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USING KNOWLEDGE ELICITATION FOR ENHANCING OCCUPATIONAL SAFETY AND HEALTH MANAGEMENT PERFORMANCE IN A WELDING WORKSHOP

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Abstract: *The purpose of this paper is to present a tool (ELICIT-SSM) created for eliciting knowledge from experts, specialists and workers in the field of occupational safety. Aldo the literature concerning elicitation is vast, encompassing significant contributions from a range of disciplines, there is a little evidence of using elicitation in the field of occupational safety. The novelty and originality of this study consists in applying knowledge elicitation within a welding company. The knowledge elicited with the help of the ELICIT-SSM tool will be used to develop an ontology based on welding workshop occupational safety knowledge that will be integrated into an expert decision support system, a powerful tool to support managerial decisions to maintain a safe working environment and prevent accidents or incidents.*
Key words: *occupational safety, knowledge elicitation, welding.*

1. INTRODUCTION

The purpose of this paper is to present a tool (ELICIT-SSM) created for eliciting knowledge from experts, specialists and workers in the field of occupational safety.

Knowledge elicitation consists of a set of techniques and methods that attempt to elicit the knowledge of a domain expert, typically through some form of direct interaction with the expert [1]. Knowledge elicitation is a sub-process of knowledge acquisition (which deals with the acquisition or capture of knowledge from any source), and knowledge acquisition is, in turn, a sub-process of knowledge engineering (which is a discipline that has evolved to support the whole process of specifying, developing and deploying knowledge-based systems) [2].

Aldo the literature concerning elicitation is vast, encompassing significant contributions from a range of disciplines including statistics, psychology, management science, economics, and environmental science [3] [4] [5], there is a little evidence of using elicitation in the field of occupational safety. The novelty and originality of this study consists in applying knowledge elicitation within a welding company.

A major challenge to current knowledge elicitation methodologies remains the ability to identify what knowledge to elicit and properly highlighting the type of barriers that pose a challenge to eliciting that knowledge [6].

2. METHODOLOGY

The aim of our knowledge elicitation was to document the work-related knowledge and expertise that has developed within a welding company over a period. In addition, we tried to capture the knowledge of individuals who are about to leave an organization or who have recently retired. These kinds of knowledge elicitation efforts form part of an effort to preserve organizational knowledge and expertise by making the knowledge available to new recruits - young welders.

In this paper we present the scheme of the elicitation instrument ELICIT-SSM, together with the steps of the elicitation process:

Step 1. Design and planning of the elicitation process;

Step 2. Eliciting and collecting data;

Step 3. Analysis of the elicited data and Identifying knowledge of general interest;

Step 4. Validation of extracted knowledge;

Step 5. Assignment of classification indices (Classification of knowledge of interest into groups and sub-groups).

2.1 Step 1 - Design and planning of the elicitation process

For the first step of our elicitation instrument, we establish clear objectives for the elicitation process and we define key questions that will help us guide the discussion and extract relevant information.

We identify the participants, namely define the key people in the welding shop who have the relevant knowledge and experience in the field of occupational safety (these can be welders, supervisors, safety officers, maintenance personnel, subject matter experts, managers or anyone involved in welding and workplace safety activities) ensuring representation from different levels and roles within the workshop.

We choose the appropriate elicitation methods and techniques for gathering information, these include individual or group interviews, questionnaires, direct observations, or a combination of these. It can also be used interactive methods such as case studies or group exercises to encourage participants to share their knowledge. In addition, for this step we established a schedule for the elicitation process, including the length and frequency of interview or data collection sessions, making sure that we have enough time for each participant and that the schedule is convenient for everyone involved. We identified the resources needed to carry out the elicitation process, such as files, reference materials or specific equipment for practical demonstrations, making sure that we have access to the necessary resources and that all equipment is functional and safe. Figure 1 shows step 1 in schematic form.

