Process operator students' abilities to assess OSH risks

Noora Nenonen[1], Sanna Nenonen[1] and Sari Tappura[1]

[1] Tampere University, Unit of Industrial Engineering and Management, FI-33014 Tampere University, Finland
{Noora.Nenonen, Sanna.Nenonen, Sari.Tappura}@tuni.fi

Abstract. Safety competence is an important process operator skill. Due to hazardous work assignment and environments, skills in assessing the risks related to occupational safety and health (OSH) are especially important. Carrying out risk assessments can be difficult, and several problems have been identified. The aim of this study was to discover how well process operator students are able to assess OSH-related risks. Risk assessment exercises with observations were carried out for students (n=35) in three vocational education and training (VET) organizations. The results showed that all students were able to identify at least some hazards. The students identified the most probable, high-risk, and easily observable hazards. Those with previous training or experience in work and risk assessment were more capable of identifying a wide range of risks. We conclude that successful risk assessment requires related competence, which should be developed via theoretical and practical learning during VET.

Keywords: Hazard recognition · Risk identification · Risk assessment · Workplace safety · Manufacturing industry

1 Introduction

Safety competence is an important skill for process operators. In the safety-critical process industry, it is one of the key determinants of company performance. Although safety issues have increasingly gained attention, safety criticality is still emphasized in the process industry [1]. For example, the increasing complexity of processes makes the safety-focused aspects of the process operator role significant [2].

A basic understanding of safety and related practices is imparted to process operator students during their studies in VET organizations [3]. Companies expect that students have obtained this basic safety knowledge (e.g., risk assessment skills) before they proceed to training or employment [4]. Training for company-specific safety requirements, culture, and practices is provided in the workplace.

The European OSH legislation states that the employer should prevent occupational risks [5]. The practices of risk assessment and management are generally considered the foundation for OSH management, and they are widely used in workplaces [6]. In addition, in many workplaces, employees must carry out a short risk assessment before starting work. Process operators especially need skills in OSH-related risk assessment because their work environment contains many hazards (e.g., dangerous materials, high

temperatures and pressure), which can lead to major accidents [1]. In addition, young and inexperienced workers typically experience more injuries than others [7, 8].

However, carrying out risk assessments can be difficult, and several problems have been identified in previous research. For example, a considerable number of OSH-related hazards in the work environment seem to remain unidentified [9–11]. Moreover, deficiencies in risk assessment and management are often mentioned among the causes of occupational accidents [12, 13].

The aim of this study was to discover how well process operator students were able to identify and analyze OSH-related hazards and means to avoid or control related risks. The differences related to student age, stage of study, safety competence, and work experience are discussed.

2 Materials and methods

In this study, risk assessment exercises (n=15) with observations and short interviews were carried out for process operator students (n=35) in three VET organizations in Finland. This study is part of a larger study [see e.g., 4] focusing on workplace learning carried out in cooperation with process industry VET organizations and companies. The VET organizations participating in this study are the organizations participating in before-mentioned the larger study. There were approximately 40–100 process operator students in the VET organizations.

The risk assessment exercises took place in the VET organizations' laboratories, and assessment targets were chosen from these laboratories. The assessment targets were chosen in collaboration with the teachers. The researchers wanted to ensure that the students participating in the study were familiar with the risk assessment targets. The students did the exercises one group at a time in groups of two or three persons. A pre-prepared checklist (see appendix) was used in the risk assessment. The list was compiled on the basis of checklists used in two process industry companies cooperating with the participating VET organizations. In addition, the Risk Assessment in Workplaces Workbook [14], which is a commonly applied tool for OSH-related risk assessment in Finland, was employed.

The exercise started with a short interview to gather students' background information. In addition, the researchers gave a short introduction on how to do the exercise and use the checklist. The students were asked to identify and describe hazards and their consequences, estimate the magnitudes of risks (on a scale from 1–3), and come up with actions to avoid or reduce the risks. However, actual training on risk assessment was not provided. The researchers observed the assessments but did not participate in them. The students were helped, and their questions were answered if they seemed to have problems carrying out the assessments. Once the group was ready with the risk assessment, the researchers went through the results and briefly discussed them with the students. Notes were taken throughout the entire exercise. For comparison, teachers in each organization did the exercises as well.

In one of the VET organizations, the risk assessment target was the sheet mold and press and the work carried out with them. In two organizations, the assessment target was work carried out in the crushing room. The risk assessments lasted between 10 and 52 minutes, with the average duration being 24 minutes. The background information

of the students participating in this study is summarized in Table 1. In two VET organizations, the participating students were mainly younger first-year students who had not yet received workplace learning. There were, however, some students who had studied longer and had been on workplace learning period. For these students, the studies lasted three years. In one of the VET organizations, all of the participating students were adult students who had been through a short two-week workplace learning period. For these students, the studies lasted 15 months.

Table 1. Background information on the process operator students (n=35).

