Teachers' Perceptions of the Safety Competence of Process Operator Students

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Abstract. In the safety-critical process industry, the safety competence of process operators is essential. Process operators are educated at vocational education and training (VET) organizations. The reform of vocational upper secondary education in Finland emphasizes the role of on-the-job learning; thus, the process operator education program has changed. Early adoption of correct safety skills enables them to be followed in the workplace. Thus, it is important to study the safety competence of process operator students and related educational requirements in the current circumstances. Seven teachers from five VET organizations were asked to estimate their students' safety competence using a previously published framework. Overall, the interviewees considered that more safety competences were easy rather than difficult for their students. Knowledge and skills related to production processes, special and high-risk work tasks, exceptional and fault situations, general view, identification of own skills, and proactive mindset were most often viewed as difficult for students.

Keywords: Process Industry, Vocational Education and Training, Workplace Learning, Safety Competence.

1 Introduction

In the safety-critical process industry, safety competence is essential for ensuring safe operations. In this industry, work typically involves dangerous materials, under extreme conditions, and with potential for major accidents. Thus, safety competence is an important skill for process operators. Furthermore, the increasing complexity of processes makes the safety-focused aspects of the process operator role significant [1]. A focus on safety and continuous competence development can also be a key determinant of company performance [2–4]. However, young and inexperienced workers typically encounter accidents more often than other employees [5–6]. Therefore, new workers and students must be introduced to safe work practices from the very beginning of their careers [5].

Competence is defined as having an ability to transform knowledge and skills into practice in a qualified manner [7]. Competence also refers to specific knowledge, experiences, abilities, skills, traits, values, attitudes, understandings, and behaviors

that are necessary for achieving a required level of performance [8–11]. Tappura et al. [12] developed a framework for process safety competence of vocational students.

Process operators working in the process industry are educated by vocational education and training (VET) organizations. If students learn to value process safety early in their education, then they are more likely to subsequently take this attitude into their workplaces [13]. Therefore, ensuring that students have sufficient safety competence is emphasized from the beginning and throughout the education process.

The education of process operators consists of studies arranged by VET organizations and involves workplace learning periods at process industry companies. As a result of vocational upper secondary education reform, learning in the workplace has increased [14, 15]. Close collaboration between students, VET providers, and workplaces has been found to be beneficial for improving student learning in general [16]. Similarly, cooperation is essential when students' safety competence is being developed. A basic understanding of safety and related practices is imparted to process operator students during their education in VET organizations [17]. Companies expect that students will have obtained basic safety knowledge before they proceed with further training or employment [18]. Training for company-specific safety requirements, cultures, and practices is provided in the workplace.

The objective of this paper is to increase understanding of how teachers view the safety competence of process operator students. Additionally, the factors that teachers think affect student safety competence are discussed.

2 Methods

This study is part of a larger study called Young Professionals in the Process Industry (NuPro) that focuses on workplace learning and safety in the process industry [see, e.g., 12, 18]. Due to the descriptive and contextual nature of the study, a qualitative approach [19] was employed. Interviews (see Table 1) were carried out in all five VET organizations participating in the project, which, to the authors' knowledge, totaled 23% of all VET organizations providing process operator education in Finland. Seven processing industry teachers were interviewed. This is the majority of the processing industry teachers in the collaborating VET organizations because there was only a few in each VET organization.

Table 1. Background information of the VET organizations and interviewees.

VET organizations (n = 5)	VET providers represented different geographic areas in Finland
	One to three processing industry teachers at each VET organization
	40–100 process operator students at each VET organization
	Process operator students mainly adults in two VET organizations, mainly young students in two, and one had adult and young students
Interviewees (7)	Six teachers and one training officer
	Two men and five women
	Work experience in current position from 3 to 18 years (average 11 years)

The interviews were based on the safety competence requirement framework (Table 2 and the Appendix) compiled in the previous phases of the NuPro study [12]. The safety competence requirements for basic process safety education of process operator students at VET institutions were originally compiled through interviews and a workshop with representatives of process industry companies, VET organizations providing education for process operators, and other expert organizations. Competence requirements were categorized as (1) knowledge and skills, (2) values and attitudes, and (3) abilities and traits, using the competence classifications presented in previous literature [8–11]. Each competence requirement was described in more detail.