2.2 Step 2 - Eliciting and collecting data

In this step are selected appropriate methods for data collection based on the objectives of the process. Common methods include interviews, surveys/questionnaires, observations, and document reviews. We determine which methods will be most effective in gathering the necessary information.

Next, we develop interview guides or questionnaires, prepare interview guides or questionnaires that align with the objectives of the elicitation process. These guides should contain relevant questions that elicit detailed and specific information about various aspects of occupational safety, such as hazard identification, safety practices, training, equipment, and incident reporting.

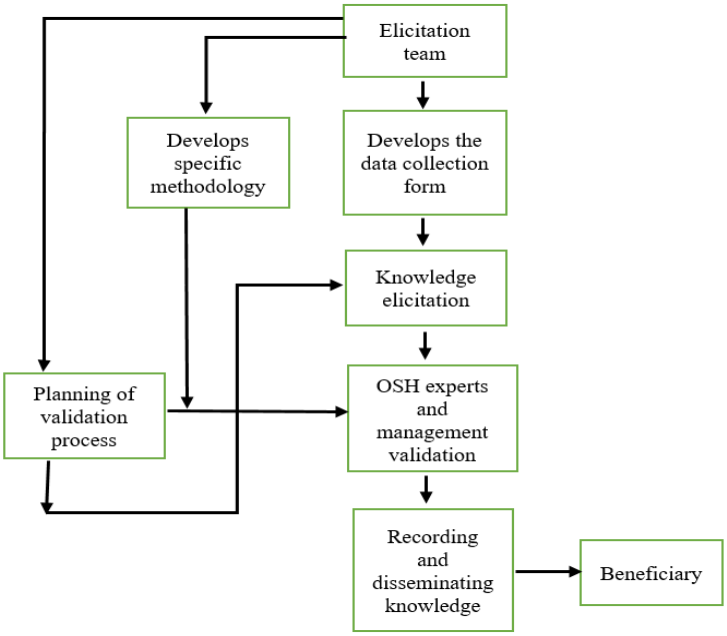

Fig. 1. Design and planning of the elicitation process.

Further we conduct interviews or surveys, scheduling and conducting individual or group interviews with the identified participants. Alternatively, we distribute the questionnaires to the targeted participants, following a structured approach to ensure consistency in data collection. It is important to encourage open and honest responses and provide clarifications if needed.

Observing workplace practices, conducting on-site observations to gather firsthand information about the actual work practices, equipment usage, and safety protocols followed in the welding workshop, observing the work environment, identify potential hazards, and document any notable practices or issues observed are the next steps. Also, is important reviewing existing documentation, such as incident reports, safety manuals, standard operating procedures, training materials, and previous audits or inspections. Analyze these documents to gather additional insights into the current state of occupational safety and to identify areas for improvement.

2.3 Step 3 - Analysis of the elicited data and identifying knowledge of general interest

Analyzing the elicited data is a crucial step in the process of eliciting occupational safety knowledge. In this step a very important aspect is the privacy and security aspects of the data collected, making sure that participants' consent to share their information and clearly explain how that information will be used and what privacy measures will be in place.

In the third step of analyzing the elicited data we begin by categorizing and organizing the elicited data, this involve sorting the information based on themes or topics related to occupational safety, such as personal protective equipment, welding procedures, hazard identification, or emergency protocols. We also use a systematic approach to ensure that the data is structured and easy to navigate, we look for patterns and trends within the data. This involves identifying common themes, recurring issues, or similar responses from different participants. By recognizing patterns, we can gain insights into areas where there might be knowledge gaps, areas of strength, or specific challenges related to occupational safety in the welding workshop. We also highlight critical issues by identifying the most critical occupational safety issues that emerge from the data analysis. These could be areas where there is a lack of awareness, non-compliance with safety protocols, or potential hazards that require immediate attention. By focusing on these critical issues, we can prioritize the necessary actions and interventions. In this step also we are:

