`, checking if the user is authenticated while visiting a specific URL.

We used customised options in the `sessionManagement()` security filter chain to prevent users from being logged in on more than one machine at a time. Through blocking concurrent sessions, we prevent unauthorised access in the event of credentials leaks. Furthermore, we added customised error pages to ensure that default exception handling mechanisms do not reveal excessive information about the client web application.

```
@Override
protected void configure(HttpSecurity http)throws Exception{
       http
           .sessionManagement()
           .sessionCreationPolicy(SessionCreationPolicy.IF_REQUIRED)
           .sessionFixation().migrateSession()
           .expiredUrl("/sessionExpired.html")
           .invalidSessionUrl("/invalidSession.html");
}
```

If a user of the INSTRUCT UI manually tries to configure a cookie, the unencrypted nature of the content present in plain text poses significant security risks. We mitigate this through use encryption for session data to include the credentials of a user. This is achieved by setting the `HTTPonly` flag to true. `HTTPonly` renders the saved cookie in the browser, making it inaccessible to third party scripts that attempt to access the cookies, blocking *XSS scripts* from collecting cookies and sending this data back to malicious hosts.
An authenticated user cookie does not have an expiration time set by default, which enables the user to remain authenticated for long periods of time, instead of constantly needing to type a password.

This approach increases convenience at the expense of security: if a malicious user gains access to a web browser, the user will not need to enter a password, as the session would still be in progress. This is mitigated through configuring the cookies to expire by calling the `cookie.setMaxAge()` method to set the expiry time.

In traditional web applications, the cookie of an authenticated user has an associated Session ID. Conveniently, the session number is also usually present in the URL to denote that the user is authenticated and still in session. This would enable a hacker intercepting unencrypted traffic to artificially construct an URL with a valid session ID and impersonate an authenticated user using a session hijacking attack. We mitigate this by creating random URLs when a user is authenticated and protect the session ID when present in the cookie files. We use the following functions to enhance the security of session cookies:

- `cookie.setSecure()` sets a cookie to always be transmitted in an encrypted HTTPS connection
- `cookie.setHttpOnly()` prevents cookies from being accessed by third party scripts
- `cookie.setPath()` sets the scope of where the cookie is sent and saved.

# Chapter 7. NLP-based Learning Outcome Mapping tool

## 7.1 Introduction

The application of Natural Language Processing (NLP) to the field of training and education for eliciting or validating learning outcomes has already yielded a number of interesting results. Work done by Guitart et al, (2016) where the authors analysed available training material using NLP in order to discover what concepts were taught and how they aligned with the LOs set forth by the course description. They designed and tested a semi-automatic system for inferring relevant topics from textual training content. In a second step, the team presented an evolution of their system, able to infer previously extracted topics with learning outcomes defined for a given training. Aeiad, E and Meziane,F (2016) addressed a similar problem. They designed an NLP-based system, able to validate specified learning outcomes by extracting relevant topics from available e-Learning resources. Their approach consists in extracting action verbs from LOs and mapping them to a pre-defined set of action verbs from Bloom's taxonomy (Bloom et al., 1956) to determine the corresponding cognitive skill of the given action. Work done by Adelman, C (2015), even though not directly related to NLP, provides a very detailed approach of how to assess the overall quality of LOs. The author also provides a set of 20 categories of operational (action) verbs, allowing a much more fine-grained mapping of cognitive activities than Bloom's six-stage taxonomy. Another interesting contribution to the problem of how to compare LOs from different qualification schemes comes from A.S Schwartz and M.A. Hearst (2003) in the shape of an algorithm allowing the identification of abbreviation definitions. LOs for the construction sector make extensive use of abbreviations and acronyms, thus making a direct comparison harder.

## 7.2 Methodology

We propose a method for measuring cross qualification scheme similarities among LOs. We divided the task in multiple steps. The first step, called pre-processing, takes care of extracting action verbs and nouns from LOs, taking care of acronyms and Multi-Word Expressions (MWE) while doing so. Results from this step will then help us in defining a dedicated thesaurus in step 2, aiming at capturing and modelling the semantics of the domain at interest, by building an ontology graph of the terminology commonly encountered in the domain of interest. The general idea of the ontology graph consists in organizing the terminology in such a way that that the parent node, also referred to as the *Hypernym* is more abstract than its children, called *Hyponyms*, who are being more specific terms.

