Journal Of Indonesian Social Society
Volume 4 ; Nomor 2 ; Juni 2026 ; Page 106-118
Doi : https://doi.org/10.59435/jiss.v4i2.816
Web : https://jurnal.padangtekno.com/index.php/jiss
E-ISSN : 2985-5705
P-ISSN : 2985-8771

Community Service In Strengthening The Governance Of Occupational Safety And Health Competency Certification Through A Web-Based Information System At PT Batamindo Investment Cakrawala

Hilda Herasmus[1*], Agus Suryadi[2], Mulyanto[3]

[1,2] Teknik Informatika, Universitas Ibnu Sina
[3]Teknik Industri, Universitas Ibnu Sina
[1*]hilda@uis.ac.id, [2]agussuryadi@uis.ac.id, [3]mulyanto@uis.ac.id

Abstrak

Pelatihan Tenaga Kerja Bangunan Tinggi (TKBT) Level 2 yang diselenggarakan PT Batamindo Investment Cakrawala menghasilkan 22 karyawan bersertifikat kompetensi dari empat divisi. Namun rekomendasi pascapelatihan dari unit HRD mengidentifikasi ketiadaan mekanisme monitoring berkala terhadap masa berlaku sertifikat dan penggunaan alat pelindung diri, sementara seluruh pengarsipan masih berbasis berkas fisik dan lembar sebar. Kondisi ini menimbulkan risiko kepatuhan terhadap Permenaker Nomor 9 Tahun 2016, karena sertifikat yang telah kedaluwarsa berpotensi tidak terdeteksi sebelum penugasan pekerjaan pada ketinggian. Kegiatan pengabdian ini bertujuan menguatkan tata kelola sertifikasi kompetensi K3 mitra melalui perancangan, implementasi, dan pendampingan sistem informasi berbasis web. Metode pelaksanaan terdiri atas enam tahap, yaitu analisis situasi, analisis kebutuhan, perancangan sistem, konstruksi, sosialisasi dan pelatihan, serta pendampingan operasional. Sistem dibangun dengan arsitektur tiga lapis dan memuat empat modul inti: pendataan sertifikat, notifikasi masa berlaku otomatis, dasbor rekapitulasi per divisi, serta pengarsipan berkas digital. Efektivitas kegiatan diukur menggunakan desain pre-test dan post-test dengan instrumen 20 butir soal yang mencakup empat domain pengetahuan, dan dianalisis menggunakan normalized gain. Pengujian fungsional dilakukan dengan metode black box, sedangkan penerimaan pengguna diukur menggunakan System Usability Scale.
Hasil kegiatan menunjukkan skor rata-rata pengetahuan peserta meningkat dari 51,4 pada pre-test menjadi 86,4 pada post-test dengan nilai N-Gain sebesar 0,72 berkategori tinggi. Pengujian black box mencapai tingkat keberhasilan 90 persen dan skor System Usability Scale sebesar 82,5, yang menunjukkan sistem diterima baik oleh pengguna.

Kata Kunci : sertifikasi kompetensi, keselamatan dan kesehatan kerja, sistem informasi

Abstract

The Level 2 Working at Height (TKBT) training conducted by PT Batamindo Investment Cakrawala produced 22 certified employees across four divisions. However, post-training recommendations from the HRD unit identified the absence of a periodic monitoring mechanism for certificate validity periods and personal protective equipment usage, while all record keeping remained paper-based and spreadsheet-driven. This condition creates a compliance risk against Minister of Manpower Regulation Number 9 of 2016, as expired certificates may go undetected before employees are assigned to work at height. This community service program aims to strengthen the partner's occupational safety competency certification governance through the design, implementation, and mentoring of a web-based information system. The implementation method consists of six stages: situation analysis, requirements analysis, system design, construction, socialisation and training, and operational mentoring. The system was developed using a three-tier architecture and comprises

four core modules: certificate record management, automated validity notification, divisional recapitulation dashboard, and digital document archiving. Program effectiveness was measured using a pre-test and post-test design with a 20-item instrument covering four knowledge domains, analysed using normalized gain. Functional testing was conducted using the black box method, while user acceptance was measured using the System Usability Scale.
The results show that participants' average knowledge score increased from 51.4 in the pre-test to 86.4 in the post-test, with a normalized gain of 0.72 categorised as high. Black box testing achieved a 90 percent success rate and the System Usability Scale score reached 82.5, indicating good user acceptance.

Keyword : *competency certification, occupational health and safety, information system, governance*

INTRODUCTION

Work at height is one of the activities with the highest fatality risk in the industrial sector. A fault tree analysis of fatal accidents caused by work at height in Malaysia shows that the failure of fall protection systems and weak supervision of worker competency are the two dominant contributing factors (Zermane et al., 2022). In Indonesia, Minister of Manpower Regulation Number 9 of 2016 requires every worker performing work at height to hold a competency certificate issued through a competency assessment by an authorised institution. This obligation is continuous in nature, because competency certificates have a limited validity period and must be renewed before they expire. Consequently, corporate compliance does not end with the delivery of training, but depends on the organisation's ability to maintain accurate and up-to-date competency status data for every worker.