- Identifying areas of strength and best practices in the elicited data, look for instances where participants demonstrate good knowledge, adherence to safety procedures, or effective practices that contribute to a safe working environment. These strengths and best practices can serve as examples to be shared and replicated throughout the workshop.
- Identifying knowledge gaps by paying attention to any knowledge gaps or misconceptions revealed in the data. These may indicate areas where additional training, education, or awareness programs are needed. Identifying the specific knowledge gaps will help in developing targeted interventions to address these areas and improve overall occupational safety knowledge.
- Prioritizing improvements. Based on the analysis of the elicited data, prioritize the areas that require improvements in occupational safety. This can involve identifying key recommendations, strategies, or action plans to address the identified issues effectively. Consider the feasibility, impact, and urgency of each improvement to guide the prioritization process.

2.4 Step 4 - Validation of extracted knowledge

For validating extracted knowledge, a process that involves verifying the accuracy, relevance, and reliability of the information obtained during the knowledge extraction, we use as approaches cross-referencing, expert review and peer review. We also conduct validation workshops or focus groups involving a diverse group of participants from the welding workshop. Here we present the extracted

knowledge and facilitate discussions to gather feedback, address questions, and validate the information. These interactive sessions provide real-time validation and help identify any gaps or misconceptions in the extracted knowledge. We use the feedback received during the validation process to refine and improve the extracted knowledge, to incorporate any necessary revisions or updates based on the input received. This iterative approach ensures that the knowledge is continuously validated and refined throughout the process.

2.5. Step5 - Classification Indices Assignment

For this step we classify knowledge of interest into groups according to classification indexes. These groups provide a structured framework for classifying and organizing the knowledge of interest based on the assigned classification indexes (Tabel 1).

1. Hazard Identification and Assessment (Code: 001): Common welding hazards identified (e.g., electrical, fire, fumes); Methods used for hazard identification (e.g., visual inspections, risk assessments); Specific hazards associated with different welding materials or techniques;
2. Personal Protective Equipment (PPE) and Personal Safety (Code: 002): Types of PPE recommended for welders (e.g., welding helmets, gloves, protective clothing); Proper usage and maintenance of PPE; Best practices for ensuring personal safety during welding operations;
3. Ventilation and Air Quality (Code: 003): Ventilation systems in place to control welding fumes and gases; Recommendations for improving air quality in the welding workshop; Monitoring procedures for checking air quality and ventilation effectiveness;
4. Fire Safety (Code: 004): Fire prevention measures implemented in the welding workshop; Proper storage and handling of flammable materials; Emergency response protocols in the event of a fire or welding-related incident;
5. Welding Techniques and Equipment (Code: 005): Recommended welding techniques and procedures for different materials; Maintenance and inspection of welding equipment; Use of welding accessories and tools to enhance safety and efficiency;
6. Training and Education (Code: 006): Existing training programs for welders on occupational safety; Ongoing education and certification requirements for welders; Strategies for promoting a safety culture and engaging employees in safety practices;
7. Electrical Safety: Precautions for working with electrical equipment in the welding workshop; Proper grounding and wiring practices; Training on electrical safety and lockout/tagout procedures;
8. Noise Control: Hazards of excessive noise in the welding workshop; Methods to control and reduce noise levels; Provision of hearing protection and its proper use;
9. Incident Reporting and Investigation: Procedures for reporting workplace incidents or near misses; Investigation techniques to identify root causes of incidents; Learning from incidents to prevent future occurrences;

Table 1

Assignment of classification indexes

	Groups of knowledge of interest	Classification Index
1.	Hazard Identification and Assessment	(Code: 001)
2.	Personal Protective Equipment (PPE) and Personal Safety	(Code: 002)
3.	Ventilation and Air Quality	(Code: 003)
4.	Fire Safety	(Code: 004)
5.	Welding Techniques and Equipment	(Code: 005)
6.	Electrical Safety	(Code: 006)
7.	Ergonomics	(Code: 007)
8.	Noise control	(Code: 008)
9.	Training and Education	(Code: 009)
10.	Incident Reporting and Investigation	(Code: 010)
11.	Emergency Preparedness	(Code: 011)
12.	Contractor Safety	(Code: 012)
13.	Regulatory Compliance	(Code: 013)