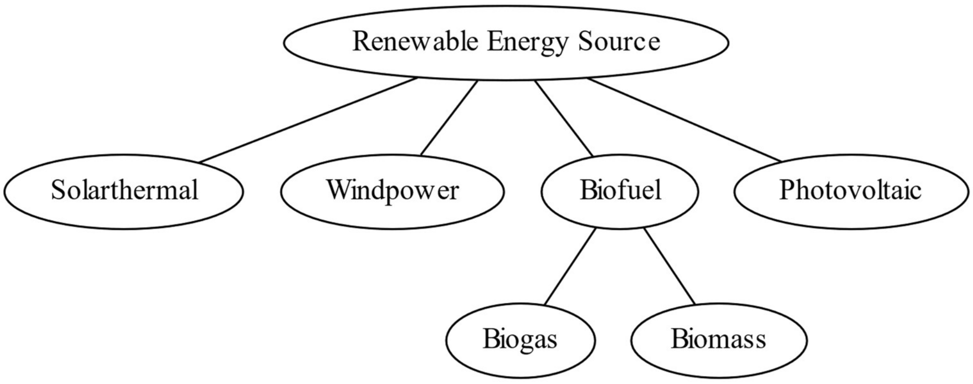



Figure 22. Ontology Graph of Renewable Energy Source

For instance, *Biogas* and *Biomass* are both a *Biofuel*, which in turn is a *Renewable Energy Source*. Biogas and Biomass are both *Hyponyms* of Biofuel whereas Renewable Energy Source is the *Hypernym* of Biofuel. Building such an ontology graph enables the use of existing similarity measures, Wu-Palmer (1994) being one of them, determining the similarity of two terms with respect to their relative position in the graph. This ontology graph will then be used in step 3 for determining similarity score of LOs across qualification schemes. We chose Python and the Natural Language Toolkit (NLTK) as our technical toolset. We furthermore selected four qualification schemes focusing on energy efficiency and to a certain extend to BIM which are, **Bimeet**, **NetUBiep**, **Prof/Trac** and **Bimzeed**.

### 7.2.1 Pre-Processing

The first step consists in extracting unique LOs from the qualification schemes of interest. The second step consists in resolving abbreviations and acronyms by replacing them with their respective long forms.

It is our assumption that learning outcomes generally follow the recommendations given by CEDEFOP (2017), calling for LOs to be defined in short sentences in action/verb/object/context format. Our third step thus consists in extracting nouns and verbs from the sentences making up the individual LOs. By doing so, the verb defining the action of the LO will allow us to determine the cognitive level of the stated action. The noun(s) in turn will help us in determining the subject and/or context at the heart of the LO. We're using a Part-of-Speech (POS) Tagger to perform this task. POS taggers are a piece of software ingesting text in a given language and decomposing individual sentences in their constituting parts such as nouns, verb, adjectives etc.

The POS Tagger will return for a given sentence a list of tokens, representing individual words with additional labels identifying them as nouns, verb, adjectives etc.

As already stated earlier, LOs generally contain a great number of MWEs. We manually curated a list of to be expected MWEs in the context of BIM trainings and energy efficiency. This list will be used by a downstream MWE Tagger, ingesting previously extracted tokens and labelling occurrences of MWEs as a single aggregated noun instead of multiple nouns.

We compiled a list of encountered terms (and verbs) and recorded the frequency of occurrence, thus allowing us to generate word clouds of encountered terms and verbs. Those word clouds help us in getting an idea where the focus lies concept-wise for a given qualification scheme, and, whether we need to adapt our pre-processing step.

### 7.2.2 Ontology Graph

We used the 76 subjects which were not mapped in the wordnet thesaurus as the concepts for the ontology graph. We organised them in a hypernym-hyponym fashion, meaning parent nodes are always more abstract than their children, and edges represent either *is_a* or *part_of* relationships. Our graph thus follows the structure of the wordnet database synonym sets (synsets). While building the graph, we quickly realised that the resulting graph included three sub-graphs, with **building information modelling**, **building** and **energy production** as their respective root nodes.

