Journal of Engineering Science and Technology
Vol. 19, No. 1 (2024) 18 - 34

A RETROFITTED DIGITAL VISUAL MANAGEMENT SYSTEM (DVMS) TO MANAGE AND CONTROL THE PRODUCTION ACTIVITIES IN THE MANUFACTURING INDUSTRY: AN EXPLORATORY STUDY

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Abstract

Visual management systems have long been successful tools for lean management in various industries. However, as technology advances in Industry 4.0, the non-interactive nature of traditional visual management systems has become less attractive, leading to the need for digital visual management systems (DVMS). This paper presents an exploratory study of retrofitting DVMS that follows a user-centred design (UCD) approach to Autokeen's production floor, which can be applied to other manufacturing companies. The UCD approach included a unique visual element in the initial design stage: emoji as the primary visual element. The process was iterative, consisting of three phases: initial, prototype, and implementation, with usability evaluations conducted at each stage. During the initial stage, the researcher collected the user requirements through surveys and observations and creatively incorporated the emoji features into the DVMS user interfaces (UIs) design. The researcher conducted a heuristic evaluation and informal interviews in the second stage to improve the DVMS's UIs design. In the final step, the researcher employed a user-based testing method to test task completion rates on the DVMS user interface's final version, followed by a Post-Study System Usability Questionnaire (PSSUQ). The results of the PSSUQ indicated a total user satisfaction score of 2.24 out of a 7-point Likert scale. The findings suggest that a UCD approach, followed by a usability evaluation of each phase, can lead to implementing a user-friendly DVMS that meets the requirements of the manufacturing industry.

Keywords: Lean management technology, Production management system, Usability evaluation, User-centred design (UCD), Visual management system, Visual management system.

1. Introduction

Industry 4.0 and the Internet of Things (IoT) are popular topics among practitioners and developers. According to previous studies, practitioners and developers have repeatedly discussed this issue on a Stack Exchange platform to keep up with the progress of this topic [1]. Many business leaders have questioned the credibility of Industry 4.0 and want to know if it will bring more excellent value to their company [2]. The advancement of information technology (IT) brings the robust computational process, creating the cyber components that integrate with the physical components which involve the physical processes in forming the cyber-physical systems (CPS), which is part of Industry 4.0, can result in improved visibility and insight into a company's operations and assets, allowing them to monitor, control, and manage their business activities more efficiently [3, 4]. In addition, by merging lean principles with Industry 4.0 technologies, companies can further streamline their production processes, eliminate waste, and enhance product quality, ultimately leading to greater customer satisfaction and increased profits [4-7]. This revolution allows lean practitioners to use Industry 4.0 technology (like automation, data analytics, and IoT) to streamline operations, optimise processes, and cut waste in manufacturing and supply chains. Utilising Industry 4.0 technology alongside lean methodologies enables streamlined operations, increased efficiency, and improved profitability in manufacturing and supply chains [8].

Visual management (VM) is a prominent lean method that complements Industry 4.0 by promoting effective communication through visual devices [9]. The Toyota Production System (TPS) is a prime example of integrating VM to display standards, ensuring any deviations are visible to all in the organisation [10]. With the innovative digitisation process in the industry, VM has expanded to include virtual and actual data integration [11] thus turning the conventional VM into a Digital Visual Management System (DVMS). The DVMS technology combines knowledge visualisation and real-time data analytics to support manufacturing improvement. It provides a platform for visualising and analysing data related to production processes, enabling better decision-making and performance optimisation in manufacturing operations [12]. As a new VM, DVMS has efficiently processed complex data through computational methods, offering visual representations of relevant actions, thereby contributing to business growth across various sectors [13-16].

The DVMS implementations can extend beyond graphs and numbers and incorporate symbols, images, and signs [6]. Emojis, as popular and universally recognisable visual communication tools, are efficient in conveying information [17] and have become integral to modern communication in various digital platforms [18]. These Unicode graphic symbols offer shorthand representation of concepts, fostering creativity and visual expression in the language [19]. Emojis add emotional context to text-based communication, enhancing message impact, understanding, and interpretation [20]. Studies have incorporated facial expressions into emojis to reduce ambiguity, demonstrating their effectiveness in conveying emotions in digital interactions [21]. Emojis in DVMS aid in swift issue identification and response, fostering real-time communication without complex explanations. They standardise visual interpretation, promoting effective industry-wide communication and collaboration. Additionally, they gauge emotional reactions to products, shaping marketing decisions and enhancing product acceptance [22].

