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Video-based method for collaborative learning and development

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beyond the obvious

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Summary

This report presents a description of a video-based method for collaborative learning and development for a nuclear power plant's maintenance activities. The purpose of the method is to enhance maintenance workers' skills, knowledge and resilience in safety-critical operations. The report gives practical guidance and examples on how to design and implement the video-viewing sessions. The case study provides information and results on using the method for lifting activities in the reactor hall during the outage of the power plant. Furthermore, the report provides insights onto how to utilise the video-based method in simulator training and in combination with meeting-based human performance tools.

The video-based method can serve a number of useful purposes for maintenance activities. The video-viewing session should be designed according to its main purpose and goal. For the successful implementation of the method, it is important to select suitable task to be video-recorded. The task should be complex, communicative, involve physical activities, and have safety-critical relevance. Furthermore, careful selection of video material is essential.

The video-based method provides a clearly new way to prepare for work and to learn from previous activities. The method provides viewpoints that cannot possibly be acquired anywhere else. The most significant challenges are related to the responsibilities and usefulness of the method, and to the selection and editing of the actual video material. To be recognized as an official method in the nuclear power plant it needs to be included in the power plant's existing guidelines and procedures.

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Contents

1. Introduction

The basic idea is simple: let's record the workers in action and make them watch the videos for learning purposes. This self-confrontation allows self-evaluation and dissemination of good practices as the workers discuss what is beneficial and what kind of activity should be avoided. The ultimate goal would be that the nuclear power plant personnel would utilize the video-based method by themselves as a practical tool for improving organisational learning.

Internationally the idea of using video to develop expertise in the nuclear domain is not new as this kind of research has been done for example at Électricité de France (EDF) by Lahlou (2010) and others (Le Bellu & Lahlou, 2010; Fauquet-Alekhine et al. 2018). Considering from more Finnish perspectives, we drew from work on interpretive practice (Norros, 2004; Savioja, et al., 2014; Norros, 2018; Wahlström et al., 2017, 2018) and workplace learning according to the 'change laboratory' tradition, with its expansive learning concept (Engeström, 2001), developed by Finnish researchers.

Specifically, the video-based method was developed within the research project SAFIR2022 PARSA (Participative development for supporting human factors in safety). The preliminary information and results were previously presented in project's intermediate research report (see Teperi et al., 2022). **Chapters 2, 4 and 5** of this report are based on Teperi et al. (2022).

2. Method

We introduced the method of video-based collaborative reflection to the maintenance personnel in the nuclear power plant. The idea is that learning takes place as the workers observe their own work practices in the video recording. Watching the events that take place during the activities allows the workers to discuss what could be done differently and what they did correctly. The facilitator asks questions and guides the discussion.

The video-viewing session is designed to match its main, selected purpose. The session may begin with a discussion on work performance based on the group's recollection of the activity. After this, task performance can be re-evaluated on the basis of the video and discussed further.

Identifying the activity to be recorded is the first and most crucial step of the video-based method. The reason for choosing a certain activity for training and development purposes should be clear, and thus the safety-critical nature of the activity is a good starting point. The activity should consist of (critical) events that take place over a reasonably short time, so that it is possible to make video-recordings that do not take too long to watch, depending on how much time is available to use for developmental activity. Furthermore, there should be enough communicative and/or physical activity to be video-recorded.

Table 1 presents the steps included in the video-based method—as visible in the table, it is crucial to decide what to record and how to apply the recordings.