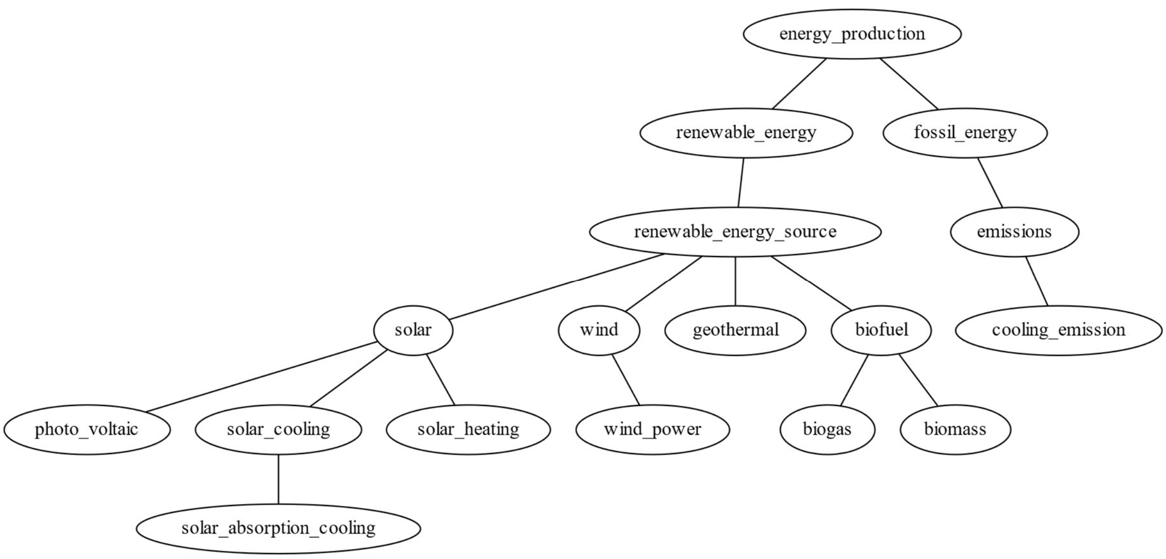



**Figure 23: Sub-graph of energy production**

As already stated earlier, we follow this structure in order to be able to apply existing similarity measures like Wu Palmer for instance. Wu Palmer similarity calculates the similarity of two concepts by considering their respective position within the graph. The similarity score is calculated as follows:

$$Sim(c1, c2) = 2 \cdot \frac{depth(lcs(c1, c2))}{(depth(c1) + depth(c2))}$$

Equation 24: Wu Palmer Similarity Score

*Depth* expresses how deep in the graph a given concept is located, starting with the root node at level 1 whereas *lcs* is the *Least Common Subsumer* and represents the lowest node in the graph that is a hypernym of both c1 and c2.

### 7.2.3 Similarity Score Algorithm

Individual LOs are going through a pre-processing step, which consists in first of all replacing acronyms and abbreviations with their corresponding long form. We've implemented three variants of similarity score algorithms in order to be able to verify that our approach offers any advantage to already existing approaches. The first approach consists in building a vector space model of each LO. To do so, each word contained in an LO defines one dimension in Euclidean space, and the number of occurrences of this word represents the value for this dimension. Similarity of two LOs in vector space is determined by the cosine of the angle between them. The measure of similarity thus obtained is referred to as *syntactic similarity*.

The second approach we've implemented is purely based on wordnets' *synsets*. Each word extracted from the first LO is looked-up in the wordnet *synset* thesaurus and a similarity score is determined for each word in the second LO. The best score is kept and the process is repeated for the next word in the first LO. Words for which no *synset* exists are discarded from the process. The third approach, which is the one we're proposing builds on top of the second approach. The addition we've made consists in looking for words for which no *synset* exists, whether these words are contained in our graph, and if so, determine a similarity score using Equation.

## 7.3 Validation

Validation of the developed method will be done by comparing the results yielded by the algorithm to a set of manually mapped Learning Outcomes. We propose to use the new trainings developed in the context of T4.2 as the standard for these comparisons. LO's identified for the different trainings will be manually mapped in parallel to LOs from the previously mentioned and already existing qualification schemes. These mappings will be validated by an internal group of experts in order to establish a kind of gold-standard for validating our algorithm.