PT Batamindo Investment Cakrawala, as the manager of an industrial estate in Batam City, conducted the Level 2 Working at Height (TKBT) Training Batch 3 on 21–23 July 2026, involving 22 employees from the Property and Housing Development (PHD), Estate Maintenance (EMT), Utility Maintenance (UMT), and Occupational Health and Safety (OHS) divisions. Based on a review of the training implementation report and interviews with the partner's HRD unit, three problems were identified at the post-training stage. First, competency certificate data are stored as physical files and separate spreadsheets in each division, so that cross-divisional recapitulation requires manual consolidation. Second, no early warning mechanism is available for certificates approaching expiry, so monitoring depends entirely on the diligence of the administrator. Third, the official recommendation of the HRD unit requires daily monitoring of personal protective equipment use and periodic evaluation of the implementation of training outcomes, yet the supporting facilities are not yet available.

These three problems converge on a single risk, namely the possibility of assigning workers holding expired certificates to high-risk work without prior detection. This risk cannot be resolved by increasing the frequency of training, but requires an intervention on the data governance side. The solution offered in this community service programme is a web-based occupational safety and health competency certification management information system that integrates data recording, automatic notification, competency status visualisation, and digital archiving within a single centralised database.

Several previous studies have developed similar systems in different contexts. Vinanda et al. (2019) developed a web-based assessment information system for professional certification bodies in vocational schools, focusing on the assessment process. Putra et al. (2019) built an online certification application to assess student competency, emphasising the conduct of the assessment rather than the maintenance of post-certification status. Hartono et al. (2021) designed a competency certification registration application for a university career development centre, whose scope is limited to registration administration. Slamet and Mulyanto (2021) examined competency assessment management at a vocational school professional certification body from a managerial perspective

without producing a software artefact. Lubis (2021) developed an online competency certification management system using the web base engineering method in the secondary education context. Internationally, Chellappa et al. (2024) mapped the use of digital technologies for construction safety education and training and concluded that research remains concentrated on the delivery phase, while the competency maintenance phase receives far less attention. Xu et al. (2024) reported that the adoption of digital technology in construction safety management is still hindered by low organisational readiness and minimal post-implementation mentoring.

An analysis of these six references reveals two gaps. First, all of the systems developed are oriented towards certification providers rather than towards companies that employ certified workers. This difference in orientation implies different functional requirements: certification bodies need registration and assessment modules, whereas companies need modules for validity monitoring and assignment readiness. Second, no system has been found that explicitly links certificate status to the work division structure so that supervisors can assess the competency readiness of their teams before issuing assignments. This community service programme addresses both gaps by developing a system oriented towards the employing company and integrating the divisional dimension into the data structure.

The objectives of this community service programme are: (1) to design and implement a web-based occupational safety and health competency certification management information system that matches the partner's governance needs; (2) to improve the knowledge and operational skills of the partner's OSH data managers in using the system; and (3) to measure the impact of the programme on participants' knowledge improvement and on the level of user acceptance of the system. The expected outputs are operational software handed over to the partner, a measurable improvement in participants' knowledge scores, and a system user guide document.

RESEARCH METHOD

Research Stages

The community service programme was carried out in the second semester of 2026 at PT Batamindo Investment Cakrawala, Batam City. Implementation was divided into six stages structured according to the waterfall software development model, with the addition of socialisation and mentoring stages as characteristic features of a community service programme. The waterfall model was chosen because the scope of the partner's requirements had been firmly defined through the HRD recommendation document, so that requirement changes in the middle of development were unlikely. The flow of the six stages is presented in Figure 1.

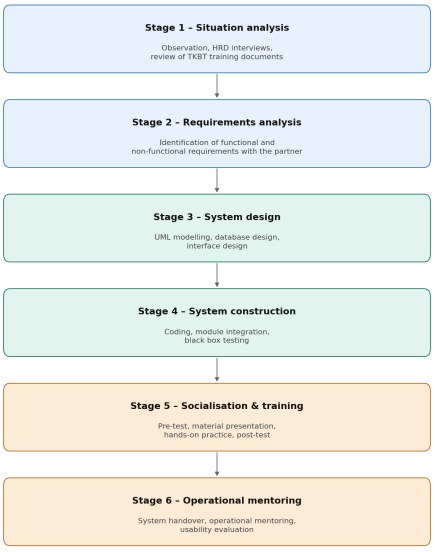

Figure 1. Stages of the community service programme

The situation analysis stage was carried out through direct observation of the partner's HRD unit and OHS division, semi-structured interviews with the training data managers, and a review of the Level 2 TKBT Training Batch 3 Implementation Report. The requirements analysis stage produced a list of functional and non-functional requirements validated together with the partner. The design stage produced a use case model, a database design, and an interface design. The construction stage covered coding, inter-module integration, and functional testing. The socialisation and training stage was conducted in a single face-to-face session beginning with a pre-test and ending with a post-test. The mentoring stage covered system handover, operational mentoring during the transition period, and evaluation of user acceptance.

