

Design and Validation of an Iranian Application Software for the Evaluation of the Permit-to-work System in Process Industries

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Background & Aims of the Study: The most important causes of accidents in process industries are related to overhaul and maintenance activities, as well as the absence or failure of a permit-to-work system. The present study aimed to design and validate an application to evaluate the permit-to-work system in the process industries.

Materials and Methods: The present applied–developmental study was conducted in 2019. Initially, 25 experts determined the data elements and the necessary capacities of the application. Original idea of the application software was coded using C sharp in the Microsoft visual 2017. The design was performed in accordance with the SDLC model. Finally, the Questionnaire for User Interface Satisfaction (QUIS) was used to evaluate the usability and user satisfaction of the final version of the application software.

Results: In the designed application software, the clients can evaluate the permit-to-work system based on the defined access limit. According to the scores, the performance of the permit-to-work system is classified as poor, average, good, or excellent, which are actually the outputs of the application software. Based on the results of the QUIS, the overall score of user satisfaction with the application software was 7.71 out of 9.

Conclusion: The developed application software can be used as a suitable tool for the evaluation of the performance of the permit-to-work system in process industries, such as oil and petrochemical refineries as well as other similar industries.

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Background

Industries such as oil, gas, and petrochemicals are considered process industries, where the raw material is converted into an intermediate product or the final product through a series of

physical or chemical processes or a combination of both (1). Production, storage, transportation, and use of hydrocarbon chemicals in these processes as well as the presence of operational parameters, including temperature, pressure, and high equipment density, have caused catastrophic accidents in these industries

throughout history, such as the Bhopal incident in India, Piper Alpha, refinery explosion in Texas, and Amoy in Venezuela (2-4). The consequences of these incidents included the release of toxic substances, fire, and explosion which led to bodily harm, environmental damage, and economic loss.

According to previous studies, the most important causes of accidents in these industries are related to overhaul and maintenance activities, as well as the lack of a permit-to-work system (5, 6). A permit-to-work system consists of a set of components, whose main purpose is to provide a safe environment and prevent accidents during work (7). To determine how any system works and functions, that system must be monitored and reviewed and the permit-to-work system is not an exception. Currently, permit-to-work systems are monitored by using audit checklists developed by organizations, such as HSE-UK and SHELL, which are observational and based on pen and paper and are randomly completed by the audit team (8). However, the time and cost of copying and completing checklists, as well as the need for statistical software to analyze audit results, are some of the disadvantages of these evaluation methods.

Today, due to the rapid growth of information technology in various fields of science, including occupational safety and health, the use of computer software is expanding in fire and explosion modeling, noise maps, and industrial ventilation (9, 10). Given the importance of evaluating and monitoring the performance of the permit-to-work system in the process industries, the present applied–developmental study aimed to develop a software that performs this task accurately. This research was approved by the occupational health department of the School of Public Health, Tehran University of Medical Sciences, Tehran, Iran (code of ethics: IR.TUMS.SPH.REC.1397.073).

Materials & Methods

The present applied–developmental study was conducted in 2019. A team of academic and industrial experts (n=25) whose scientific and practical backgrounds indicated their familiarity and sufficient mastery of the permit-to-work system were selected to collaborate in the implementation of this project. Software design was performed in accordance with the Software Development Life Cycle model. SDLC is an approach followed in the production or redesign of an application, which includes all operations, such as how to produce, maintain, replace, modify, or improve the quality of the software (figure 1) (11).