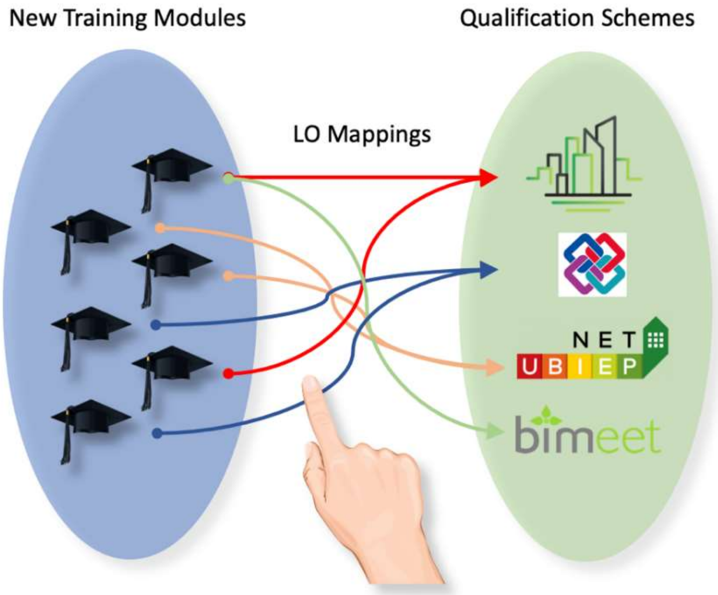



Figure 25: Manual mapping of LOs

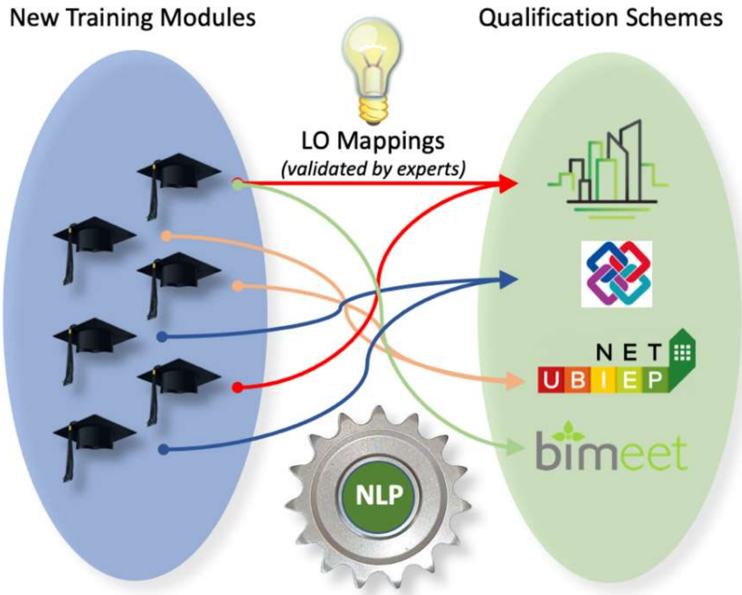



Figure26:Comparison of mappings yielded by NLP algorithm against validated mappings

## 7.4 Application

The method presented is expected to be validated through the application on the new training modules developed as part of T4.2. Other applications are foreseen for the other demonstration pilots which would require training.

Beyond the scope of the INSTRUCT project, this instrument presents interesting potential applications to overcome some issues associated with the several, heterogeneous and sometimes concurrent competency frameworks developed in the area of Energy Efficiency training. The ability to compare training modules based on sets of learning outcomes extracted from multiple competency frameworks will eventually enable better comparisons of training, and even skills, thus contribute to ease the establishment of digital skills registers.

# Chapter 8. Conclusions

To summarise, this report aimed at evidencing the connections between previous work in the context of the INSTRUCT project with regards to prerequisites that are necessary for the development of the digital tools which will be available at the www.energy-education.com platform. The report's objective was to highlight ways with which the following requirements are being integrated and translated into digital tools, in alignment with the requriements that were identified in (INSTRUCT, 2021): 1. The elicitation of functional requirements, 2. The deployment and eventual adaptation of existing competency/skill matrices in the system, the update and continuous feeding of the database of energy-related training modules across EU, 3. The development of additional widgets that would be required to the portal, including a skills register, 4. The development of a web interface adapted to mobile devices, and 5. Information package for home and building owners. The proposed solutions include the extension of the INSTRUCT energy-education.com platform, the Blockchain based training platform, and the INSTRUCT User Interface, and lastly, an NLP -based LO Matrix to facilitate measuring cross qualification scheme similarities among LOs.