Subjects and Location of the Programme

The subjects of the programme were 22 employees who participated in the Level 2 TKBT Training Batch 3, together with the HRD unit personnel responsible for training data administration. The composition of participants by division of origin is presented in Figure 2. The PHD and EMT divisions each contributed eight people or 36.4 percent of the total participants, the OHS division four people or 18.2 percent, and the UMT division two people or 9.1 percent. This composition became the basis for determining the divisional data structure in the system developed.

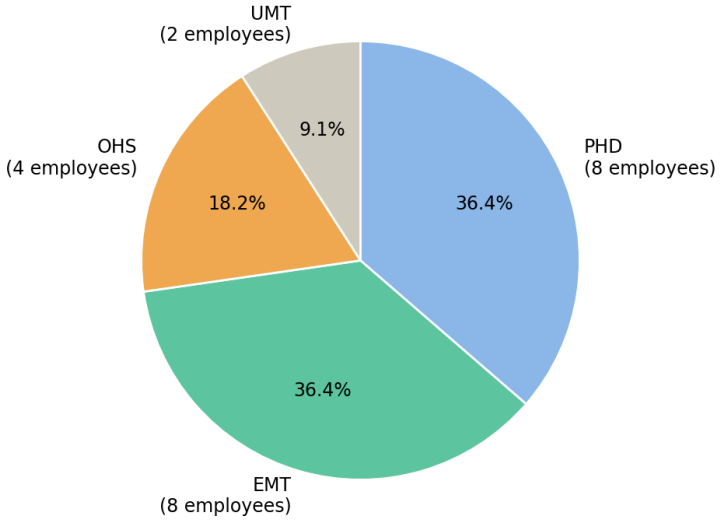

Figure 2. Distribution of Level 2 TKBT Training Batch 3 participants by division (n = 22)

Instruments and Data Collection Techniques

Data were collected through four instruments. First, an observation sheet and interview guide for the situation analysis stage. Second, a knowledge test instrument in multiple-choice form consisting of 20 items used in both the pre-test and the post-test with an identical item arrangement. Third, a black box test sheet for functional verification of the system. Fourth, a System Usability Scale (SUS) questionnaire consisting of ten statements on a five-point Likert scale to measure user acceptance. The blueprint of the knowledge test instrument is presented in Table 1.

Table 1. Blueprint of the pre-test and post-test instrument

Knowledge domain	Indicator	Item numbers	Total
D1. Regulations and certificate validity	Provisions of Minister of Manpower Regulation 9/2016, certification obligation, consequences of expired certificates	1, 2, 3, 4, 5	5
D2. Competency document governance	Filing workflow, completeness of certificate data attributes, centralised data principle	6, 7, 8, 9, 10	5

D3. System operation	Authentication, data entry, file upload, certificate status update	11, 12, 13, 14, 15	5
D4. Dashboard and notification use	Reading the dashboard, following up notifications, compiling divisional reports	16, 17, 18, 19, 20	5
Total			20

Data Analysis Techniques

The effectiveness of knowledge improvement was analysed using normalized gain as formulated by Hake (1998). The N-Gain score was calculated using Equation (1).

$$N\text{-}Gain = (S\_post - S\_pre) / (S\_max - S\_pre) \qquad (1)$$

where S_post is the mean post-test score, S_pre is the mean pre-test score, and S_max is the ideal maximum score of 100. Score interpretation refers to three categories, namely low if the N-Gain is below 0.3, moderate if it lies within the range of 0.3 to 0.7, and high if it exceeds 0.7. The functional success rate of the system was calculated using Equation (2).

$$Success\ rate\ (\%) = (Number\ of\ valid\ scenarios / Number\ of\ scenarios\ tested) \times 100 \qquad (2)$$

The SUS score was calculated by summing the contribution of odd-numbered items, taken as the response value minus one, and even-numbered items, taken as five minus the response value, and then multiplying the total by 2.5 to produce a range of 0 to 100. A SUS score above 68 is interpreted as above-average acceptance

RESULTS AND DISCUSSION

Results of the Situation and Requirements Analysis

The document review and interviews produced a mapping of the existing condition of OSH competency certification governance at the partner, as presented in Table 2. The mapping was compiled by comparing current practice against the condition required by the HRD recommendation and by regulatory provisions

Table 2. Mapping of the existing condition and the targeted condition

Aspect	Existing condition	Targeted condition
Data storage medium	Physical files and separate spreadsheets per division	Centralised relational database with digital file copies
Validity monitoring	Manual, dependent on periodic checks by the administrator	Automatic notification 90 and 30 days before expiry
Cross-divisional recapitulation	Manual consolidation, requiring several working days	Recapitulation dashboard updated in real time
Verification before assignment	Verbal confirmation to the divisional supervisor	Per-employee competency status lookup within the system
Reporting to management	Recompiled each time it is requested	Competency report export per division and per period

Based on this mapping, the functional requirements of the system were formulated into seven items as presented in Table 3. Priorities were determined together with the partner using the mandatory and optional categories so that the development scope remained under control.