The study began with the completion of a questionnaire by experts (n=25) to perform a needs assessment and to determine the required capabilities of the application software. In order to make it comprehensive, the original idea was coded using C sharp in the Microsoft visual 2017. The SQL server 2012 was used to create the database, and ADO.net technology was applied in order to make a connection to the database. The think-aloud method was used to evaluate the usability of the software and potential problems of users while using it; accordingly, it was possible to find solutions

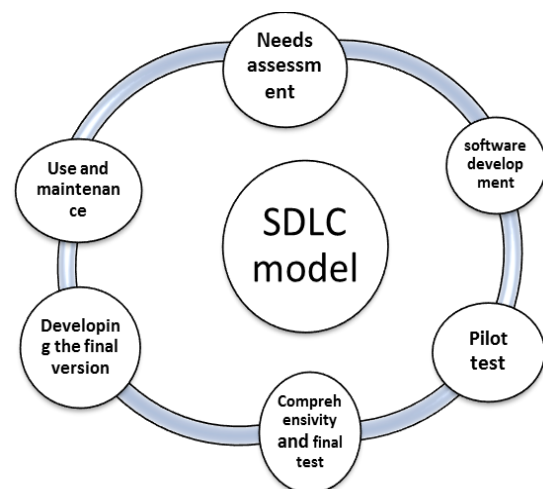


Figure 1) Phases of the SDLC model

for them and improve the software (12). This method is one of the most widely used software evaluation methods. For the implementation of this method, users were asked to perform an evaluation of the permit-to-work system software and express their opinions about its capabilities within 15 working days. User comments and feedback on the primary version of the software were applied in the final version. Finally, the Questionnaire for User Interface Satisfaction (QUIS) was used to evaluate the usability and user satisfaction of the final version of the software.

Results

The developed application software supports English and Persian languages and has admin and client access levels. The admin is responsible for assessing and defining the number (N) of clients. Clients evaluate the permit-to-work system based on the defined access limit. Afterward, the data collected from the evaluation performed by the administrator were analyzed. Based on the scores, the performance of the permit-to-work system was classified as poor, average, good, or excellent, which were actually the outputs of the software (Figure 2). The software also has the ability to

Organization Management	
Create Evaluation	
Evaluation Status	
Evaluation report	
Report of units	
Report of users	
Help contents	
About application	
Change user	

Figure 2) Main menu of the developed application software

identify hidden flaws in the permit-to-work system and provide users with recommendations in the form of corrective actions in order to improve its performance.

Based on the results of the QUIS, the overall score of users' satisfaction with the software was 7.71 out of 9 while the scores for software performance, User Interference, terms and data, learning, and overall system capabilities were 7.58, 7.37, 7.75, 8.11, and 7.74, respectively. It can be concluded that the software facilitates the systematic and flexible analysis of the permit-to-work system.

Discussion

The developed software in this study is a new tool in the field of safety, which can be used to facilitate monitoring and evaluating the performance of the permit-to-work system. This software cannot be compared to similar software in terms of design and performance since no other application software has been developed for the evaluation of the function of the permit-to-work system. However, Karimi et al. recently designed and coded the SQCRA software in Visual Basic with the aim of facilitating the chemical risk assessment process. The SQRA software does not support the Persian language, which can be considered as a limitation (13).

Afari et al. also developed a software for designing the ventilation systems in the Visual Basic environment which improved the computing process, saved time, and reduced computational errors (14). Regarding the above-mentioned software, no information is available about the evaluation of the level of user satisfaction. Moreover, these software used a checklist that was designed by a foreign organization. However, in the present study, the software worksheet was based on a domestically developed questionnaire with confirmed validity and reliability.

Conclusion

The developed application software in this research project can provide a variety of reports according to the users' needs, supports the Persian language, is easy to use and multi-purpose, and benefits from a powerful graphical interface. Therefore, it can be used as a suitable tool to evaluate the performance of the permit-to-work system in process industries, such as oil and petrochemical refineries as well as other similar industries.

Footnotes

Acknowledgements

The present study is extracted from the thesis completed by the first author of this study. Moreover, the ethical code of IR.TUMS.SPH.REC. 1397.073 was approved by Tehran University of Medical Sciences, Tehran, Iran. We acknowledge the invaluable support of experts in the Department of Abadan Oil Refinery Safety, Abadan, Iran, who contributed to this research.

Conflict of Interest

The authors declare that there was no conflict of interest in this study.

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