This research conducts an exploratory study by retrofitting the DVMS into Autokeen's production floor to facilitate business growth in Malaysia's manufacturing industry. This study presented the user-centred design (UCD) process as a method for designing and evaluating the emoji-based DVMS user interfaces (UI).A unique approach will be taken by incorporating emojis, a popular form of visual communication in daily life, to represent indicators in implementing the retrofitted DVMS [23]. This process involves understanding the needs and requirements of users, developing design concepts, prototyping, and conducting usability evaluations [24]. Including the existing visual tools on the production floor in retrofitting process, enables the users to recognise the innovative process towards VM efficiently [25].

2. Emoji in Digital Visual Management System (DVMS) of Industry 4.0

Industry 4.0 has brought about significant advancements in visual management systems, leading to the evolution of traditional visual management into Digital Visual Management Systems (DVMS) [26]. Visual management systems have long been used in manufacturing production to improve operations. These systems support ongoing strategy implementation and implementation, facilitate performance measurement and review, enable people engagement, improve internal and external communication, enhance collaboration and integration, support the implementation of a continuous improvement culture, and foster innovation [27].

In the context of DVMS, considering emojis as visual elements is pertinent. Emojis have recently gained significance and widespread on social media and digital communication platforms. While there is limited research specifically on the inclusion of emojis in DVMS, studies have explored the impact of emojis on various aspects of communication and engagement. For example, research has shown that emojis can influence brand engagement on social media platforms [28]. However, it is essential to note that, including emojis in DVMS should be cautiously approached. Emojis are not a standalone language but an evolution of older visual language systems that use digital technology to create more excellent layers and nuance in asynchronous communications [19]. Therefore, using emojis in DVMS should align with the overall goals and objectives of the system, ensuring that they enhance communication and understanding rather than detract from it.

Industry 4.0 technologies have significantly propelled DVMS in manufacturing. DVMS has effectively bolstered strategy implementation, performance measurement, communication, collaboration, and continuous improvement. This exploratory study focuses on retrofitting DVMS with emojis to enhance visual representation and employs UCD to collect user feedback.

3. Methods

This research aims to retrofit the Digital Visual Management System (DVMS) with emojis at Autokeen's production floor. The methods explained the user-centred design (UCD) processes to design and evaluate the user interfaces (UI) of the emoji-based DVMS, aiming to enhance visual communication and improve operational efficiency. Based on the flowchart shown in Fig. 1, the implementation process included prototyping the DVMS, establishing the production environment, management environment, and database environment, testing the full functionality of the DVMS in a real-world scenario, and refining the DVMS functionality and design.

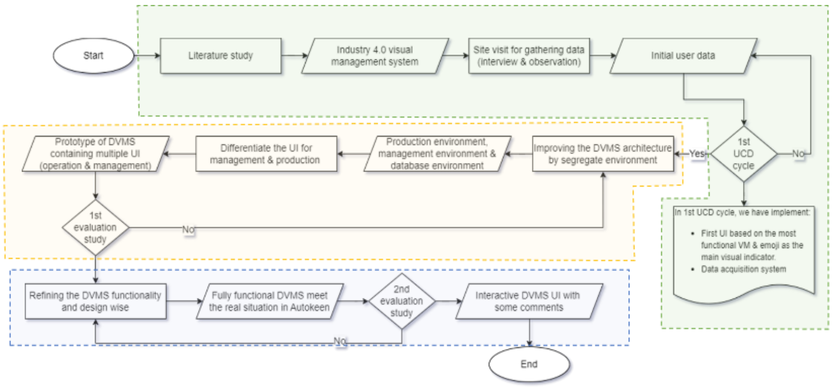

Fig. 1. Flowchart of the implementation process of retrofitted DVMS.

3.1. Company background

Established in March 1988, Autokeen Sdn. Bhd. excels in stamping and sub-assembling of metal components for the automotive industry, partnering with major Malaysian automakers. This exploratory study delves into their sub-assembly, focusing on the welding process for automotive stamped panels. The study aims to upgrade the outdated VM in the Welding Spot Stationary (WSS) Line with customised DVMS with emoji as the primary visual representative due to poor communication on the production floor. The study targets three cells using stationary spot weld machines in kilo-Volt-Ampere (kVA) and integrates Industry 4.0 for better operator interaction towards their productivity.