Table 2. Excerpt of the safety competence requirement framework used in the interviews.

Category	Safety competence requirement	Description
Knowledge and skills	Production processes	Understanding the operating principles of the process (e.g., how the automation works, what energies are involved, and how to react to process alarms)
Values and attitudes	Serious attitude toward safety	Taking safety into account in all activities Active participation in developing safety (e.g., reporting safety observations) Following rules and reacting to unsafe behaviors
Abilities and traits	Courage	Courage to work in hazardous work environment business Courage to ask for help if the task at hand is new or beyond one's own competencies The confidence to act safely even under pressure

In the interviews, safety competence requirements were discussed with the interviewees, who were asked to give their opinion on whether a certain requirement is easy, and students possess the basic competence related to it, or whether this competence is difficult for most process operator students, and could be improved. The interviewees were asked to base their opinions on their overall experiences gained from different sources (e.g., discussions with students, seeing their behavior at work and exams covering some safety aspects) during their teaching careers. In addition, the reasons why some of these requirements are more difficult were discussed. All interviews were recorded and transcribed. The interviewees' views were categorized and summarized according to the safety competence framework and according to the themes arising from the data.

3 Results

3.1 Teachers' Appraisal of the Safety Competence of Process Operator Students

The views of the interviewed teachers on the safety competence of process operator students are summarized in a table in the appendix, according to the safety competence framework used in this study. Overall, most interviewees considered that there were more items in which the students would gain sufficient knowledge in than those items that were considered to be difficult for students.

In terms of the knowledge- and skill-related competences, the interviewees considered more than half of the 14 total items to be easy, and the remaining items (slightly less than half) difficult. For competences related to values and attitudes, most of the interviewees considered only one of the six items to be difficult—namely, admitting own mistakes—while the rest of the items were thought of as easy for the students. Concerning safety competences related to abilities and traits, five out of ten items were more often rated as easy rather than difficult. With respect to abilities and traits, the interviewees often pointed out that these competences vary considerably among students.

The items most often considered to be easy for students were all related to the knowledge and skills aspects of safety competence requirements. All interviewees believed that students gain sufficient competences related to general practices in the workplace. Furthermore, the majority of the interviewees believed that students either already have or would have sufficient competences concerning the operational environment, companies' safety procedures, and learning from experience. Similarly, all items that the interviewees most often considered to be difficult for students were related to safety knowledge and skills. Adopting knowledge and skills related to production processes, special and high-risk work tasks, exceptional and fault situations, general view, identification of own skills, proactive mindset, and hazard identification were all emphasized as being difficult for students. There were three items that the respondents equally often considered as either easy or difficult—items related to consequences of own actions, rationality, and carefulness.

3.2 Factors Affecting the Safety Competence of Process Operator Students

The interviewees mentioned that most items related to safety knowledge and skills were basic issues that are included in process operator education. Consequently, students should receive at least basic knowledge and skills related to these items, often during their education at VET organizations, before they move on to workplace learning. In addition, the interviewees reasoned that, e.g., because special and high-risk work tasks (as well as exceptional and fault situations) occur less often and are less emphasized during studies, these tasks are then more difficult for the students.

With respect to the competences related to values and attitudes, the interviewees mentioned that students learn these competences, at the latest, during workplace training. In companies, a serious attitude toward safety is unquestionable. The interview-

ees emphasized that there is a noticeable difference in safety values and attitudes of students before and after they participated in workplace learning or otherwise gained work experience, e.g., through a summer job. This particularly applies to younger students, who may first downplay safety issues while learning at a VET organization. Once students have experienced the workplace, they do not question the importance of safety and follow safety instructions better at VET than they did before. Nevertheless, some interviewees emphasized the importance of theoretical studies as well, indicating that they enable better practical learning results. Some interviewees noted that VET organizations should be as firm as companies about safety rules and behavior compliant with these rules. Moreover, acknowledging positive safe behaviors, such as making safety observations, was highlighted.