Table 3. List of system functional requirements

Code	Functional requirement	Actor	Priority
FR-01	Master data management for employees and divisions	HRD Admin	Mandatory
FR-02	Recording of competency certificates including issue and expiry dates	HRD Admin	Mandatory
FR-03	Upload and download of digital certificate files	HRD Admin	Mandatory
FR-04	Automatic notification for certificates approaching expiry	System	Mandatory
FR-05	Recapitulation dashboard of competency status per division	Divisional supervisor	Mandatory
FR-06	Export of competency reports in a structured format	Divisional supervisor	Optional
FR-07	Personal competency history lookup	Employee	Optional

System Design Results

The interaction between actors and system functionality was modelled using a use case diagram as presented in Figure 3. Three actors were identified with role-based access separation. The HRD Admin has full authority over master data and certificate data. The divisional supervisor has authority to read data within the scope of their division and to receive notifications. Employees can only look up their own competency history. This separation was applied as a control over the personal employee data stored in the system.

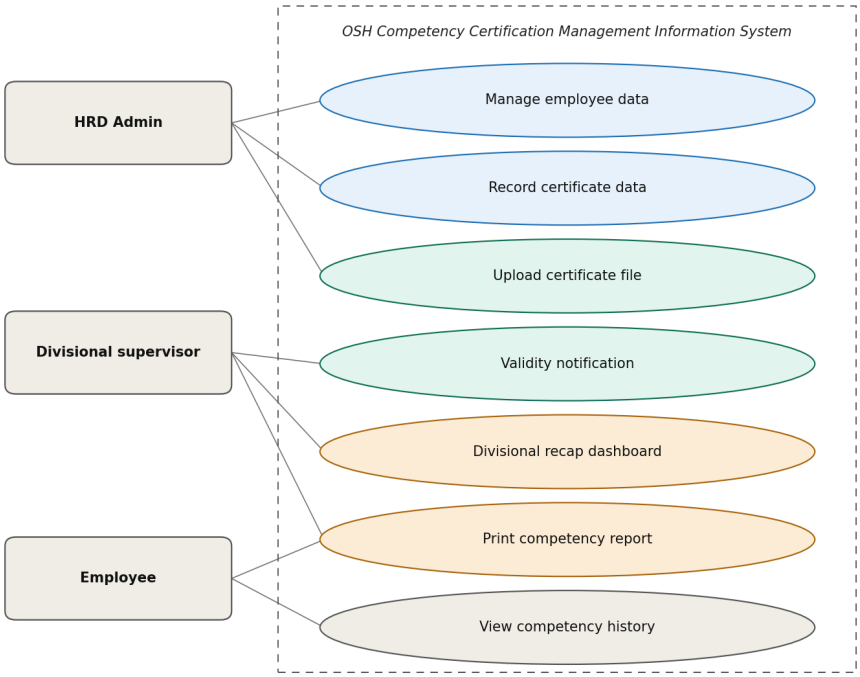

Figure 3. Use case diagram of the OSH competency certification management information system

The system architecture was arranged in three tiers as presented in Figure 4. The separation of the presentation, application, and data layers is intended to allow maintenance of the notification module without altering the user interface. The system is operated on the corporate intranet network so that employee competency data are not exposed to public networks.

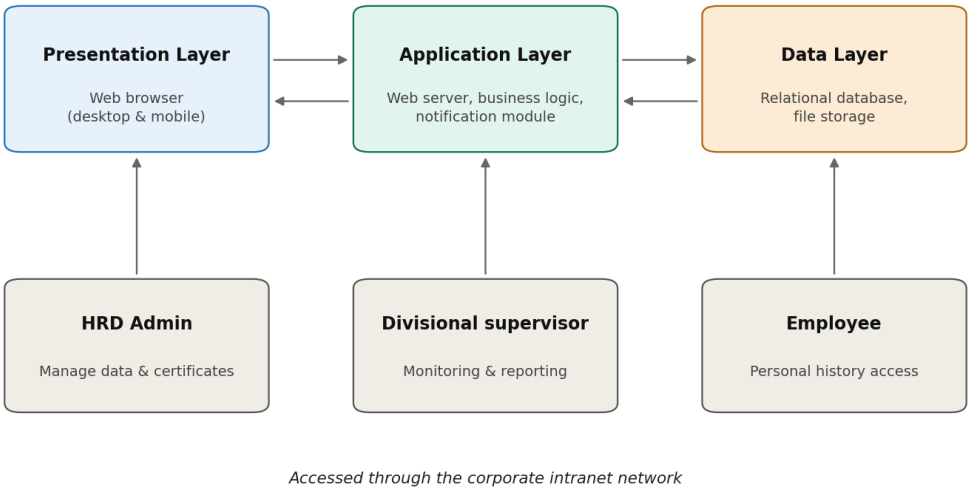

Figure 4. Three-tier architecture of the information system

The database structure was designed with six entities as presented in Figure 5. The certificate_type entity was separated from the certificate entity so that the validity period can be configured per certification type, allowing the system to remain usable when the partner adds certification types other than TKBT. The expiry_date attribute in the certificate entity is the main reference for the notification module, while the notification entity stores the history of warning deliveries as an audit trail.