Fig. 2 shows the current state of the two cells in the WSS Line, each cell containing a WSS machine operated by an operator. Conventional VM tools are around the workstations and attached to the building walls. Behind the pallets storing complete and incomplete automotive stamped panels, there is a pathway for forklifts to transfer them to the storage department. To get a clearer picture of the WSS Line. Figure 3 shows a diagram of the working area, highlighting the selected cells (50 kVA 5, 35 kVA, and 50 kVA 6) responsible for spot-welding nuts and bolts to the automotive panels. These cells serve as the control point for the retrofitted DVMS, where operators utilise the retrofitted equipment throughout the activity.

Fig. 2. 55 kVA 6 and 35 kVA in WSS line.

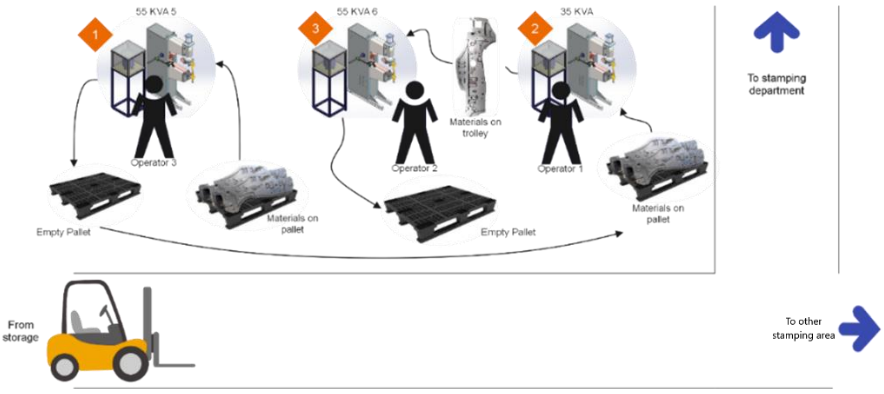

Fig. 3. Material handling process in the WSS line diagram.

3.2. The implementation process of retrofitted DVMS towards Autokeen

The DVMS implementation process involved an iterative approach organised into three primary phases: initial, prototyping, and implementation. In each stage, the UCD method will be followed by the usability evaluation processes. The users' feedback according to the developed systems will be acquired. The main objective of the DVMS is to get the user's interaction. Evaluation was identified and taken according to the developed DVMS in each phase [29-31]. Mainly, the implementation of the retrofitted DVMS for Autokeen followed a UCD process, which involves designing products or systems with the end-user in mind. This approach includes gathering user needs and requirements through various data-gathering methods and applying them throughout the design process. The ISO-14307 standard, which defines the human-centred design process, was used as a guideline to ensure that the retrofitted DVMS meets the users' needs and expectations [32, 33].

Fig. 4 illustrates the UCD cycle during the DVMS designing process. It involves understanding the context of use in observing the working area of Autokeen, specifying user and organisational requirements through interviews, creating design solutions based on the current trend of using emoji in communication, and evaluating those designs against provisions in a cyclical manner to ensure a product that aligns with user needs and functions effectively.

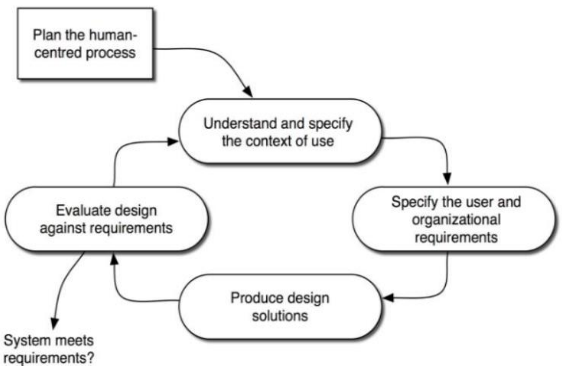

Fig. 4. The human-centred design process cycle [24].

The DVMS implementation involved three key phases: initial, prototyping, and implementation. The processes in these phases iteratively ensured user needs, usability, and functionality. Usability evaluations, detailed in Table 1, were conducted in each phase to enhance user interaction and production. The initial phase used surveys and observations to understand user requirements, followed by heuristic evaluations and user-based testing in subsequent steps. The process concluded with the Post-Study System Usability Questionnaire (PSSUQ) for a comprehensive usability assessment. Detailed implementation explanations for each phase will be discussed further in the following sub-sections.

Table 1. DVMS usability evaluation processes.