Number of students	VET organization A (37%), B (26%), C (37%)
Age	Between 16 and 53 years, average: 23, median: 19
Gender	Men (89%), women (11%)
Years of study	First-year students (30), second-year (4), fourth-year (1)
Workplace learning	51% of the students had been in the workplace learning, 49% had not
Work experience	77% of the students had work experience, 14% did not (9% unknown)
Experience in risk assessment	Yes (40%), no (60%)
Safety training	All of the students had received some safety training
Familiarity with the assessment target	51% of the students had worked in the assessment target, 49% had not, but they were otherwise familiar with the target

3 Results

The checklist used in the risk assessment exercises contained a total of 28 different items in five categories. Both students and teachers identified hazards related to all categories. The students identified on average 13 (range: 5–28) different hazards for 12 (range: 5–20) different items. The teachers identified on average 24 (range: 18–30) hazards for 17 (range: 14–20) items. Table 2 summarizes the number of hazards identified in the two different assessment targets of this study.

Table 2. The number of hazards identified in risk assessments.

Target	Students	Teachers
Sheet mold and press	Hazards average 8 (range: 5–13)	18 hazards
	Items average 8 (range: 5–12)	14 items
Crushing room	Hazards average 17 (range: 8–28)	30 hazards
	Items average 15 (range: 8–22)	20 items

The appendix summarizes the results of the hazard identification by hazard category and item. With regard to the sheet mold and press, there was only one risk all student groups identified: the risk of fingers being crushed between the sheet press. Otherwise, the students identified mainly accident hazards, although some groups and teachers identified some other hazards as well.

In the risk assessments concerning the crushing room, all student groups identified the hazards related to small pieces of rocks being hurled from the crushing mill and noise from the devices used. There were also many other hazard items in the crushing

room that most student groups identified (e.g., objects being dropped and unsafe activities).

The students identified some hazards that the teachers did not identify and vice versa. For example, the teachers did not recognize the hazard posed by the noise from a machine near the sheet mold and press, probably because the noise did not exceed limit value and there was an instruction to use hearing protectors while this machine was in use. Moreover, the students pointed out that safety orientation concerning emergencies (e.g., the location of the first aid equipment) in the laboratory was given to students only in the beginning of the school year. There were some students who had started their studies in the middle of the school year and therefore had not participated in the orientation. The teachers recognized, for example, the risk of falling from a safety ladder while opening the compressed air (a short person cannot reach the switch without a ladder).

Many student groups pointed out that there was no first aid equipment in the crushing room, whereas the teachers probably considered it sufficient that first aid equipment was available in the nearby laboratory. In addition, the students brought up the dust from rocks in connection with two items in the checklist: suffocation and dust and fiber. The teachers reported this in connection only with the item "dust and fiber." The students discussed the possibility of dust causing allergic reactions and therefore suffocation.

The groups with adult students (with previous work experience) identified more hazards than younger students. Moreover, students with more experience from work and study identified more risks than inexperienced first-year students. In many of the groups that identified many hazards, the students had some previous experience in risk assessment (e.g., school exercises). However, there were also groups in which students had risk assessment experience but did not recognize many risks, and there were groups in which the students had no previous risk assessment experience but still recognized many hazards.

The consequences of the risks were rarely described, although such descriptions were requested in the exercise. Moreover, some students mentioned that it was difficult to define actions to avoid or control risks. Often the students mentioned controls that were already in use (e.g., personal protective equipment). Some students mentioned that it would have been easier to do the assessment if they had been more familiar with the assessment target. In addition, the students often estimated a larger magnitude of risk when they considered the risk highly probable, although the consequences were also considered. The students also often estimated the risks as less severe than the teachers.

4 Discussion

The results showed that all the students were able to identify at least some hazards. The students identified the most probable, high-risk, and easily observable hazards. Among the students, risks with very small consequences, low probability of occurrence, or existing controls were not considered relevant risks by the students. The students discussed these issues in the assessments, but did not document them in the actual assessment tool. Students with previous training or experience in work and risk assessment were more capable of identifying a wide range of risks. Overall, the teachers seemed to

identify more hazards and assess the magnitudes of the risks more highly than the students.

We conclude that successful risk assessment requires related competence, which should be developed via theoretical and practical learning during VET. Workplace learning supports process operator students' risk assessment and safety skills. However, safety training should begin in the early phases of the studies and continue systematically throughout the studies. Skills in OSH-related risk assessment are likely to support the assessment of risks related to process safety as well.

Acknowledgments. The authors gratefully acknowledge the Finnish Work Environment Fund for the funding of this study and the teachers and students of the cooperating VET organizations for their contributions.

