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A conceptual framework of blockchain-based portfolios to assess digital competence in WIL

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Abstract

There appear to be three major problems when using ePortfolios to assess student competence with WIL (Work Integrated Learning) information systems, namely, the lack of information sharing, the lack of a link to the job market, and the lack of enhanced learning skills in the 21st century. This research aims to solve these problems by presenting a conceptual framework for blockchain-based portfolios to assess digital competence in WIL. The research methodology has four steps: step one – finding the situation and problems of using ePortfolios to assess competence in work-integrated learning (WIL), step two - analysing the causes and effects, step three - designing solutions, and step four - designing a conceptual framework.

Keywords: ePortfolio, WIL, Work integrated learning, Blockchain-based portfolio, Digital competence

1. Introduction

Currently, higher education institutions are seeking to develop educational programmes to meet the needs of the job market. Work-integrated learning (WIL) thus becomes an educational programme that meets the requirements of these higher education institutions. WIL can develop students' professional skills through on-the-job learning. However, as the world progressed into the 21st century, there were changes in the world due to technological progress. The ways of life of people are completely different from those in the previous century. Therefore, higher education institutions need to change their teaching and learning styles to be in line with 21st century learning skills [1].

However, WIL focuses on promoting professional competencies while ignoring digital competencies, which are very important to people in the 21st century; and therefore is insufficient to drive the workforce today. In addition, the current WIL information management system focuses on collecting information to manage teaching and learning within the university without disseminating information to the public. Evidence of WIL's professional practice may benefit students in future job applications but is unfortunately ignored.

Another interesting aspect of WIL programmes at higher education institutions is that they all share the same principles and management methods, but information resources are not shared with each other. The consequence of this issue is the lack of a sharing economy. However, it can be argued that digital information that is shared with others or shared publicly on the job market is easy to counterfeit, making it not widely shared. This may be true because the nature of digital information is easy to modify and transfer at any time. Therefore, it raises the question: is there any current technology that can solve this problem?

This research solves all of the aforementioned problems with the integration of WIL, digital competence and modern technologies in the form of a conceptual framework with guidance on their implementation.

2. Materials and methods

2.1 WIL

WIL has a long history of developing academic competence through on-the-job learning. Therefore, WIL should be an important programme for supporting professional learning skills for the 21st century job market. Recent studies have presented applications of information systems with WIL. Examples include applying digital media (blogging and podcasts) to learning in WIL [2], using blogging to create learning opportunities in WIL [3], using video mobile technology to enhance learning assessments in WIL [4], and improving the WIL experience via mobile technology [5]. The study of existing WIL research found that most of the studies focused on the development of experience and professionalism. However, no existing research was found that brings information from WIL to the labour market. Evidence of these students' experience and skills is the best information that will give them the opportunity to obtain a job in the future, but unfortunately the information has been abandoned.

2.2 ePortfolio

An ePortfolio is a popular educational tool because it can be used to prepare students for the job search process in WIL and can substantially reflect life experiences [6]. It provides evidence of processes that support the academic achievement and personal and professional development of a student [7]. In addition, the ePortfolio uses technology as a packaging for students and professors to collect and manage evidence in media formats (audio, video, graphics, and text). This includes using hypertext to manage educational materials and linking evidence to appropriate goals or standards [8]. Most portfolio research studies focus on retaining information for the benefit of students' education. However, digital information has the disadvantage of being easily counterfeited, so no research studying making the credibility of the portfolio difficult to counterfeit has been found.

2.3 Assessment of the WIL ePortfolio

The ePortfolio is an important WIL assessment method because it represents the efforts, progress, and success of students. In addition, the ePortfolio stores WIL activities in document form and coordinates students in their evaluation processes. The ePortfolio is effective when preparing students' opportunities to reflect on what they have learned. The ePortfolio provides authentic assessments, formative assessments, and summative assessments. It is also an ideal tool for self-assessment because it has the potential to encourage students to drive personal search [9]. The ePortfolio is an ideal platform for managing assessments with straightforward and timely feedback to students. In addition, it maintains normal structural and formal communication when students are scattered over different locations due to the course they are studying [10]. The ePortfolio provides a visual progress record that can be used to improve and demonstrate the achievement of employability based on experience gained through the integration of WIL [11]. The ePortfolio can be integrated between learning components and working, learning responses, professional competencies, and career management [12].