To adress the requirements, the following tools have been developed:

a. A Blockchain training network integrated into the energy-education.com platform to support passports/registers for workers at regional/national level and support for their take up at EU level.
b. A mobile interface using QR codes integrated into the energy-education.com platform for facilitating the comparison of workers' skills and qualifications between countries,
c. A dedicated legislation service exposed the energy-education.com to presented and inform about new legislative frameworks or public procurement practices,
d. A dedicated training service complemented with energy sustainability services to support and incentivise initiatives for home and building owners, and,
e. A professional network service and a comunity of 200+ registerd users from the field of energy efficiency aimed to facilitate new partnerships with producers and retailers.
f. An NLP- based Matrix, which will enable to compare training modules based on sets of learning outcomes extracted from multiple competency frameworks.

These solutions are in line with the requirements which identified: trust, self-sovereingty, transparency, immutability, decetralisation and collaboration.

Overall, this report explains how the digital tools were developed for the the https://www.energy-education.com platform, demonstrates the enhancement of the platform through the Blockchain based training platform concept, and presents the INSTRUCT User Interface.

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# 10. Appendix

## 10.1 User Profile Codes

```
pragma solidity ^0.4.19;

contract UserProfile {
    uint storedData;

  address[] public addresses;
  bytes16[] public usernames;
  bytes[] public ipfsHashes;

struct UserInfo {
    string Forename;
    string Surname;
    string Birthday;
    string Profession;
    string Email;
    string Country;
}
  string private profession;
  function setProfession(string Profession) private {
    profession = Profession;
  }
  string private email;
  function setEmail(string Email) private {
  email = Email;
  }
  string private birthday;
  function setBirthday(string Birthday) private {
  birthday = Birthday;
  }
  string private country;
  function setCountry(string Country) private {
  country = Country;
  }
mapping(address => uint) private addressToIndex;
mapping(bytes16 => uint) private usernameToIndex;

  function User() public {
    addresses.push(msg.sender);
    usernames.push('self');
    ipfsHashes.push('not-available');
  }

  function hasUser(address userAddress) public view returns(bool hasIndeed)
{
    return (addressToIndex[userAddress] > 0 || userAddress == addresses[0]);
  }
  function usernameTaken(bytes16 username) public view returns(bool
takenIndeed) {
    return (usernameToIndex[username] > 0 || username == 'self');
  }

   function createUser(bytes16 username, bytes ipfsHash) public returns(bool
success){
```

```
    require(!hasUser(msg.sender));
    require(!usernameTaken(username));
    addresses.push(msg.sender);
    usernames.push(username);
    ipfsHashes.push(ipfsHash);
    addressToIndex[msg.sender] = addresses.length - 1;
    usernameToIndex[username] = addresses.length - 1;
    return true;
  }
  function updateUser(bytes ipfsHash) public returns(bool success){
    require(hasUser(msg.sender));
    ipfsHashes[addressToIndex[msg.sender]] = ipfsHash;
    return true;
  }
  function getUserCount() public view returns(uint count){
    return addresses.length;
  }

  // get by index
  function getUserByIndex(uint index) public view returns(address
userAddress, bytes16 username, bytes ipfsHash) {
    require(index < addresses.length);
    return(addresses[index], usernames[index], ipfsHashes[index]);
  }
  function getAddressByIndex(uint index) public view returns(address
userAddress){
    require(index < addresses.length);
    return addresses[index];
  }
  function getUsernameByIndex(uint index) public view returns(bytes16
username){
    require(index < addresses.length);
    return usernames[index];
  }
  function getIpfsHashByIndex(uint index) public view returns(bytes
ipfsHash){
    require(index < addresses.length);
    return ipfsHashes[index];
  }

  // get by address
  function getUserByAddress(address userAddress) public view returns(uint
index, bytes16 username, bytes ipfsHash) {
    require(index < addresses.length);
    return(addressToIndex[userAddress],
usernames[addressToIndex[userAddress]],
ipfsHashes[addressToIndex[userAddress]]);
  }
  function getIndexByAddress(address userAddress) public view returns(uint
index){
    require(hasUser(userAddress));
    return addressToIndex[userAddress];
  }
  function getUsernameByAddress(address userAddress) public view
returns(bytes16 username){
    require(hasUser(userAddress));
    return usernames[addressToIndex[userAddress]];
  }
  function getIpfsHashByAddress(address userAddress) public view
returns(bytes ipfsHash){
    require(hasUser(userAddress));
```

```
    return ipfsHashes[addressToIndex[userAddress]];
  }

  // get by username
  function getUserByUsername(bytes16 username) public view returns(uint
index, address userAddress, bytes ipfsHash) {
    require(index < addresses.length);
    return(usernameToIndex[username], addresses[usernameToIndex[username]],
ipfsHashes[usernameToIndex[username]]);
  }
  function getIndexByUsername(bytes16 username) public view returns(uint
index){
    require(usernameTaken(username));
    return usernameToIndex[username];
  }
  function getAddressByUsername(bytes16 username) public view
returns(address userAddress){
    require(usernameTaken(username));
    return addresses[usernameToIndex[username]];
  }
  function getIpfsHashByUsername(bytes16 username) public view returns(bytes
ipfsHash){
    require(usernameTaken(username));
    return ipfsHashes[usernameToIndex[username]];
  }
}
```