Evaluation Process	Initial Phase	Proto-typing Phase	Implem-entation Phase	Purpose
Survey and observation	✓			To determine users' needs and requirements
Heuristic usability evaluation		✓		To identify potential upgrades and issues with the prototype
In-formal interview		✓		To obtain users' opinions of the DVMS usability
User-based testing method usability evaluation			✓	Observe and collect feedback from users as they interact with the system.
Post-Study System Usability Question-naire (PSSUQ)			✓	To evaluate the usability of the final product by distributing a standardised questionnaire to the users

3.2.1. First part: Initial phase

The iteration process began with the initial stage, where the researcher prepared literature on conventional VM and Industry 4.0 integrated VM. The researcher then visited Autokeen Sdn. Bhd. to initiate the UCD process by gathering user requirements and data on the tested cells through surveys and observations. Based on this information, the research identified the most functional VM tools available for the WSS machine. Subsequently, the researcher followed a design process of user interfaces (UI) with a sketch on a blank paper. The next step involved producing design solutions by mocking up the UI based on Python Tkinter, a standard GUI toolkit to visualise real-time data that is based on the Raspberry Pi (RPi)., Research choose the RPi due to its successful usage in diverse IoT applications [34]. An emoji was chosen as the primary visual indicator to represent the productivity rate as users increasingly use emoji in network communication. Blending the emoji with short text can make the communication immersive [17, 35]. Additionally, the researcher also employed colours to highlight or minimise information on the UI. During the selection of colours in the design process, the focus was on keeping things simple, consistent, clear, and using colours that conveyed the intended message [36, 37]. Furthermore, this research implemented data capture, utilising proximity sensors to measure the product output while building the UI to retrofit the DVMS, simulating the WSS machine sensors that count the product. Stakeholders then assessed the early design of DVMS to obtain quick criticism on the structure and organised utility of the framework, which is one of the primary pillars of UCD.

3.2.2. Second part: Prototyping phase

During the prototyping phase, the researcher refined the mock-up DVMS into a semi-functional system based on user feedback from surveys and observations of improvement areas from the initial phase. After discussing with experts, the architecture of the DVMS was implemented in the prototyping phase, as shown in Fig. 5. The architecture encompassed the production UI, management UI, and database environments that utilised MySQL services to store all production data. MySQL is an open-source relational database management system (RDBMS) widely used for organising and retrieving data using structured query language (SQL). The database management ran on the RPi model 3B+, separated from all environments. The DVMS UI is split into two UIs to classify job scopes for management and production operation, which also run on different computing units. The management environment was running on a laptop, while the operation environment was running on a RPi 4, and the proximity sensor connected directly towards it to capture the production data. After designing the DVMS UI, three experts will evaluate the system using heuristic methods. The researcher also conducted informal interviews with operators to ensure a convenient and usable DVMS.

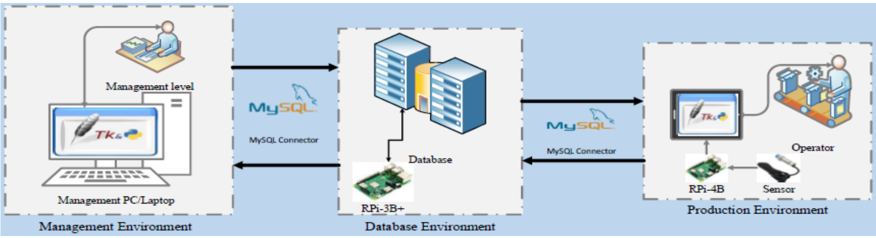

Fig. 5. DVMS architecture.

3.2.3. Third part: Implementation phase

The retrofitted DVMS UIs undergo a refinement process to fulfil the first two iterations of the UCD cycle. During the previous iteration phase, the researcher conducted heuristic evaluations and informal interviews to complete the UCD cycle of the design process [29]. The conducted evaluation resulted in the implementation phase, where the researcher finished the DVMS into a fully functional system and furnished the UI based on experts' and operators' opinions. The researcher tested the DVMS designed to match Autokeen's production processes before this phase's final evaluation. After a series of tests, a user-based testing method evaluation study will be performed in Autokeen's selected cells to evaluate the DVMS's usefulness and usability [29], as shown in Fig. 6. Researcher provides the operators visualised in Fig. 6, a 7-inch touchscreen monitor running RPi to allow the operator to interact with the DVMS Operation UI. A line leader was also assigned a laptop to visualise the DVMS Management UI to disseminate the tasks. The researcher asked the operators and line leader to complete the tasks regarding the actual production situation tasks using the DVMS. Tasks included tracking production status, assigning tasks, and monitoring progress. Testing occurred in a realistic environment with observation by a research assistant. Participants completed all tasks given. The evaluation process follows with the operators answering a standardised Post-Study System Usability Questionnaire (PSSUQ). This questionnaire offers advantages in standardisation, reliability, validity, and ease of use, making it a valuable tool for accurately measuring user satisfaction with product or system usability [31].