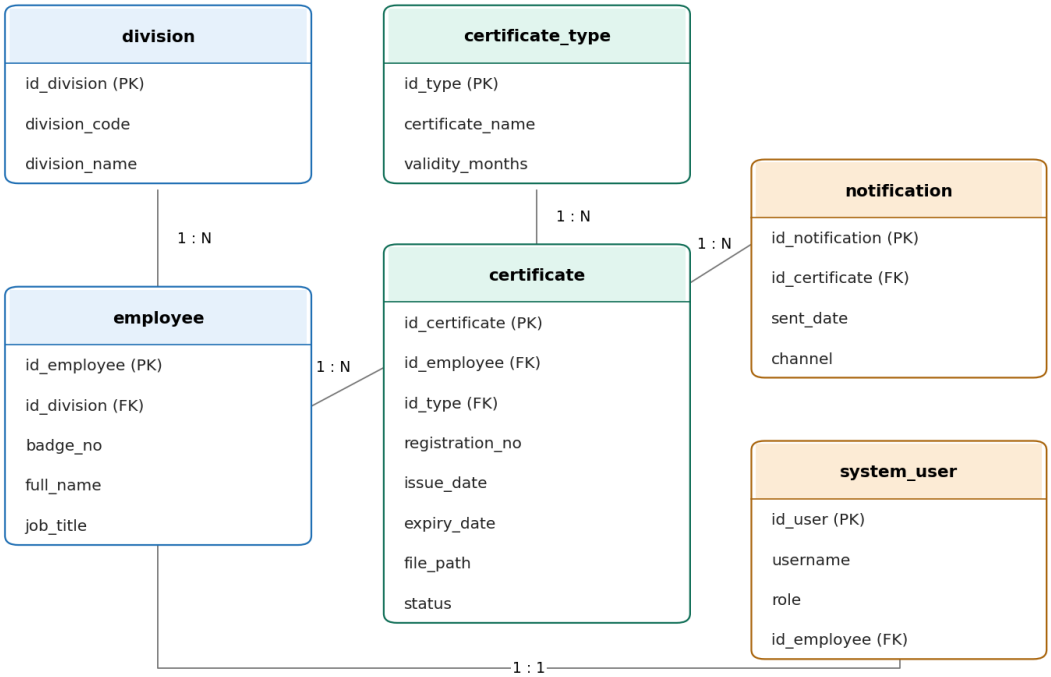

Figure 5. Entity relationship diagram of the system

Implementation and Functional Testing Results

The system was implemented in four modules aligned with the functional requirements in Table 3. Functional testing was carried out using the black box method against scenarios representing each requirement. A recapitulation of the test results is presented in Table 4.

Table 4. Recapitulation of black box testing results

Code	Test scenario	Expected result	Status
TC-01	Authentication with valid and invalid credentials	Access granted according to role; incorrect credentials rejected	Valid
TC-02	Adding a new employee record with its division relation	Data stored and displayed in the employee list	Valid

TC-03	Recording a certificate with a valid issue date	Expiry date calculated automatically	Valid
TC-04	Recording a certificate with an empty issue date	System rejects the entry and displays a validation message	Valid
TC-05	Uploading a certificate file in PDF format	File stored and can be downloaded again	Valid
TC-06	Triggering the notification 30 days before certificate expiry	Notification sent and recorded in the history	Not yet valid
TC-07	Displaying the recapitulation dashboard per division	Number of active and expired certificates displayed accurately	Valid
TC-08	Exporting the competency report per division	Report file downloaded with data matching the filter	Valid
TC-09	Employee access to another employee's data	Access denied in line with role restrictions	Valid
TC-10	Personal competency history lookup	History displayed completely and correctly	Valid

Based on the results in Table 4, the functional success rate of the system was 90 percent, that is, nine of ten scenarios were declared valid in the first round of testing. The scenario that was not yet valid, namely TC-06 on triggering the notification for a certificate 30 days before expiry, was caused by a scheduled task that had not been adjusted to the server time zone. This scenario was followed up in the correction stage before handover to the partner, so that all functional requirements in Table 3 were fulfilled before the system was operated by the partner.

Socialisation Results and Knowledge Measurement

The socialisation and training session on the use of the system was conducted in one day and attended by 22 participants of the Level 2 TKBT Training Batch 3 together with HRD unit personnel, following a sequence of pre-test, material presentation, hands-on practice with the system, and post-test. The presentation material was arranged according to the four domains in the instrument blueprint in Table 1, with the largest share of hands-on practice given to the system operation domain. Documentation of the session is presented in Figure 6, while the recapitulation of pre-test and post-test scores is presented in Table 5.