10. Emergency Preparedness: Emergency response plans specific to the welding workshop; Evacuation procedures and assembly points; Training on emergency response and first aid/CPR;
11. Contractor Safety: Guidelines for ensuring the safety of contractors working in the welding workshop; Contractor pre-qualification and safety assessment processes; Communication and coordination with contractors regarding safety protocols;
12. Regulatory Compliance: Understanding and complying with applicable safety regulations and standards; Recordkeeping and documentation requirements; Engaging with regulatory bodies and inspections.

Also, we can create a simple formula to represent the overall Occupational Safety Knowledge (OSK) score for the welding workshop. This formula will consider the presence or absence of specific knowledge areas as indicated by the classification indexes. Here's an example of how you can construct the formula: let's assume that the classification indexes are represented by variables as follows:

- HI = Hazard Identification and Assessment (Code: 001);
- PPE = Personal Protective Equipment (PPE) and Personal Safety (Code: 002);
- VAQ = Ventilation and Air Quality (Code: 003);
- FS = Fire Safety (Code: 004);
- WTE = Welding Techniques and Equipment (Code: 005);
- TE = Training and Education (Code: 006);
- ES = Electrical Safety (Code: 007);
- ERG = Ergonomics (Code: 008);
- NC = Noise Control (Code: 009);
- IRI = Incident Reporting and Investigation (Code: 010);
- EP = Emergency Preparedness (Code: 011);
- CS = Contractor Safety (Code: 012);
- RC = Regulatory Compliance (Code: 013).

Then, the OSK score (S) for the welding workshop can be calculated using a simple formula that sums up the presence (1) or absence (0) of each knowledge area:

$$S = HI + PPE + VAQ + FS + WTE + TE + ES + ERG + NC + IRI + EP + CS + RC \quad (1)$$

In this formula, the OSK score (S) will be a value ranging from 0 to 13, representing the total number of knowledge areas that are present or addressed in the welding workshop. The higher the OSK score, the more comprehensive the occupational safety knowledge is within the workshop.

We can also assign different weights or importance to each knowledge area based on their codes, with 001 (Hazard Identification and Assessment) being the most significant and we can use a weighted sum formula. We will assign higher weights to the knowledge areas with lower codes, indicating their greater importance. We can calculate the weighted OSK score (S_weighted) for the welding workshop assuming the following weights:

- Weight for HI (Hazard Identification and Assessment) = 5;
- Weight for PPE (Personal Protective Equipment and Personal Safety) = 4;
- Weight for VAQ (Ventilation and Air Quality) = 3;
- Weight for FS (Fire Safety) = 2;
- Weight for WTE (Welding Techniques and Equipment) = 1.

Further, the weighted OSK score (S_{weighted}) for the welding workshop can be calculated using the following formula:

$$\{S_{\text{weighted}} = (5 * \text{HI}) + (4 * \text{PPE}) + (3 * \text{VAQ}) + (2 * \text{FS}) + (1 * \text{WTE}) \quad (2)$$

In this formula, the OSK score will be a value ranging from 0 to 25, representing the total weighted score based on the importance assigned to each knowledge area. The highest weight is given to Hazard Identification and Assessment (HI) with a weight of 5, followed by decreasing weights for other knowledge areas in the order of their codes.

3. DISCUSSION AND FUTURE MODEL

In this case, the goal of knowledge elicitation is to generate representations of knowledge that will be exploited in the context of computerized systems. The knowledge elicited with the help of the ELICIT-SSM tool will be used to develop an ontology based on welding workshop occupational safety knowledge that will be integrated into an expert decision support

system, which will be a powerful tool to support managerial decisions to maintain a safe working environment and prevent accidents or incidents. We will use the classification index to define classes, properties, and relationships in a coherent and well-organized way, ensuring that the ontology captures the hierarchies, constraints, and data types relevant to occupational safety in the welding shop.