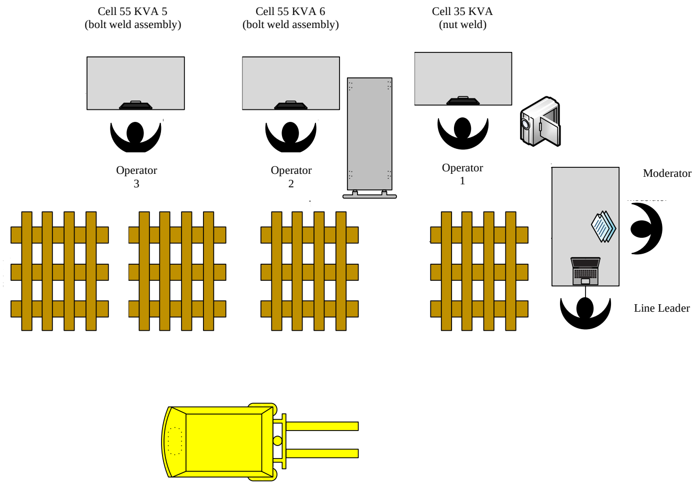

Fig. 6. User-based testing method evaluation study setup.

3.3. Participants

The study included participants from Autokeen Sdn. Bhd., is a Malaysian automotive stamping panel industry. This research selected the participants comprising 13 individuals, with three managers aged from early forty until mid-fifty and ten operators from early twenty until late thirty for the operators. The operators were experts in the production department with more than five years working experience and representing local and foreign individuals from Bangladesh, Indonesia, and Vietnam. The managers supervised and managed the production process, while the operators performed the daily production tasks.

4. Results

This section presents the results of the DVMS designing process using UCD and research findings on a retrofitted DVMS in manufacturing, aiming to digitalise the visual management system and assess its efficiency. Usability evaluation techniques were used in each final cycle of UCD to ensure user satisfaction, productivity, and cost reduction.

4.1. Implemented Emoji-based digital visual management system (DVMS)

The emoji-based DVMS aims to attract production operators to the new digital VM system and improve their interaction with the visual representation around their working area. This innovation helps operators understand information related to their production activities, such as the number of finished goods, scraps, and productivity rates. Figs. 7(a) and (b) show the prototype UI of the DVMS implementation designed using Python Tkinter, a standard GUI toolkit, to visualise real-time data from the MySQL database. Programmed in Python, these UIs managed and displayed production activities for the monitored cell in Autokeen. They utilised the MySQL connector to transfer data to ensure users had real-time information interactively. Figs. 7(a) and (b) reveal improvements in the initial implementation, where this research separated features into two UIs. The DVMS Management UI (Fig. 7(b)) empowered the management team to oversee production processes. At the same time, the DVMS Operation UI (Fig. 7(a)) allowed operators to track their productivity rate in the form of numbers and actively changing emojis, thus helping them control activities in the production environment. Figs. 7(a) and (b) show the elements contained in the DVMS:

DVMS Management UI in Fig. 7(a):

- **Production History**: Allows management to review past production by cell, operator, and part ID, facilitating performance analysis and operator reassignment for continuous improvement.
- **Machine Monitoring**: Enables monitoring of machine conditions by operators before tasks, aiding in identifying maintenance needs.
- **Overall Equipment Effectiveness (OEE)**: Displays real-time OEE, including availability, performance, and quality, with a time-based graph for production trend analysis.
- **Communication Box**: Facilitates communication between management and operations interfaces, exchanging messages in this box.
- **Line Activity**: Manages and monitors production activities by assigning tasks to operators and providing real-time production status updates in the cell.