Figure 6. Documentation of the socialisation and training session on the OSH competency certification management information system with participants and the community service team

Table 5. Recapitulation of pre-test and post-test scores per knowledge domain (n = 22)

Domain	Mean pre-test	Mean post-test	Difference	N-Gain	Category
D1. Regulations and validity	58.2	88.2	30.0	0.72	High
D2. Document governance	52.7	85.5	32.8	0.69	Moderate
D3. System operation	45.5	87.3	41.8	0.77	High
D4. Dashboard and notification	49.1	84.5	35.4	0.70	Moderate
Overall mean	51.4	86.4	35.0	0.72	High

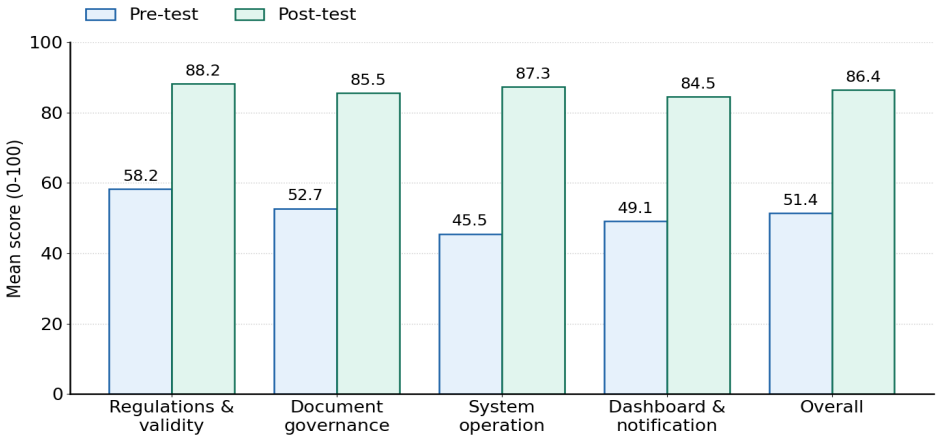

Figure 7. Comparison of pre-test and post-test scores per knowledge domain

The results were interpreted by comparing the N-Gain scores across domains. The domain with the lowest N-Gain score indicates material requiring reinforcement in follow-up mentoring sessions, while the domain with the highest score demonstrates the effectiveness of the hands-on practice method applied. Per-domain analysis provides more operational information than an aggregate score, because it enables the partner to set priorities for refresher material in a targeted manner.

In this programme, domain D3 on system operation obtained the highest N-Gain of 0.77, while domain D4 on dashboard and notification use obtained the lowest value of 0.70. This difference is consistent with the share of hands-on practice time allocated to each domain during the session, and became the basis for compiling the follow-up mentoring agenda for the partner.

User Acceptance and Programme Evaluation

User acceptance of the system was measured using the System Usability Scale with ten respondents, namely two HRD unit personnel acting as system administrators and eight supervisors and data officers from the four divisions. Scores per aspect are reported on the SUS item contribution scale of 0 to 4, while the overall score is reported on a scale of 0 to 100. A recapitulation of the results is presented in Table 6.

Table 6. Recapitulation of System Usability Scale scores (n = 10)

Aspect	Items	Mean score	Remarks
Ease of use	3, 7, 9	3.44	Very good
System complexity	2, 4, 6	3.13	Good
Interface consistency	5, 8	3.35	Very good
Willingness to reuse	1, 10	3.30	Good
Overall SUS score	1-10	82.5	Excellent (grade A), above the 68 average threshold

The overall SUS score of 82.5 is above the industry average threshold of 68 and falls into the excellent category with grade A acceptance. The ease of use aspect obtained the highest score of 3.44, while the system complexity aspect obtained the lowest score of 3.13. This pattern indicates that the system interface is easy to operate, although some respondents considered that the certificate recording workflow still requires adjustment to existing work habits. Based on this finding, simplification of the certificate data entry form was set as the priority improvement in the operational mentoring stage. As a comparative context, the evaluation of the Level 2 TKBT Training Batch 3 that formed the background of this programme shows a high level of participant satisfaction. Twenty of 22 respondents or 90.9 percent stated that the training objectives were fully achieved and two respondents or 9.1 percent stated that they were exceeded, while 15 respondents or 68.2 percent rated the effectiveness of the training at the maximum level. A recapitulation of that evaluation is presented in Figure 8.