2.4 Digital competence

Digital competence is a group of skills, knowledge, and attitudes that create confidence, creativity, interaction, and digital coordination to create digital works. Digital competence gives us confidence in addressing data and computational thinking that is essential for students to communicate. In addition, digital competence is a factor that contributes to the potential for success in today's careers. Digital competence is one of the educational programmes. In addition to being able to read, write, and calculate, it is consistent with 21st century learning skills in the aspects of information, media, and technology. Moreover, it can be applied to the real world of work. Digital competence appears to be well known by the publication of the Digital Competence Framework for Citizens in 2013 by the European Commission. The framework aims to be a tool to improve the digital competence of people and help create policies to support digital competence building. The Digital Competence Framework provides a language that can be understood to identify and describe the scope of digital competence [13]. The framework covers five main areas and 21 competences as follows [14]:

1. In information and data literacy it covers 3 competencies: (1) browsing, searching and filtering; (2) evaluating data, information, and digital content; and (3) data management, information, and digital content.
2. In communication and collaboration it covers 6 competences: (1) digital technology interaction, (2) digital technology sharing, (3) citizenship engagement through digital technologies, (4) digital technology collaboration, (5) netiquette, and (6) digital identity management

3. In digital content creation it covers 4 competences: (1) developing digital content, (2) integrating and re-elaborating digital content, (3) copyrights and licences, and (4) programming.
4. In safety it covers 4 competences: (1) protecting a device, (2) protecting personal data and privacy, (3) protecting health and well-being, and (4) protecting the environment.
5. In problem solving it covers 4 competencies: (1) technical problem solving, (2) identification of needs and technological response, (3) creative use of digital technologies, and (4) identification of digital competence gaps.

In the research studies related to digital competence, no research has been found that integrates digital performance into an ePortfolio, although digital competence is essential to the workforce in the 21st century.

2.5 Cloud computing technology

Cloud computing is a service of processing resources that can be accessed and shared as needed, are convenient and are accessible everywhere. Procurement and termination of cloud computing can be done quickly with very little management or interaction with service providers [15]. The rapid change in technology requires organizations to constantly upgrade their software and hardware, causing increased cost problems. However, reducing the quality of hardware and software to solve costly problems is not a good choice as it causes many other problems. The best cost solution is to use cloud computing services because organizations can choose to use the service as needed at an affordable price. Moreover, cloud service providers are constantly upgrading their services. Currently, cloud computing is increasingly popular among organizations, both public and private.

A survey of the cloud services market shows that enterprise clouds around the world are growing. For example, according to Forbes magazine in 2017 [16], hybrid cloud service usage has grown three times since 2016. Enterprise IT budgets on cloud services is up to 80%. Seventy-three percent of companies plan to move their software and datacentres to the cloud within two years. Public clouds are most commonly used in the service business (28%) and engineering (30%). Private clouds are most commonly used in the government sector (29%). The leading countries for public cloud use are Australia (33%) and Canada (32%). The leading private cloud countries are Saudi Arabia and the United Arab Emirates (30%).

2.6 Blockchain technology

A blockchain is a distributed database recording things, known as transactional public ledgers or digital events that are processed and shared among stakeholders. Each transaction in the public ledger will be monitored by the consensus of the relevant parties in the system. Once a transaction has entered the system, it cannot be removed from the system [17]. As a result, a blockchain is a faithful digital ledger of economic transactions. A blockchain can write programmes to record both financial and nonfinancial transactions. Each unit of value is represented by a transaction recorded in a blockchain, and the resources of the peer-to-peer network are extracted for verification and approval of each transaction [18]. The origins of the blockchain started with the white paper "Bitcoin: A Peer-to-Peer Electronic Cash System" by Satoshi Nakamoto in 2008 [19], which explains the principles of a blockchain and its implementation in cryptocurrencies called bitcoins. Since then, the blockchain has become a new disruptive technology that has caused many existing changes.