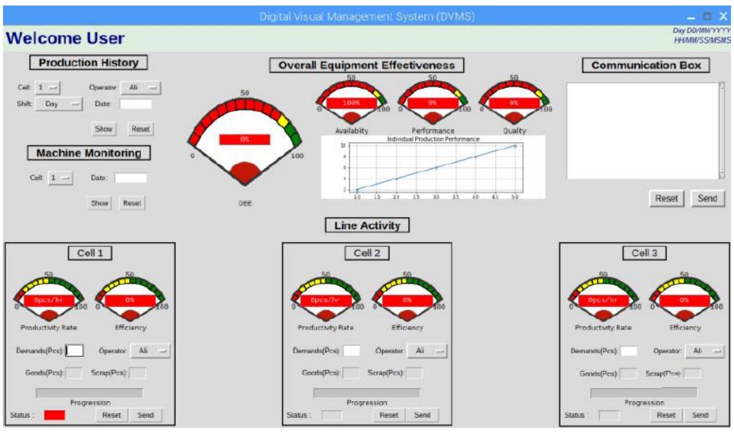

Fig. 7(a). DVMS management UI in the prototyping phase.

DVMS Operation UI in Fig. 7(b):

- **General Info**: Top section to greet and basic information (date & time).
- **Operator Progress**: Count production and break time taken by the operator.
- **Production Data**: Displays real-time production demands, finished goods, scrap count, and productivity trend graphs.

- **Activity Rate**: Displays productivity rate, defects, and emojis.
- **Communication Box**: Displays messages from management and allows operator feedback.
- **Machine Monitoring**: Enables reporting of machine conditions before production.

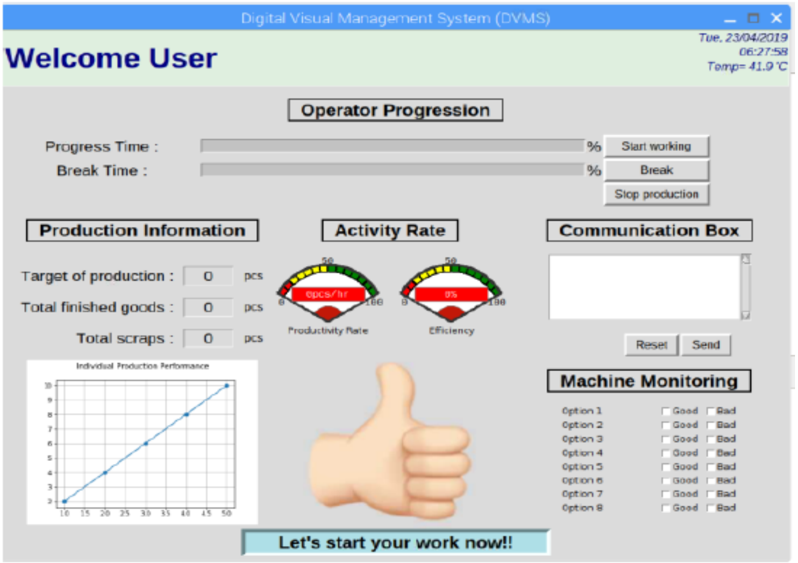

Fig. 7(b). DVMS operation UI in the prototyping phase.

After undergoing a heuristic evaluation by Autokeen's experts and having an informal interview with operators, the research finally has the final design of the DVMS UIs. Figs. 8(a) to (e) shows the final design of DVMS prototype. Although the architecture of the DVMS remained the same, some features and functionalities in the system were changed. The UI was also made more colourful and given a dark theme to match Autokeen's environment and attract users who operate the DVMS. The revised elements of the DVMS also appear to be shown in Figs. 8(a) to (e).

DVMS Management UI in Fig 8(a):

- **Production History**: Allows management to review past production by cell, operator, and part ID, facilitating performance analysis and operator reassignment for continuous improvement.
- **Machine Monitoring**: Enables monitoring of machine conditions by operators before tasks, aiding in identifying maintenance needs.
- **Production Real-time Data:** Replacing OEE features based on expert's orders into a summary of the real-time production numbers in gauge.
- **Communication Box**: Facilitates communication between management and operations interfaces, exchanging messages in this box.
- **Line Activity**: Manages and monitors production activities by assigning tasks to operators and providing real-time production status updates in the cell.
- **Variable Management**: Located on the Line Activity's left side, users can edit system's settings.