The interviewees emphasized that student competence varied a great deal, particularly regarding safety-related abilities and traits. These competences were regarded as important as the other competences. The interviewees pointed out the impact of age and previous work experience on safety-related abilities and traits. Adult students can reflect on the issues to be learned in light of their previous work experience. Younger students usually have less work experience that they could use as a background for their learning.

The interviewees also mentioned that some issues in the safety competence framework are more difficult to teach while others are easier. For example, some of the safety-related skills and abilities, such as stress tolerance, were considered to be less emphasized in process operator education. In addition, the interviewees mentioned production processes. The difficulty is that the same process element, such as steam, can be hazardous in some process environments but harmless in others, and students need to be able to estimate this depending on the given environment.

The interviewees summarized that adult students mostly have better safety competence than younger students. However, adult students may have previously adopted a less correct safety attitude, which they then need to try to change. The interviewees pointed out that adult students may sometimes, for instance, believe that a zero-vision goal is impossible to achieve.

4 Discussion

This study contributes to previous literature by providing teachers' perceptions of the safety competence of process operator students. The results can be used to guide the development of safety education for process operator students during VET. Companies may use the results to improve the competence of their current workforce.

Many of the safety competencies the teachers considered difficult for students were similar to those mentioned in previous studies. Congruent with previous studies, competences related to hazard identification [20, 21] and exceptional and fault situations, such as emergency response [21], were emphasized as difficult for students. Moreover, previous studies concluded that students' safety attitudes are poor and need improvement [21]. Similarly, this study showed that before workplace learning students' safety values and attitudes could be better.

In addition, the teachers' pointed out some industry-specific competences related to understanding of production processes and individual characteristics of the students that require special attention in the education of process operator students. As automation systems and technologies become more complicated, the importance of related safety competencies, such as situational awareness [1] and systems thinking [22], become even more important to ensure safe operations. Many safety researchers consider humans to be heroes in resolving system vulnerabilities [23–25], and the human factors approach has gained increasing attention in the process industry [1, 13].

This study has several limitations. The appraisal of the safety competence of process operator students was based on subjective opinions of only a small number of teachers. Further research should apply and compare different ways of assessing students' safety competence, such as assessments based on examinations or self-assessments of students with larger and more comprehensive data. The impact of students' background (e.g., work experience) on safety competence should be studied. Moreover, the framework used in this study describes safety competences on a general level while technical competence requirements vary across process industry companies.

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Appendix Teachers' views of the safety competence of process operator students.

Safety competence requirements	No. of interviewees			
	E*	D*	V*	-*
Knowledge and skills related to				
Production processes	2	5	0	0
Chemicals and chemistry	4	3	0	0
Special and high-risk work tasks	2	5	0	0
Exceptional and fault situations	2	5	0	0
Reading and following instructions	4	3	0	0
General practices in the workplace	7	0	0	0
Operational environment	6	1	0	0
General view	1	5	1	0
Consequences of own actions	3	3	1	0
Learning from experience	5	1	1	0
Identification of own skills	2	5	0	0
Proactive mindset	1	5	1	0
Companies' safety procedures	6	1	0	0
Hazard identification	4	3	0	0
Values and attitudes				
Serious attitude toward safety	4	2	1	0
Prioritizing safety	4	3	0	0
Zero-vision mindset	4	3	0	0
Lifelong learning	4	2	1	0
Professional attitude toward work	4	2	1	0
Admitting own mistakes	3	4	0	0
Abilities and traits:				
Perceptual ability	3	1	2	1
Concentration	3	4	0	0
Stress tolerance	2	4	1	0
Rationality	2	2	2	1
Carefulness	2	2	2	1
Humility	3	2	2	0
Prudence	3	1	2	1
Vigilance	3	1	2	1
Calmness	3	1	2	1
Courage	2	3	1	1

*E: Easy for students; they already have good or basic competence or gain it during their education. D: This can be or is often difficult for students. V: Varies among students. | -: Do not know / No assessment.