Aside from finance, the blockchain's advantageous features can also be applied to other businesses as there are new ways and business opportunities to which blockchains can be applied to change business models [20]. In a blockchain, documents can be shared without being hacked because of the transparency of the transaction history. Blockchain security is more secure than those of other historical systems because transactions must be approved before being recorded. Once a transaction has been approved, it will be encrypted and then linked to the previous transaction. The way in which information is stored across a computer network instead of just a single server makes it difficult to spoof transaction data by hackers. A blockchain is suitable for use in the case of companies that need to track products that have a complex supply chain. If the transaction history is recorded in a blockchain, it will be easier to verify the reliability of the product and prevent fraud. In the traditional trading process, paperwork and an intermediary are needed to prove reliability, which is time consuming and highly error prone. Bringing trading processes into a blockchain will lead to greater speed and efficiency. In a blockchain, everyone uses the same set of information to gain credibility without needing an intermediary. Moreover, since there is no need for an intermediary to confirm credibility, a blockchain can reduce the costs of documenting to complete a trade, as in the traditional format.

2.7 Research methodology

The conceptual framework design of a blockchain-based portfolio to assess digital competence in WIL has the following four steps:

1. Document research to gather information on the situation and problems of the WIL ePortfolio assessment
2. Analysis of the causes and effects
3. Designing a solution
4. Conceptual framework design

2.8 Document research to gather information on the situation and problems of the WIL ePortfolio assessment

Among the research papers from 2005 to 2017, there are nine researches related to using an ePortfolio to assess students' competence in WIL: Jorgenson and Senini [21], Hodges [22], Hayward et al. [23], Johrendt et al. [24], Jaekel et al. [25], McNamara [26], Koch [27], Robles & Alanson [6] and Jackson et al. [28]. All studies apply various concepts to select components in order to assess a WIL ePortfolio. However, there are some common components that can be summarized in the following table.

Table 1 The comparative components for assessing WIL ePortfolio in studies from 2005 -2017.

Assessment components	Jorgenson & Senini, 2005	Hodges, 2008	Hayward et al.,2008	Johrendt et al., 2009	Jaekel et al., 2011	McNamara, 2011	Koch, 2012	Robles & Alanson, 2016	Jackson et al., 2017	(n)	%
1. CV/Resume		✓		✓	✓		✓	✓		5	55.56
2. Employer assessment		✓		✓	✓	✓	✓	✓		6	66.67
3. Self-assessment	✓	✓	✓		✓	✓	✓	✓		7	77.78
4. Peer assessment	✓	✓			✓					3	33.33
5. Checklist					✓					1	11.11
6. Oral presentation	✓			✓	✓	✓	✓		✓	6	66.67
7. Written reports	✓	✓	✓	✓	✓	✓	✓	✓	✓	9	100.00
8. Rubrics				✓	✓	✓		✓		4	44.44
9. Interview	✓			✓	✓		✓	✓		5	55.56
10. Peer review		✓	✓		✓			✓		4	44.44
11. Work/Career planning		✓	✓	✓	✓	✓	✓		✓	7	77.78
12. Seminar									✓	1	11.11
13. Record book	✓						✓		✓	3	33.33

When the data in Table 1 are used to create radar diagrams, there are clear differences in the comparison of the components for assessing WIL ePortfolios, as shown in Figure 1.

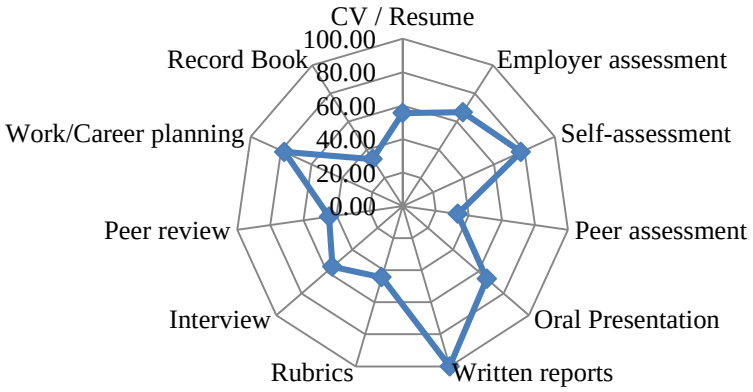

Figure 1 Diagram of the comparative components for assessing WIL ePortfolios in research from 2005 - 2017.