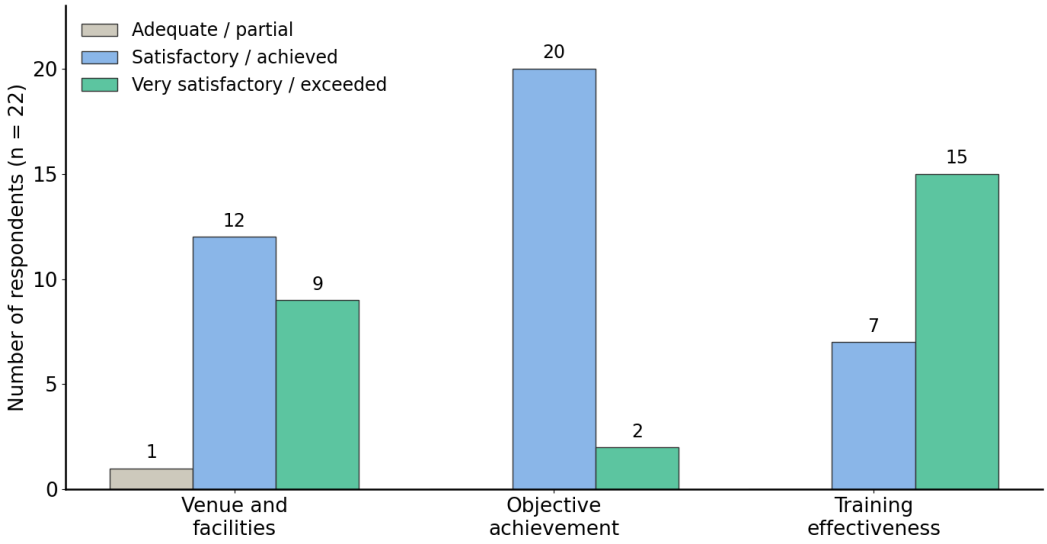

Figure 8. Recapitulation of the Level 2 TKBT Training Batch 3 evaluation (n = 22)

The data in Figure 8 reinforce the argument that the partner's problem does not lie in the quality of training delivery, but in the mechanism for maintaining competency after the training is completed. This finding is consistent with Chellappa et al. (2024), who noted that research and practice attention in safety training remains concentrated on the delivery phase, while the maintenance phase receives a far smaller share. Written feedback from training participants requesting the provision of personal protective equipment appropriate to Level 2 TKBT requirements and the periodic delivery of refresher training shows that the need for a continuous monitoring mechanism is also recognised by workers in the field.

Discussion

The system developed in this programme has two differentiators compared with similar systems in previous studies. First, user orientation. Vinanda et al. (2019), Putra et al. (2019), and Hartono et al. (2021) developed systems for certification providers, so that their dominant modules are registration and assessment. The system in this programme is oriented towards the company employing certified workers, so that its dominant modules are validity monitoring and verification of assignment readiness. Second, integration of the divisional dimension. Linking the certificate entity to the division entity through the employee entity enables supervisors to assess the competency readiness of their teams without examining data one by one, which is a specific need of organisations with a complex divisional structure such as the partner.

From a regulatory compliance perspective, this system functions as an administrative control over the obligations regulated by Minister of Manpower Regulation Number 9 of 2016. Notifications at 90 and 30 days before expiry provide sufficient lead time for the HRD unit to schedule refresher training or re-assessment before the certificate expires. This function directly addresses the partner's HRD recommendation regarding the need for periodic monitoring and evaluation of the implementation of training outcomes.

The findings of Xu et al. (2024) regarding barriers to the adoption of digital technology in safety management were taken into account in designing the mentoring stage. The availability of software does not by itself produce a change in practice unless it is accompanied by strengthening of operator capacity and clear assignment of responsibility. For that reason, the sixth stage of the programme does not stop at handover, but covers operational mentoring during the transition period and the preparation of a user guide as an independent reference for the partner.

The limitation of this programme lies in the scope of impact measurement, which is still confined to knowledge improvement and user acceptance in the short term. Impact on more substantive safety indicators, such as a reduction in the number of assignments involving expired certificates or a change in the near-miss rate for work at height, requires observation over a longer period. Another limitation is the scope of the system, which so far covers only TKBT certification, whereas the partner manages several other types of competency certification. Expanding the coverage of certification types is the next development direction, which has been accommodated through the separation of the certificate_type entity in the database design.

CONCLUSION

This community service programme produced a web-based OSH competency certification management information system designed to address the problem of post-training data governance at PT Batamindo Investment Cakrawala. The situation analysis showed that the partner's problem does not lie in the quality of training delivery, but in the absence of a centralised and automatic mechanism for monitoring certificate validity, creating a risk of assigning workers with expired certificates to high-risk work. The system built integrates certificate recording, automatic notification ahead of expiry, a recapitulation dashboard per division, and digital file archiving within a single centralised database with role-based access restriction.

Quantitatively, this programme achieved three main results. Black box testing of ten scenarios produced a functional success rate of 90 percent in the first round of testing, and all scenarios were declared valid after corrections were made prior to handover. Measurement of participants' knowledge showed an increase in the mean score from 51.4 in the pre-test to 86.4 in the post-test, with an N-Gain of 0.72 which falls into the high category, the highest achievement being in the system operation domain at 0.77 and the lowest in the dashboard and notification use domain at 0.70. User acceptance of the system obtained a System Usability Scale score of 82.5, which is above the average threshold of 68, so that the system is considered fit to be operated independently by the partner. Sustainability of the programme is directed towards operational mentoring over one full notification cycle, reinforcement of material in the dashboard and notification domain that obtained the lowest N-Gain, and expansion of the system's coverage to other occupational safety and health certification types beyond TKBT through a follow-up cooperation scheme between the proposing institution and the partner.

