

An operational model for developing process operator students' safety competence in on-the-job learning

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Abstract. In the safety-critical process industry, safety competence is emphasized. It is essential to ensure that process operator students adopt good safety competence during their studies. Due to Finnish vocational education and training (VET) reform, on-the-job learning has increased, inducing a need for new methods. In this study, an operational model for developing process operator students' safety competence in on-the-job learning was constructed and evaluated. The model was compiled in cooperation with six process industry companies, five VET organizations, and eight expert organizations. The main data collection methods were interviews and workshops. The model consists of eight phases and provides instructions, tools, and good practices for implementing on-the-job learning. Companies and VET organizations considered the model useful and identified several purposes of use for the model.

Keywords: On-the-job Learning · Process Industry · Vocational Education and Training · Vocational Student · Workplace Safety

1 Introduction

New technologies, materials, extreme conditions, and the lack of young professionals are challenges in the process industry, where the potential for major hazards and accident risks is always present [1,2]. Industrial operators have a significant role in process safety [3]. The education of operators should include proper safety education, as young workers typically have a higher injury rate than more experienced ones [4].

The new legislation on vocational education and training (VET) in Finland emphasizes the role of on-the-job learning in vocational education [5]. On-the-job learning is an essential part of developing process safety competence in process operator students. Successful learning at a workplace needs effective cooperation between a VET provider, a company, and a student and the integration of students' different learning environments [6]. The reconciliation of workplace demands and educational goals is important for the student to achieve the desired learning outcomes [7]. For the cooperation of process industry companies and vocational institutions, new methods were needed. The aim of this study is to construct and evaluate an operational model for developing process operator students' safety competence in on-the-job learning.

2 Materials and Methods

This study utilized a constructive research approach, which aims to solve problems through the construction of a practical solution [8]. In this study, an operational model was developed to find solutions that support the development of students' safety competence in the context of on-the-job learning in the process industry. The compilation of the model was based on the main phases typical of constructive research: setting of requirements, construction of alternative solutions, and validation of the constructions [8].

First, the development needs concerning students' safety competence and on-the-job learning in the process industry were charted to define the requirements for the model. Second, the design and content of the model were constructed by synthesizing the data collected for the study. Third, the model was revised according to the review comments of the study participants, and its utilization/usefulness was evaluated.

The model was compiled in cooperation with chemical and process industry companies (n=6), their collaborator VET organizations (n=5), and other expert organizations (n=8) including, for example, labor unions, trade associations, and safety authorities. The main data collection methods were interviews and workshops (Table 1). In addition, a risk assessment exercise with observation, an accident analysis, a questionnaire for students, and the literature are used.

Table 1. Methods and materials used in the construction of the model

Phase	Methods	Participants
Phase 1 Setting of requirements	Interviews	All participating organizations (18 interviewees)
	Workshop 1 Development needs	All participating organizations (19 participants)
Phase 2 Construction of design and content	Company interviews	Company representatives (n=46) from all companies (workplace instructors, superiors, safety and HR specialists, students)
	Workshop 2 Process safety competence	All participating organizations (20 participants)
	VET provider interviews	Process industry teachers (n=7) from all VET institutions
	Risk assessment exercise with observation	Process industry teachers (n=9) and process operator students (n=35) from three VET institutions
	Accident analysis	Accident (n=1381) data and reports (n=17) involving process operators and industry from the Finnish Workers' Compensation Center
	Safety outlook questionnaire	Process operator students (n=117)
Phase 3 Validation	Literature	Previous research, legislation, other guidance related to on-the-job learning
	Workshop 3 Review of the model	All participating organizations (16 participants)
	Feedback interviews	All participating organizations (19 interviewees)

Interview and workshop participants included persons involved in on-the-job learning in companies and VET organizations and other experts in the field of on-the-job

learning and safety. The interviews were mainly semistructured individual interviews and were recorded and transcribed. The workshops were facilitated by the researchers and consisted of common discussions, group works, and presentations of research results. The interviews and workshops covered several topics relevant for the study, for example, good practices and development needs related to on-the-job learning and safety, safety competence requirements, and the usefulness of the model [e.g., 9-11].

The risk assessment exercise aimed to discover how well process operator students can assess risks [12]. The accident analysis provided a summary of the circumstances and consequences typical of accidents at work involving process operators and industry and recommendations for accident prevention. The aim of the questionnaire was to study whether the students had the safety attitude and ability desired by the process industry companies. The data were collected through an e-survey directed to the process operator students of the cooperative VET institutions. The questionnaire was based on previous studies and consisted of items covering perceptions toward accidents, safety instructions, communication, the role of safety, safety competence and training, and safety performance, responsibilities, and risks.

3 Results

3.1 The operational model

The operational model describes the process of on-the-job learning. The model consists of eight phases realized either while preparing for or during on-the-job learning (Fig. 1) [13]. The model describes in more detail each phase and its significance and implementation. In addition, safety issues relevant for each phase are emphasized.