Table 1 shows that the most common component in assessing a WIL ePortfolio is report writing, which appears in every research (100%). This shows the highest importance of report writing in a WIL ePortfolio. The other specific components that were greater than 50% were self-assessment (77.78%), work/career planning (77.78%), workplace assessments (66.67%), oral presentations (66.67%), interviews (55.56%), and educational background (55.56%). The findings from these studies will be considered in the design of the conceptual framework in the next step.

2.9 Analysis of the causes and effects

The collected research information on a student's competence assessment in a WIL ePortfolio can be used to analyse problems. The causes and effects can be summarized as follows.

Table 2 Summary of the causes and effects of student competence assessment in a WIL ePortfolio.

Primary causes	Secondary causes	Problem
The problems of not sharing WIL information among higher education institutions	Business competition among higher education institutions	Lack of opportunities to benefit from a sharing economy
The problem of not connecting WIL information on the job market	Digital evidence lacks credibility	The job market lacks applicant information on the experience and the authentic assessment results
The problems of not enhancing learning skills in the 21st century	The WIL programme focuses only on professional competence	Lack of digital competence enhancement

The problem analysis seeking to find the causes and effects of a student's competence assessment in an WIL ePortfolio shows that there are three main issues: higher education institutions, information, and competencies. Each issue has a primary cause and a secondary cause that affects each problem. The following fishbone diagram clearly shows the cause and effect analysis of each issue.

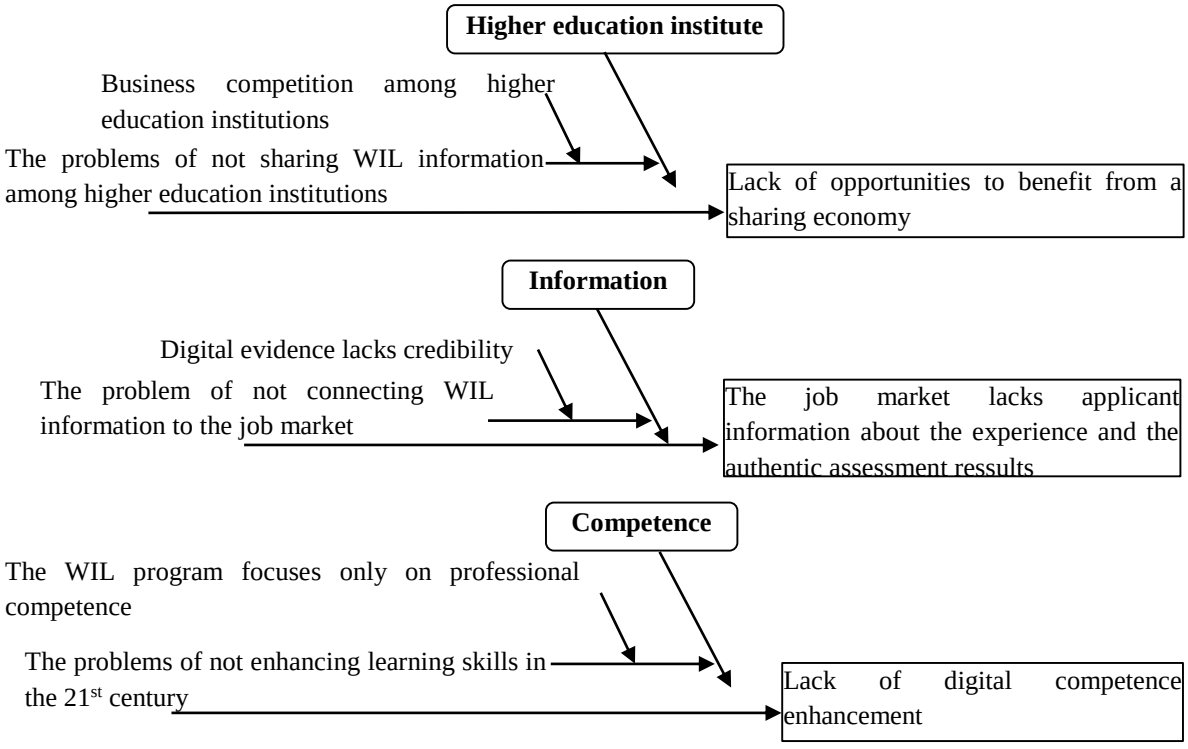

Figure 2 Fishbone diagram (causes and effects analysis) of competence assessment in the WIL ePortfolio.