ACKNOWLEDGEMENT

The authors would like to thank the management of PT Batamindo Investment Cakrawala, in particular the Human Resource Development unit and the Occupational Health and Safety division, for their willingness to act as partner and for granting access to data and permission to publish this programme. Thanks are also extended to all participants of the Level 2 TKBT Training Batch 3 who took part in the knowledge measurement and system acceptance testing, and to the Institute for Research and Community Service of Universitas Ibnu Sina for supporting the funding of this programme.

REFERENCES

Bao, L., Tran, S. V. T., Nguyen, T. L., Pham, H. C., Lee, D., & Park, C. (2022). Cross-platform virtual reality for real-time construction safety training using immersive web and industry foundation classes. Automation in Construction, 143, 104565.

Chellappa, V., Mésároš, P., Spišáková, M., Kaleja, P., & Špak, M. (2024). Digital technologies (DTs) for safety education and training in construction. Work, 79(4), 1–15.

Hake, R. R. (1998). Interactive-engagement versus traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses. American Journal of Physics, 66(1), 64–74.

Hartono, R., Sofya, N. D., & Nawassyarif. (2021). Aplikasi pendaftaran sertifikasi kompetensi pada Career Development Center (CDC) Universitas Teknologi Sumbawa berbasis web [Web-based competency certification registration application at the Career Development Center (CDC) of Universitas Teknologi Sumbawa]. Hexagon: Jurnal Teknik dan Sains, 2(2), 32–42.

Lubis, B. O. (2021). Sistem informasi pengelolaan sertifikasi kompetensi online pada SMK dengan metode web base engineering [Online competency certification management information system for vocational schools using the web base engineering method]. JISICOM: Journal of Information System, Informatics and Computing, 5(2).

Peraturan Menteri Ketenagakerjaan Republik Indonesia Nomor 9 Tahun 2016 tentang Keselamatan dan Kesehatan Kerja dalam Pekerjaan pada Ketinggian [Minister of Manpower Regulation of the Republic of Indonesia Number 9 of 2016 on Occupational Safety and Health in Work at Height]. Berita Negara Republik Indonesia Tahun 2016 Nomor 386.

Peraturan Pemerintah Republik Indonesia Nomor 50 Tahun 2012 tentang Penerapan Sistem Manajemen Keselamatan dan Kesehatan Kerja [Government Regulation of the Republic of Indonesia Number 50 of 2012 on the Implementation of the Occupational Safety and Health Management System]. Lembaran Negara Republik Indonesia Tahun 2012 Nomor 100.

Putra, R. E., Wijanarko, D. V., Usodoningtyas, S., & Singke, J. (2019). Pengembangan aplikasi sertifikasi online untuk menguji kompetensi mahasiswa Unesa [Development of an online certification application to assess the competency of Unesa students]. Journal of Information Engineering and Educational Technology, 3(2), 90–96.

Slamet, M., & Mulyanto. (2021). Manajemen uji kompetensi Lembaga Sertifikasi Profesi (LSP) SMK Negeri 1 Kebumen [Competency assessment management of the Professional Certification Body (LSP) of SMK Negeri 1 Kebumen]. Jurnal Media Manajemen Pendidikan, 4(2), 206–215.

Stefan, H., Mortimer, M., Horan, B., & Kenny, G. (2023). Evaluating the preliminary effectiveness of industrial virtual reality safety training for ozone generator isolation procedure. Safety Science, 163, 106125.

Undang-Undang Republik Indonesia Nomor 1 Tahun 1970 tentang Keselamatan Kerja [Law of the Republic of Indonesia Number 1 of 1970 on Occupational Safety]. Lembaran Negara Republik Indonesia Tahun 1970 Nomor 1.

Vinanda, A. R., Wicaksono, S. A., & Amalia, F. (2019). Pengembangan sistem informasi asesmen lembaga sertifikasi profesi berbasis web (Studi kasus: SMK Negeri 4 Malang) [Development of a web-based assessment information system for professional certification bodies (Case study: SMK Negeri 4 Malang)]. Jurnal Pengembangan Teknologi Informasi dan Ilmu Komputer, 3(6), 6220–6229.

Xu, J., Li, J., & Chen, X. (2024). Assessment of technology adoption in construction safety management: Case study in China. Science Progress, 107(4).

Zermane, A., Mohd Tohir, M. Z., Baharudin, M. R., & Mohamed Yusoff, H. (2022). Risk assessment of fatal accidents due to work at heights activities using fault tree analysis: Case study in Malaysia. Safety Science, 151, 105724.