Table 1. Steps included in the video-based method

#	**Name of the phase**	**Description, considerations, and practical tips**
1	Identifying a safety-critical activity that can be video-recorded	In considering what to develop, safety criticality motivates training. The recording should consist of critical events that are reasonably short. In this manner, it is possible to take video-recordings that don't take too long to watch. It is worth to consider how much time there is to use for developmental activity. Furthermore, the activity should entail communicative and/or physical elements—so that there is something visible and audible to record to the video (e.g. videoing office work might not be very enriching).
2	Setting up a work team	The work team should include people with expertise in: 1) the to-be-developed work, to understand the critical phases of the work, these can be trainers, senior workers or such; 2) video-recording and editing for practical purposes; and 3) facilitation of the developmental sessions; human factors research or training expertise is beneficial here.
3	Making the video recordings	In videoing the work tasks, good audio quality and well considered video angles are necessary: the recordings should capture the issues that portray the activity and influence the worker decision-making—the latter points to the notion that it might be necessary to record the worker's field of vision in addition to the workers themselves. Here, head cams for recording the workers' point-of-view can be useful. If several cameras are used, time-stamps are beneficial to combine and compare video material.
4	A brief analysis of the recordings	After making the recordings, it is necessary to analyse and identify which clips of videos should be used for the training sessions. This requires consideration, but generally, the clips that elicit developmental discussion include the following: 1) unexpected incidents, 2) decision-making points, 3) vivid discussions: joint interpretations of the situation and joint decision-making, 4) safety-critical events, 5) variations between teams or individuals in behaviour (why some work teams do the same thing differently), 6) successes and, 7) failures (if not too sensitive for the workers).
5	Editing the videos	The videos should be edited according to the analysis of the previous phase #4. Subtitles may be added if the quality of audio is poor.
6	Designing and realizing the developmental sessions	The developmental sessions using the videos should be designed so that shared understanding emerges in the discussions. It can be beneficial to utilise task-related procedures in the sessions—these can be applied as a good, shared reference to guide the discussion. Given the aim of joint understanding, the questions posed by facilitators of the session can be relatively free of form. The composition of the sessions may vary, in including the workers involved and/or their managers. (See chapter 3 about designing the session.)
7	Follow-up and reporting	After the video-based sessions, it is worth evaluating the method used and its results. The feedback questions addressed here are as follows: Did the workers appreciate the sessions? What did they learn that was new? If new learning occurs, the management should be informed of the new working practices or new styles of working for motivating further developmental sessions and for the managerial evaluation of the new work practices.

3. Design of a developmental video-viewing session

This chapter provides examples on how to design the collaborative video-viewing session. The first example is for a session that takes place before the work task and is thus meant for preparing for work. The second example is for a session, which supports reflection and learning after the work task performance. The themes and questions of the examples can be utilised as such, but it should be noted that the content of the sessions should be created according to the purpose of the session.

EXAMPLE 1
Before task session
Session time: 1–1.5 hours (depending on the purpose)

Session participants: People participating in the work task (including supervisors), technical support (video material), session leader, other relevant personnel (training personnel, safety culture expert etc.)

Goals for preparatory video session:

- Revising and ensuring good work practices, considering safety
- Finding possible new ways of working and agreeing on the related practices
- Highlighting possible defects (in tools, procedures etc.) and agreeing on the related actions
- Supporting the collaboration, learning and mutual understanding of people participating in the work task
- Agreeing on the topics that will be taken into pre-job briefing (HU tool) - Note: see **Chapter 6**.

Before task session - phase 1 (~15 min.)
- A reminder of the session goals
- Assignment - think individually or discuss in pairs:
- *What is most difficult and critical in the [task];*
- *What makes the [task] safety critical?*
- Discuss the assignment questions in the group
- Materials: task-related procedures, plans

Before task session - phase 2 (~45 - 75 min.)
- Watching of the produced video material
- Assignment - Discuss in the group:
- *Which good practices are good to remember and execute?*
- *What would you do differently? Which new practices should be utilised?*
- *What unclear aspects and uncertainties are related to [task] performance?*
- *Tools and procedures: Are they all relevant, any updates needed?*
- *Use of HU tools: Is it sufficient?*
- *Task-specific topics: what should you pay special attention to?*
- Input to pre-job briefing (HU tool): What are the results from this discussion that should be taken into the pre-job briefing?