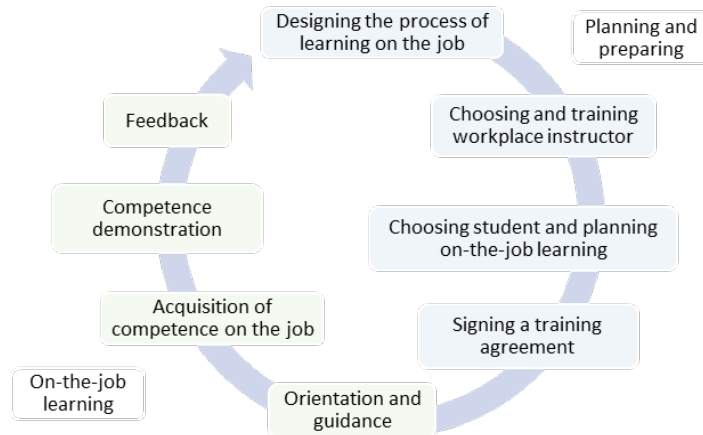


Fig. 1. Phases of the on-the-job learning process

For every phase of the process, the model contains examples of good practices on how to implement the phase. Moreover, the operational model provides tools and

instructions for helping workplaces, VET providers, and students apply it in cooperation (Table 2). The tools and instructions can be used for several purposes, for example, defining practices related to on-the-job learning, self-assessment of safety competence, and training teachers and workplace instructors.

Table 2. Tools and instructions for applying the operational model

Tool or instruction	Description
Everything okay? - checklist	The most important tasks of the VET provider, workplace, and student at each phase
Features of a good workplace instructor	List of features associated with a good workplace instructor
Topics for workplace instructor training	Topics to be covered when training workplace instructors
Students' essential safety competence	Safety competence requirements essential for process operators
Safety outlook questionnaire	Questionnaire on students' outlook on safety and considering safety matters in education
Occupational safety responsibilities	Instruction on safety responsibility distribution between VET provider organization, workplace, and student
Topics for orientation and guidance	Topics that should be included in orientation and guidance
Risk assessment exercise	Tips for giving risk assessment exercises to students
Tips from companies to students	Companies' general expectations for student attitudes and behaviors during on-the-job learning
Accident information	The overview of accidents in the process industry
Topics for teacher visits during on-the-job learning	Topics to discuss between the teacher, student, and workplace representative when the teacher visits the workplace during on-the-job learning
Exercises for students during on-the-job learning	Examples of exercises that teachers or workplaces can give students during on-the-job learning
Tips for planning and conducting competence demonstrations	List of things to consider when planning a competence demonstration, tips on how to prepare for a competence demonstration, and questions and subjects to cover during the competence demonstration
Examples of feedback questions	Examples of questions for collecting feedback for development from a student to a company or VET organization, from a company to a VET organization, or vice versa

3.2 Usefulness of the model

The cooperative organizations of the study considered the model useful and identified several purposes of use for it. The main reason why the model was considered useful was because it defines and documents the process for on-the-job learning. The study participants further explained that defining and documenting this process ensures the quality of the on-the-job learning and guidance given to students, unifies related practices, and clarifies the parties' roles. The model can be used to define, develop, benchmark, and train the processes, practices, and responsibilities related to on-the-

job learning. These were rarely documented in the companies and VET organizations, and related information was mainly scattered and tacit.

The model was considered a useful practical guide with good examples for VET institutions and workplaces. Good practices in the operational model serve as checklists, diminishing the need to remember things and making operations smoother. Moreover, companies and vocational institutions can utilize the model when developing and unifying their practices in cooperation. Vocational institutions become familiar with companies' practices and vice versa. For example, the operational model can be used when drawing up an agreement on cooperation between a company and a vocational institution. The model can also be used to train teachers and workplace instructors.

4 Discussion

As a result of the study, an operational model for developing students' safety competence in on-the-job learning in cooperation with companies and vocational institutions was compiled. The operational model defines the general process of on-the-job learning through eight phases and related safety issues. Its purpose is to offer an example and good practices to companies and vocational institutions, who can define and document their own process of planning and carrying out on-the-job learning with the help of the model.

At least in Finland, a common documented model for on-the-job learning has not been available. Dang [14] considers the relationship between vocational education training providers and enterprises and proposes a model to link those in Vietnam. The paper does not define the process, but it emphasizes the importance of the cooperation between the government, the school, and the industry.

Good communication has been suggested as an essential but often inadequately functioning factor in successful safety management, particularly in situations where several parties are involved [15]. Poortman et. al. [16] have reported ineffective communication between school and work in dual higher professional education. In this study, it was noticed that the cooperation and development of students' safety competence will benefit from using similar practices in companies and vocational institutions, for example, performing safety observations.

This study has some limitations. It covered only a limited number of companies and vocational institutions. The model should still be further tested in practice in different sectors. Nevertheless, the study participants considered the model useful in ensuring the overall quality of the on-the-job learning process and suitable for multiple purposes. The fluency of the on-the-job learning process and the focus on safety competence can increase companies' and VET organizations' attractiveness to students. Moreover, developing the process safety competence of vocational students increases their prospects of finding employment and provides a qualified workforce for the process industry in the future.

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