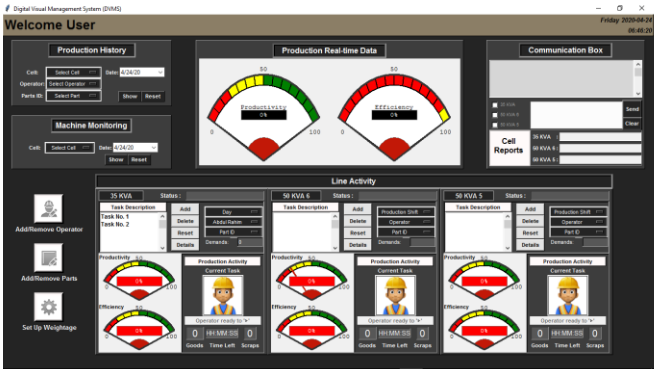

Fig. 8(a). DVMS management UI in the implementation phase.

DVMS operation UI in Figs. 8(b) to (e):

- **General Info**: Top section to greet and basic information (date & time).
- **Safety Requirements**: Operators must wear basic personnel protective equipment (PPE) as shown in this feature.
- **Task Management**: Shows the available tasks for the day.
- **Task Description**: Showing the upcoming task's standard operation procedure (SOP).
- **Task Completion Rates**: Percentage of completed throughout the day.
- **Machine Monitoring**: Enables reporting of machine conditions before production.
- **Task Information**: Showing a picture of the product output that, if clicked, will show the SOP as in Task Description.
- **Time Management**: Showing the ongoing time, need to key in if going for break or changeover.
- **Emoji**: Interactively changing based on the situation and production rates in the production operation are ongoing.
- **Production Status**: Displays real-time production demands, finished goods, scrap count, and gauges for productivity rate and production efficiency.
- **Emergency Button**: To report for emergency.
- **Break Frame**: Visualise that whoever is around the workstation can see the screen when the operator is not in cells.

Fig. 8(b). 1st frame DVMS operation UI in the implementation phase.

Fig. 8(c). 2nd frame DVMS operation UI in the implementation phase.

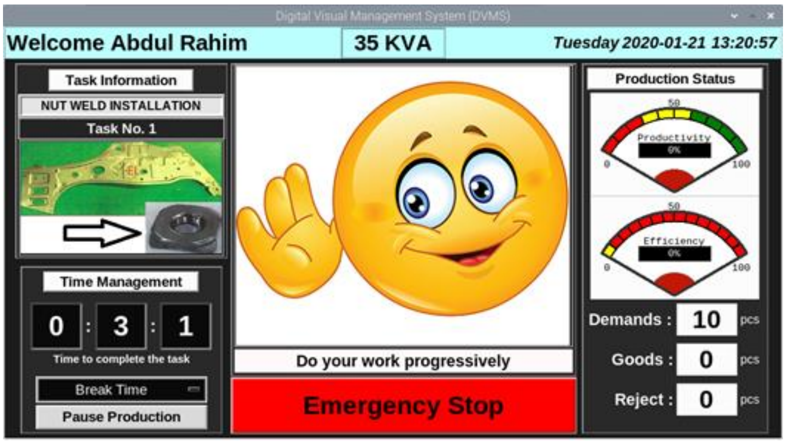

Fig. 8(d). 3rd frame DVMS operation UI in the implementation phase.

Fig. 8(e). Break frame DVMS operation UI in the implementation phase.

4.2. User's feedback insight for DVMS implementation

During comprehensive user evaluations of the DVMS, this research gathered several strengths and areas for improvement, offering valuable insights for its enhancement. From the evaluation process, the study recognised a positive aspect of its user-friendly interface, noted for its intuitive design that facilitated easy navigation and quick understanding without requiring extensive training. Users appreciated the system's effective visual representation of data, enabling swift comprehension and informed decision-making. Moreover, the DVMS was commended for its seamless alignment with daily production operations, actively contributing to real-time decision-making and streamlining workflow processes.

4.3. PSSUQ results

The PSSUQ, which utilises a 7-point Likert scale, evaluates user satisfaction in: System Usefulness (SysUse), Information Quality (InfoQual), and Interface Quality (IntQual). Results shows that the DVMS scored highly in all areas, SysUse measures the perceived usefulness of the system. It assesses how well the system supports the tasks the user wants to accomplish and how effectively it enables users to achieve their goals. In this case, the DVMS received an average score of 2.22 (SD = 1.441), indicating that users found the system highly useful in supporting their tasks. After that, InfoQual evaluates the quality of the information the system provides. It examines whether the information is clear, accurate, and helpful in guiding the user's actions. The DVMS scored an average of 2.20 (SD = 1.218) in this category, suggesting that users found the information provided by the system to be clear and helpful. Finally, IntQual measures the quality of the system's interface. It assesses whether the interface is easy to use, visually pleasing, and it facilitates smooth interaction with the system. The DVMS scored an average of 2.39 (SD = 1.252) in this category, indicating that users found the interface easy to use and visually pleasing.