This expert decision support system was designed in a multi-layer architecture, to fit the support needs of the decision-makers. The basic layer of the system consists of an Information Tutorial System. Then comes an intermediate layer, a Reference System - expert evaluation system (in which the knowledge elicited with ELICIT-SSM will be integrated) based on which the decision will be adopted. The last layer, the top layer of the system is a Procedural System that includes prevention procedures and risk control measures.

Information Tutorial System - It contains basic notions related to general occupational health and safety legislation as well as those specific to welding workshops, necessary for making decisions in accordance with the current legislation in force.

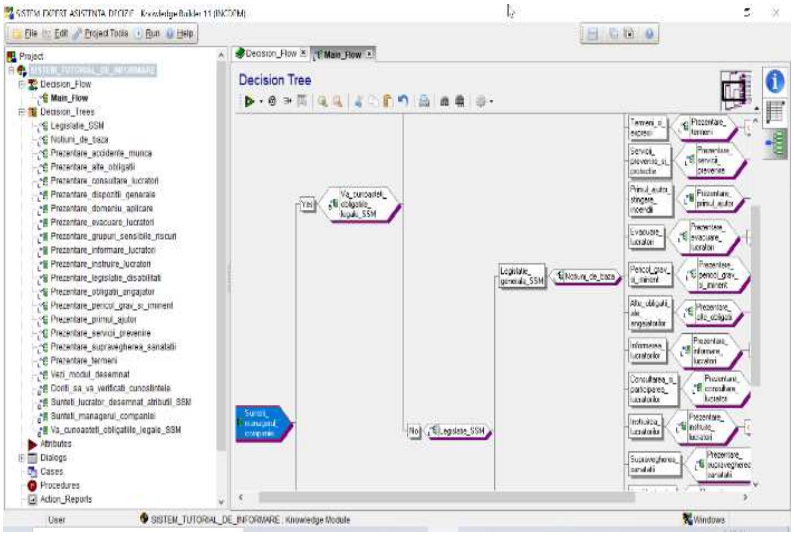

Fig. 2. Information Tutorial System.

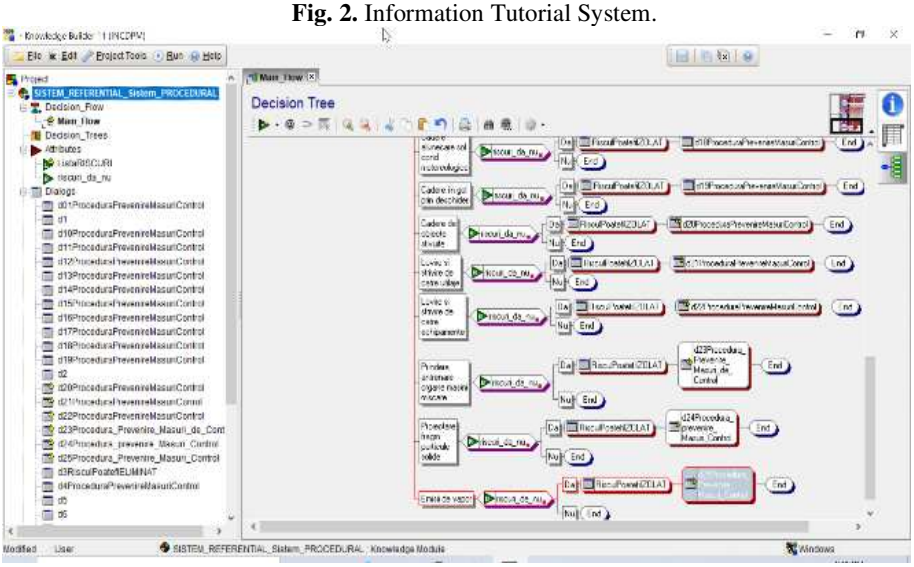

Fig. 3. Procedural System.