References

1. Rodríguez, M., Díaz, I.: A systematic and integral hazards analysis technique applied to the process industry. Journal of Loss Prevention in the Process Industries 43, 721--729 (2016)
2. Nazir, S., Sorensen, L.J., Øvergård, K.I., Manca, D.: How Distributed Situation Awareness Influences Process Safety. Chemical Engineering Transactions 36, 409--414 (2014)
3. Tappura, S., Kivistö-Rahnasto, J: Annual school safety activity calendar to promote safety in VET. In: Arezes, P.M. et al. (eds.) Occupational Safety and Hygiene VI: Proceedings of the 6th International Symposium on Occupation Safety and Hygiene (SHO 2018), pp. 131--135. CRC Press, London, (2018)
4. Tappura, S., Nenonen, S, Nenonen, N.: Developing Safety Competence Process for Vocational Students. In: Ahram T., Karwowski W., Taiar R. (eds) Human Systems Engineering and Design. IHSED 2018. Advances in Intelligent Systems and Computing, vol 876, pp. 668--674. Springer, Cham (2018)
5. Council Directive 89/391/EEC on the introduction of measures to encourage improvements in the safety and health of workers at work (1989)
6. European Agency for Safety and Health at Work: Summary - Second European Survey of Enterprises on New and Emerging Risks (ESENER 2). Publications Office of the European Union, Luxembourg (2015)
7. Laberge, M., Ledoux, E.: Occupational health and safety issues affecting young workers: a literature review. Work 39, 3, 215--232 (2011)
8. Salminen, S.: Have young workers more injuries than older ones? An international literature review. Journal of Safety Research 35, 5, 513--521 (2004)
9. Albert, A., Hallowell, M.R., Skaggs, M., Kleiner, B.: Empirical measurement and improvement of hazard recognition skill. Saf. Sci. 93, 1--8 (2017)
10. Bahn, S.: Workplace hazard identification and management: the case of an underground mining operation. Saf. Sci. 57, 129--137 (2013)
11. Heikkilä, A-M., Malmén, Y., Nissilä, M., Kortelainen, H.: Challenges in risk management in multi-company industrial parks. Saf. Sci. 48, 430--435 (2010)
12. Carter, G., Smith, S.: Safety hazard identification on construction projects. J. Constr. Eng. Man. 132(2), 197--205 (2006)
13. Haslam, R.A., Hide, S.A., Gibb, A.G.F., Gyi, D.E., Pavitt, T., Atkinson, S., Duff, A.R.: Contributing factors in construction accidents. Appl. Ergon. 36, 401--415 (2005)
14. Ministry of Social Affairs and Health: Riskien arviointi työpaikalla – työkirja. Ministry of Social Affairs and Health and The Centre for Occupational Safety (2015)

Appendix: Results of the hazard identification by hazard category

Categories and items in the checklist	Target 1[a]		Target 2[a]		Examples of identified hazards by category
Accident hazards	S[b]	T[c]	S[b]	T[c]	
Slipping, stumbling, falling (down/over)	4	Y	7	Y	Crushing fingers between the sheet press; Dropping the weights of sheet mold; Stumbling on the platform used on sheet mold; Pieces of rocks can hurtle from the mill; Suffocation because of dust and allergic reaction
Fall of a person / falling from height	4	Y	3	Y	
Electric shock or static electricity	3	Y	6	Y	
Reduction of oxygen, suffocation	0	N	5	N	
Goods transport and other traffic	1	N	4	Y	
Objects being dropped or falling over	5	Y	8	Y	
Objects/material being hurtled around or hit by a moving object	1	Y	9	Y	
Being crushed between objects or entangled in a moving object	6	Y	6	Y	
Being slashed, cut, or stabbed	0	N	6	Y	
Physical hazards and strain	S	T	S	T	
Noise	3	N	9	Y	Lifting heavy weights of the sheet mold in a circular motion repeatedly; The devices in the crushing room are noisy; Lifting the rock material in heavy buckets and using poor lifting postures; The crushing room can be hot
Hot and cold objects and surfaces	2	N	1	1	
General and local ventilation	0	N	3	Y	
Lightning	1	Y	1	N	
Vibration	1	N	6	Y	
Radiation	0	N	0	N	
Poor working postures, repeated movements, and lifting or carrying with hands	2	Y	7	Y	
Usability of tools, machinery, and devices	1	N	4	Y	
Organization and personnel activities	S	T	S	T	
Exceptional situations and disturbances (e.g., unexpected starting of machine)	2	Y	6	Y	Unexpected descent of sheet press when compressed air opened; Not obeying instructions
Unsafe activities	1	Y	8	Y	
Safety arrangements	S	T	S	T	
Personal protective equipment (PPE), safeguarding (condition and use)	1	Y	4	Y	Requiring more strictly the use of PPEs; Emergency exits are not clear (objects stored); Rehearsing emergency situations
Alarm and rescue equipment	2	Y	2	N	
Walkways and corridors and their safety and indicator lightning	2	Y	6	Y	
First aid arrangements and equipment	2	N	7	N	
Chemical and biological hazards	S	T	S	T	
List of chemicals	0	N	1	Y	Chemical register only available in teachers room in the laboratory; Dust from rock and ore material in the crushing room
Labeling of chemical packages	0	N	0	N	
Hazardous or harmful chemicals (allergenic, carcinogenic, flammable, explosive)	0	N	2	N	
Dust and fiber	1	N	7	Y	
Gases, vapor, fumes, and smoke	0	N	1	N	
Other hazard	0	Y	3	N	Cramped workspace

[a] Target 1: Sheet mold and press, Target 2: crushing room

[b] S: Number of student groups (in target 1 n=6, in target 2 n=9) that identified a hazard or hazards related to this item

[c] T: Did teachers identify a hazard or hazards related to this item (Y=yes, N=no)