2.10 Designing a solution

The problem of not sharing WIL information among higher education institutions is caused by business competition. This problem affects the lack of benefits from the sharing economy. The solution is to develop a centralized WIL information system to share information.

The problem of not connecting WIL information to the job market is caused by the lack of credibility of digital evidence. This problem affects the job market, which lacks information about real experience in WIL and the results of actual job competence assessments. The solution is to develop information systems using blockchain technology on the cloud so that information can be disclosed to the public in the job market with credibility.

The problem of not enhancing learning skills in the 21st century is due to the emphasis on only professional competences. This problem affects the lack of digital competence enhancement. The solution is to add components to the digital competence assessment together with the professional competence assessment.

After compiling the problems and solutions together, all the issues can be summarized in the following table.

Table 3 The solutions for assessing student competence by using a WIL ePortfolio.

Problems	Solution
The problems of not sharing WIL information among higher education institutions	The development of a WIL centralized information system for information sharing
The problem of not connecting WIL information on the job market	The development of information systems using blockchain technology on the cloud
The problems of not enhancing learning skills in the 21st century	The development of a digital competence assessment system together with a professional competence assessment

The solution is designed by selecting the components of a student's competence assessment with the WIL ePortfolio that is appropriate for each problem. The research findings show that the appropriate components are report writing (100%), employer evaluation (66.7) and rubrics (44.4%). Then, the appropriate technical elements can be selected to develop a system that can solve the problem.

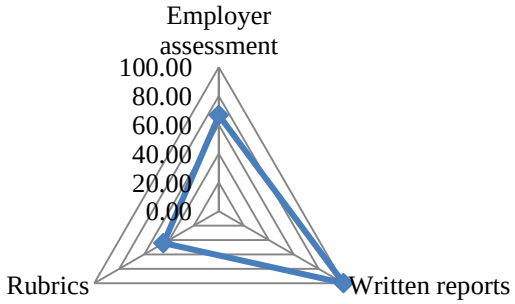

Figure 3 Assessment components selected for problem resolution.

The technical components are chosen to be components of the system development to suit three main factors, which are higher education institutions, information, and competences. Each of the selected technical components and their chosen reasons can be summarized in the following table.

Table 4 Summarization of the technical components and the reasons chosen for solving the problem.

Factor	Technical components	Reasons
Higher education institute	Cloud computing technology	In order to be able to efficiently share information among higher education institutions
Information	Blockchain-based portfolio	To make the information from the system reliable when being distributed to the public
Competences	Digital competence framework 2.0	To enhance learning skills in the 21st century

The technical components will be integrated into the conceptual framework as follows.

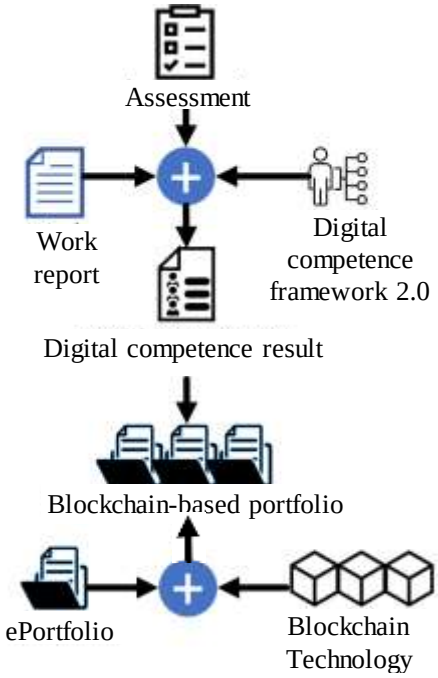

Figure 4 The integration of the technical components of the conceptual framework components in a cloud-based WIL information system.

Blockchain-based portfolios arise from the integration of technical components, ePortfolio and blockchain technology. The components of the digital competence results are based on the integration of work reports, assessments, and the digital competence framework 2.0. The results of this assessment will eventually be included in a blockchain. All components of the WIL information system are processed using cloud computing resources.