## 10.2. Lifelong Training Codes

```
pragma solidity ^0.4.13;

contract LifelongTrainingContract {
    uint storedData;

struct TrainingInfo {
    string trainingTitle;
    string trainingScore;
    string trainingOutcomes;
    string trainingLink;
    string trainingValidity;
}
  string public trainingTitle;
  function setTrainingtitle(string Trainingtitle) public {
  trainingtitle = Trainingtitle;

  string public trainingScore;
  function setTrainingScore(string TrainingScore) public {
  trainingScore = TrainingScore;
  }
  string public trainingOutcomes;
  function setTrainingOutcomes(string TrainingOutcomes) public {
  trainingOutcomes = TrainingOutcomes;
  }
  string public trainingLink;
  function setTrainingLink(string TrainingLink) public {
  trainingLink = TrainingLink;
  }
  string public trainingValidity;
  function setTrainingValidity(string TrainingValidity) public {
  trainingValidity = TrainingValidity;
  }

struct userID {
    bytes32 user_ID;          // User ID
    bytes32 institution;      // Institution ID
    bytes32 userName;         // User name
}
struct TrainingDataID {
    bytes32 datasetID;        // Dataset ID
    string datasetDesp;       // Dataset description
    bytes32 timeOfCreation;    // Dataset creation time
}

struct TrainingData {
    TrainingDataID   trainingdataID;    // Dataset ID struct
    string datasetLoc;                  // An URL or a data object hash
    bytes32 keycipher;                   // Cipher of the encryption key for
Industries
    address bcAdapter;                  // Blockchain adapter address
}
struct userData {
    userID userid;                      // userID i an institution
    mapping (bytes32 => TrainingData) trainingCollection;
// All Learning-Training for a user in an industries
}
```

```
uint256 private _value;
event ValueChanged (uint256 value);
function retrieve() public view returns (uint256) {
        return _value;
}
mapping (address => userData) userDataSet;  // User info for the Learning-
Training datasets

function addUser (bytes32 _user_ID, bytes32 _institution, bytes32 _userName,
address _user) public {
    userDataSet[_user].userid.user_ID=_user_ID;
    userDataSet[_user].userid.institution=_institution;
    userDataSet[_user].userid.userName=_userName;
} //To add a user to Blockchain

function addTraining(string _loc, bytes32 _keycipher, bytes32 _datasetID,
string _datasetDesp, bytes32 _timeOfCreation, address _user) public {

userDataSet[_user].trainingCollection[_datasetID].trainingdataID.datasetID=
_datasetID;

userDataSet[_user].trainingCollection[_datasetID].trainingdataID.datasetDes
p=_datasetDesp;

userDataSet[_user].trainingCollection[_datasetID].trainingdataID.timeOfCrea
tion=_timeOfCreation;
    userDataSet[_user].trainingCollection[_datasetID].datasetLoc=_loc;
    userDataSet[_user].trainingCollection[_datasetID].keycipher=_keycipher;
    userDataSet[_user].trainingCollection[_datasetID].bcAdapter=msg.sender;
} //To submit an Learning-Training metadata to Blockchain
}
```


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