EXAMPLE 2
After task session
Session time: 1–1.5 hours (depending on the purpose)

Session participants: People participating in the work task (including supervisors), technical support (video material), session leader, other relevant personnel (training personnel, safety culture expert etc.)

Goals for after task video session:

- Revising and ensuring good work practices, considering safety
- Finding possible new ways of working and agreeing on the related practices
- Highlighting possible defects (in tools, procedures etc.) and agreeing on the related actions
- Supporting collaboration, learning and mutual understanding of people participating in the work task

After task session - phase 1 (~15 - 30 min.)
- A reminder of the session goals
- Assignment - Discuss in the group before watching the video material:
- *What is the goal of the [task]?*
- *What makes the [task] safety critical? What are the most important and critical phases of the [task]?*
- *How did the task performance go compared with the plan and procedures?*
- *What kind of errors occurred? What kind of successes occurred?*
- *What would you like to see from the video material (if possible to produce)?*
- Materials: task-related procedures and plans, document from post-job review (HU tool) if available

After task session - phase 2 (~45 - 60 min.)
- Watching of the produced video material
- Assignment - Discuss in the group:
- *How did your understanding of your own or other people's work performance change? Did something surprise you?*
- *What would you do differently? What caused uncertainty, what went well?*
- *Was something done differently than it was written in the plan or procedure? Why?*
- *Would you have wanted to do something differently than it was written in the plan or procedure? Why?*
- *What would you like to change or improve in the [task] performance, considering safety?*
- Writing down agreed changes and improvements; agreeing on the next steps.

4. Implementation - the case study

This section presents examples of the implementation of the video-based method within a case study. The chosen case was lifting of the nuclear reactor shield in the reactor hall. The primary purpose of the test sessions was to test the method and collect feedback from the nuclear power plant personnel. The design examples in Chapter 3 are based on these case study sessions.

4.1 Creation of video material

Nuclear power plant's maintenance workers' heavy lifting activities were recorded during the annual outage by the power plant's video development personnel. The selected case was the lifting of a reactor shield unit, as it is one of the safety critical tasks during the outage, and accidents during this task could have serious consequences.

The main workers in the lifting task are the crane operator ("driver") and the person who reads the procedure aloud and takes notes ("navigator"). The main workers communicate with each other and also with personnel outside the crane control room (in the reactor hall). Additionally, the lifting supervisor, radiation safety person and other relevant personnel are present in the crane control room, but not necessary all the time.

During the recording of the work, the video camera was positioned so that all the lifting crew members in the crane control room were visible, and their faces were towards the camera. The camera microphone recorded any speech. The researchers watched the collected material and created a video compilation of six excerpts representing activities that would be interesting for the collaborative discussion in the video session and research.

The criteria for selecting the clips were that they contained a certain amount of discussion between the heavy-lifting crew, for example, problem-solving, asking questions, contradictions, confusion about task performance, and suggestions for improvement. The clip lengths varied from approximately 40 seconds to two-and-a-half minutes. Subtitles were added to the final selected clips as the audio quality was not always good. In addition, a minute-long time-lapse video was created from the material recorded in the nuclear reactor hall, showing the movements of the reactor shield unit. The video compilation was used in two sessions with the maintenance workers who were involved in the heavy lifting activities.

4.2 First test session

The first test session was prepared after the lifting operations, meaning that the video session was held with the people involved in the lifting task soon after the lifting and outage. The session materials included the selection of video clips and a list of questions and themes for discussion. The agenda was divided into two parts: the first part focused on the discussion based on the individuals' and groups' recollection of the lifting task, without the video material. In the second phase, the video clips were shown to promote further discussion (see chapter 3, example 2). The session was held in the NPP's training facilities and lasted one hour. The researchers facilitated the discussion.