2.11 Conceptual framework design

The conceptual framework design uses a system approach consisting of four components: input, process, output, and feedback.

1. The input consists of three components: participants, technology, and digital competence. The participants component includes the employers and students. The technology components include cloud computing technology, blockchain technology, and the WIL ePortfolios. The components of the digital competence framework 2.0 were the rubrics of various competences.
2. The process is a WIL information system that has a blockchain-based portfolio on the cloud to assess digital competence.
3. The output is digital evidence distributed to the job market.
4. Feedback is a comment from the job market that returns to the system.

The conversion of the assessment component into conceptual framework components can be summarized in the following table.

Table 5 Applying assessment components in the conceptual framework.

Assessment components	Conceptual framework components
Report writing	WIL work report in the ePortfolio
Rubrics	Digital competence has been converted into rubrics for assessment in the portfolio
Employer assessments	The portfolio, combined with rubrics, becomes a digital competence assessment by employers

4. Results and discussion

When the components of the framework are combined, the structure of the framework consists of two parts: the environment and the process. The environmental structure arises from the combination of technological

components, including cloud computing technology, ePortfolios, and blockchain technology. The result of the integration of the technology components is the cloud-based WIL information system with blockchain-based portfolios. The system process structure is the result of bringing participants into the system. When students enter the WIL programme, work reports will be created. In addition, employers will assess work reports according to the rubric criteria. The result is digital competence that is brought to the blockchain-based portfolio, which will eventually be distributed to the job market.

When the job market uses digital evidence to consider job applicant qualifications, it will provide the job market with in-depth job applicant performance information. The experience in WIL and the digital competence assessment results obtained from the blockchain-based portfolio provide details of the applicant's internal capabilities. This information is more detailed than paper evidence and is convenient, fast, and easy to search online via the internet. The advantage for the job market is the ability to quickly select employees to meet the needs of a company. The information saves considerable time when selecting employees. In addition, the work history information in WIL and the digital competence that job applicants received from the blockchain-based portfolio are reliable because blockchain technology makes it difficult to tamper with information, which can solve the lack of credibility of the digital evidence.

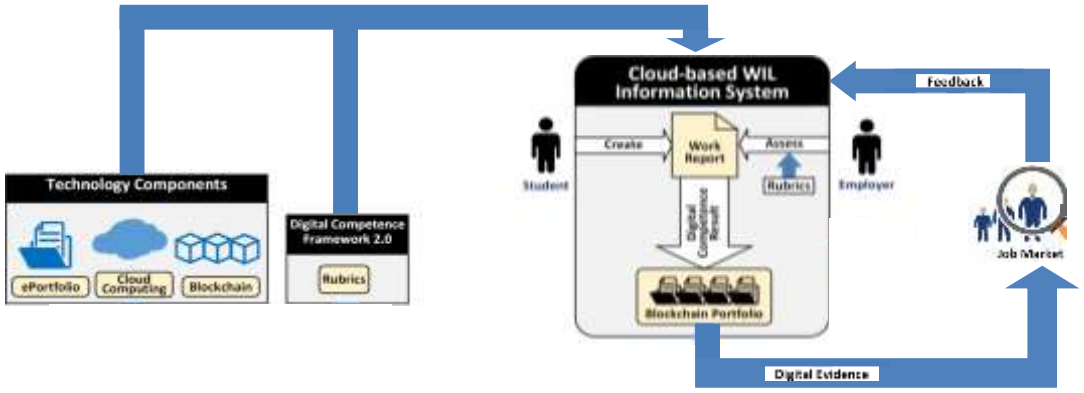

Figure 5 A conceptual frameworks of blockchain-based portfolios to assess digital competence in WIL.

The conceptual framework was divided into three parts according to a systematic approach. In the input part, there are three main components: the participants, technology, and the digital competence framework 2.0. The participants component includes employers and students. The process is the information system on the cloud. Blockchain-based portfolios are available to support student work evidence and employer competence assessments of WIL. The work reports that students create will be combined with the rubric of digital competence for employers to assess competence. The results of the competence assessment will be brought to the blockchain-based portfolio to confirm the credibility of the transaction, which is the solution to the lack of credibility of digital evidence when released to the public. As for the output, the digital evidence stored in the blockchain-based portfolio will be distributed to the job market. The job market can quickly access online evidence in the system, resulting in a significant reduction in employee selection time. In addition, the job market can send feedback to the system for the system development team to improve the system in the future. The continuous improvement of the system will make the system complete and ready to use at all times, resulting in long-term sustainability.