The PSSUQ results present a compelling narrative of the DVMS's reception among users. With high SysUse, InfoQual, and IntQual scores, the DVMS emerges as a successful system in meeting user expectations and delivering a positive user experience. These findings reinforce the system's effectiveness in aiding users with tasks, providing clear and helpful information, and offering an intuitive and visually pleasing interface. Such user satisfaction indicates the DVMS's potential to enhance user workflow, support informed decision-making, and contribute to a more efficient production environment.

In conclusion, the results suggest that its users received the DVMS that its users received the DVMS well. They found it helpful, were satisfied with the quality of information it provided, and found the interface easy to use and visually pleasing. These encouraging results suggest that the DVMS is a user-friendly system that effectively supports users' tasks. However, it is important to note that there is always room for improvement, and user feedback should be continuously collected and analysed to enhance the system's usability further.

5. Discussion

Implementing the retrofitting process for the Digital Visual Management System (DVMS) witnessed several significant phases, marked by transitions in design, functionality, and user interface enhancements. The progression through the Initial, Prototyping, and Implementation phases showcases a comprehensive development path that addresses the operational needs of both the production and management teams. The initial phase laid the foundation for a unified interface, which was subsequently refined and expanded upon during the prototyping and implementation stages. The segregation of the DVMS into operation and management interfaces was a pivotal step, allowing dedicated focus on distinct functionalities for each team's requirements. This separation facilitated a more tailored approach to address the diverse needs of shop floor operators and management personnel. In the operational interface's journey enhancement, a form of a single-frame design to the multi-frame layout in the implemented phase reflects an iterative process driven by user feedback and testing. The shift to multiple frames with customisable features empowers the shop floor operator by providing a more transparent and interactive interface. The integration of safety guidelines, task-specific information, and productivity indicators in the form of emojis not only motivates operators but also enhances their understanding of tasks and operations, fostering a more responsive and informed workforce. Simultaneously, the management interface evolved to encompass a broader range of functionalities crucial for efficient oversight of production activities. Significantly enhancing managerial capabilities, incorporating real-time production data, user-controlled settings affecting the operation UI, and the ability to communicate and distribute tasks among different cells is achieved. Including line activity features facilitate streamlined coordination and real-time monitoring of tasks, ensuring a more synchronised and productive workflow across other cells.

Throughout the phases, a prominent highlight is the emphasis on the User-centred design (UCD) approach. The system's development journey involved continuous user evaluations and feedback, leading to refinements that catered to the specific needs and preferences of the end-users. The iterative nature of the design process, evident in the incorporation of safety guidelines, task-specific information, and user-controlled settings, reinforces the commitment to enhancing user experience and system functionality. The successful implementation of the DVMS highlights its potential to revolutionise manufacturing operations by bridging Industry 4.0 technologies with lean principles. Integrating visual management tools, emojis, and real-time data visualisations not only optimises information dissemination and paves the way for self-motivation for the operators to understand their production activities.

Further exploration and refinement could improve the system's responsiveness and scalability. Incorporating predictive maintenance features, expanding the scope of real-time data analysis, and integrating AI-based functionalities could further enhance the system's capacity to anticipate and address production challenges proactively.

6. Conclusion

In conclusion, the journey of the DVMS from its inception to the current stage demonstrates a dedication to user-centric design, a commitment to technological advancement, and a potential for further innovation in the manufacturing industry. This study is a foundation for the broader adoption and evolution of similar systems, facilitating efficient production management and fostering a more interconnected manufacturing ecosystem.

Acknowledgements

This research was supported by Universiti Tun Hussein Onn Malaysia (UTHM) through RE-GG grant (VOT H889).

Abbreviations

AR	Augmented reality
CPS	Cyber-physical system
DVMS	Digital Visual Management System
HCI	Human-computer interaction
IoT	Internet of Things
IT	Information technology
OEE	Overall Equipment Effectiveness
PPE	Personnel Protective Equipment
PSSUQ	Post-Study System Usability Questionnaire
RPi	Raspberry Pi
SD	Standard deviations
SOP	Standard Operating Procedure
TPS	Toyota Production System
UCD	User-centred design
UI	User interface
VM	Visual Management
VR	Virtual reality
WSS	Welding Spot Stationary

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