The knowledge elicited with the help of the ELICIT-SSM tool will be used, in the end, to generate new procedures, examples of good practices, own instructions, prevention and

control measures (with a high degree of specificity for the welding workshop).

Procedural System - The knowledge extracted will be expressed in the form of good practices and procedures that involve translating the valuable insights and recommendations obtained from the elicitation process into clear and actionable guidelines. The knowledge extracted from the elicitation process can be expressed in the form of clear, practical, and user-friendly good practices and procedures. This will empower the welding workshop to implement robust safety measures and create a safer work environment for everyone involved.

4. CONCLUSION

Through a structured approach involving various methods such as interviews, observations, and surveys, a wealth of information related to different aspects of occupational safety could be obtained. The process encompassed several key steps, including designing and planning the elicitation process, conducting the elicitation activities, analyzing the data, and expressing the extracted knowledge in the form of good practices and procedures.

By engaging workers, supervisors, and subject matter experts, a comprehensive understanding of occupational safety challenges and requirements within the welding workshop was achieved. The elicited data provided insights into hazard identification, personal protective equipment, ventilation, fire safety, welding techniques, training, electrical safety, ergonomics, noise control, incident reporting, emergency preparedness, contractor safety, and regulatory compliance.

The analysis of the elicited data involved rigorous review, coding, and categorization of the information. Various data analysis techniques such as content analysis, thematic analysis, and comparative analysis were employed to identify patterns, themes, and correlations within the data. This facilitated the identification of key knowledge areas, knowledge gaps, strengths, and weaknesses in the welding workshop's occupational safety practices.

Furthermore, the validation of the extracted knowledge involved cross-referencing with credible sources, expert reviews, peer feedback, stakeholder input, and validation workshops. This validation process ensured the accuracy, relevance, and reliability of the extracted knowledge, enhancing its credibility and applicability within the welding workshop.

The results of the elicitation process were then translated into practical outcomes through the development of good practices and procedures. These actionable guidelines addressed the identified occupational safety areas and aimed to mitigate risks, promote compliance with regulations, and improve overall safety performance within the welding workshop.

Overall, the elicitation process successfully captured and synthesized essential occupational safety knowledge specific to the welding workshop. The extracted knowledge and developed good practices and procedures provide valuable resources for promoting a safe and healthy work environment, fostering a proactive safety culture, and reducing occupational hazards and risks [7],[8].

It is important to note that the elicitation process should be viewed as an ongoing and iterative endeavor. Regular reviews, updates, and feedback loops should be established to ensure the continuous improvement and relevance of the elicited knowledge in response to changing circumstances, emerging risks, and advancements in occupational safety practices.

By embracing the findings and recommendations derived from the elicitation process, the welding workshop can proactively enhance its occupational safety measures, protect the well-being of its workers, and strive towards a safer and more productive work environment.

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Utilizarea cunoștințelor elicite pentru îmbunătățirea managementului de securitate și sănătate în muncă într-un atelier de sudură

Scopul acestei lucrări este de a prezenta un instrument (ELICIT-SSM) creat pentru a obține cunoștințe de la experți, specialiști și lucrători în domeniul securității muncii. Deoarece literatura de specialitate în domeniu este vastă, cuprinzând contribuții semnificative dintr-o serie de discipline, există puține dovezi ale utilizării elicitației în domeniul securității ocupaționale. Noutatea și originalitatea acestui studiu constă în aplicarea obținerii de cunoștințe în cadrul unei firme de sudare. Cunoștințele obținute cu ajutorul instrumentului ELICIT-SSM vor fi folosite pentru a dezvolta o ontologie bazată pe cunoștințele de securitate a muncii în atelierul de sudură, care va fi integrată într-un sistem expert de asistență pentru decizii, un instrument de sprijinire a deciziilor manageriale în vederea menținerii unui mediu de lucru lipsit de accidente de muncă.

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