This research is an effort to apply the blockchain to education that is similar to Blockcerts of MIT Media LAB. Blockcerts are similar to the concept of this research in the certificate collection, which is similar to evidence collection of digital competence and WIL experience. Both Blockcerts' certificate and evidence of the digital competence and WIL experience of this research benefit from blockchain technology, which has brought credibility to the public.

Table 6 Comparison of the similarities between MIT's Blockcerts and this research.

Item	MIT's Blockcerts	This research
Type of information	Graduation certificate	WIL experience and digital competence
Purpose	Evidence of graduation	Evidence of WIL experience
Public distribution	Job market	Job market

The approach to implement this conceptual framework is to take advantage of the WIL mechanism by creating a consensus process of a blockchain with WIL stakeholders, including universities and participating

companies. The ideal blockchain for this conceptual framework is the permissioned blockchain because it has more advantages such as faster computation speed and better scalability.

The conceptual framework of this research is an attempt to integrate blockchain technology with ePortfolios for educational purposes. This research's proposal has some similarities with Blockcerts, but this research has some significance differences. First, the objective of Blockcerts is to keep the certificate, the downstream result of education, on the blockchain to increase credibility. However, this research aims to collect evidence of the WIL experience, the midstream result of education. Second, Blockcerts used the permissionless Bitcoin blockchain. However, this research aims to use the permission blockchain from the combination of higher education institutions to reduce the computing time and costs. Third, the concept of this research is dedicated to promoting digital competence that led to employment in the job market while Blockcerts is not focused on this issue.

However, there are limitations to the implementation of this conceptual framework. First, the goal of this conceptual framework is to focus on the convergence of higher education institutions to create a permission blockchain. Therefore, the incorporation of higher education institutions is very important but not easy in practice. Because of the incorporation of a large number of higher education institutions, there must be an agreement among the institutions. This negotiation will take time, and there may be a large deal at the national level. Second, the blockchain from this conceptual framework must be distributed to the job market. Hence, the implementation must create an interface to the job market across multiple platforms, which is not easy.

5. Conclusion

This research addresses the problems of assessing student competence using portfolios in WIL by creating a conceptual framework with the following steps: step one – collect research papers to study the conditions and problems in the assessment of ePortfolios in the WIL information system, step two - cause and effect analysis, step three - design solutions, and step four – design the conceptual framework.

The results of step one and step two concluded that the lack of information sharing among higher education institutions is caused by competition among higher education institutions. The problem of the lack of linking WIL information to the job market is caused by the lack of credible digital evidence. The problems of the lack of enhancement for learning skills in the 21st century are caused by focusing on only professional skills.

In step three, the solution was designed by selecting the components for assessing the student's competence with the WIL ePortfolio that is appropriate for each problem. The appropriate components include report writing, employer assessments, and rubrics. For appropriate technical competences, the higher education institution issues will be addressed by choosing cloud computing technology to enable effective sharing of information among higher education institutions, the information issues will be addressed by selecting blockchain-based portfolios to ensure the reliability of information when distributed to the public, and the competence issues will be addressed by choosing the digital competence framework 2.0 to enhance learning skills in the 21st century.

The result of step four, conceptual framework design, uses system approaches (input, process, output, and feedback). The input consists of three components: participants, technology, and digital competence. The components of the participants were the employers and students. The technology components include cloud computing technology, blockchain technology, and WIL ePortfolios. The components of the digital competence framework 2.0 include the digital competence rubrics. The process is a WIL information system that has a blockchain-based portfolio to assess digital competence. The output is the digital evidence distributed to the job market. The feedback the is information from the job market to improve the system.

The advantage of this conceptual framework is that higher education institutions benefit from a sharing economy that helps reduce costs and manage information resources better. The job market benefits from the digital evidence of job seekers on their WIL experience and reliable digital competence from blockchain-based portfolios. Finally, students benefit from the digital competence enhancement of the system, which is consistent with 21st century learning skills.

6. Acknowledgements

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