4.3 Second test session

After the first session, it was agreed with the NPP personnel that the next session would be held before the lifting tasks began. The second test session was thus held for the maintenance workers (supervisor level) directly before the outage and its heavy lifting activities. The participants were also involved in the development of the lifting training. The session's agenda was again divided into two parts: the first part consisted of discussion without the video clips and the latter part was supported by the video material (see chapter 3, example 1). However, the time-lapse video was shown during the first part. The six video clips were the same as those in the first session. In the session, certain themes guided the questions, for example, questions related to good work practices and uncertainties related to the lifting activities. In addition to encouraging self-reflection, the session included questions on the developing the method for maintenance workers' training, for example, how and in what situations the method could be used.

5. Results from the case study

The video-based method has a number of useful purposes for maintenance activities. These purposes include at least the following:

- In *before-task operations,* the video session takes place just before the work, and prepares workers for the forthcoming task.
- *After-task operations* are for reviewing the group's work directly after the performance.
- *The after-incident video-review* can be especially useful for discussing why something went wrong and how to prevent it from happening again.
- The video method can also be used for *training new people.*
- *Developing procedures*.

According to the NPP personnel, all five purposes were relevant in the maintenance context. The before-task session could provide refresher training for experienced workers and could also be part of training for new workers, which was seen as an especially relevant purpose for the method. Using the method to review specific incidents would provide an effective way to evaluate the causes of an incident. This type of session would possibly be more limited to a certain critical event, and the video material would thus be easier to prepare. The more general after-task video session could potentially encourage more sharing of good practices and organizational learning through collaborative reflection and support post-job review practices.

It is evident that video material can stimulate discussion and reflection in a group. During the test sessions, the video material helped the participants recall important issues and revealed which activities' performance could be improved. The discussion also revealed some contradictions between the participants' comments. The attitude towards the method was positive in general. It is noteworthy that filming people during their work and watching the material together in a group is a novel approach, and has not previously been utilised in NPPs (in Finland).

Careful selection of a suitable task for the video recordings is important. The task should be complex, communicative, involve physical activities, and have safety-critical relevance. Furthermore, careful selection of video material is essential for successful implementation of the method. The responsible person or team should at least have time and sufficient competence to make choices. Competence in video-editing would be needed as well. However, these selections and the related work depend on the purpose of the video session: if the aim is to watch one specific critical event, the editing should not be very laborious.

5.1 Technical and organizational challenges and conditions for implementation

The method was further evaluated together with the nuclear power plant's video development team. The following general and specific challenges, requirements and conditions were identified in relation to the implementation of the video method in the heavy lifting task (Tables 2 and 3).

Table 2. Technical requirements and challenges

Suitable equipment in general	Proper equipment should be acquired, which suits the work environment. During the case study, the camera overheated and turned itself off a few times. The audio quality (voice recording) was not always good.
Camera angles and positions	Combining the video footage from the crane control room (lifting crew) and that from the reactor hall (movements of the lifted object) would bring more context to the video material. Currently, synchronizing the footage is challenging. Furthermore, seeing the user interfaces/control panels that are being used would also be useful.
Video-editing competence	Sufficient competence is required for editing the video material. Subtitles are required if the audio quality is poor. A specific person or team for video-editing is recommended. It is also important to decide who will select the video excerpts.

Table 3. Organizational requirements and challenges

Consent	Permission is always required for filming in the NPP. People's privacy must be carefully considered, consent requested, and people should be removed from the footage if they so desire. GDPR must be considered.
Ownership and responsibility	A person in the NPP should be appointed to be responsible for the method.
Usefulness	The usefulness of a new method must always be proven if it is to be officially recognized in the NPP. The method is proven useful, for example, if: 1) the use of method results in a clear, beneficial change in the chosen activity 2) (several) relevant people in the NPP consider it beneficial 3) research results support the use of the method 4) the use of the method produces good results in other NPPs.
Processes and procedures	Processes and procedures are required for using the method in the NPP.

Schedule	The schedule of, for example, the annual outage can be challenging and might require an on-duty person for video recording (this concerns the appointed responsible person). Automation of the recording process could be considered.

6. Video-based method and meeting-based human performance tools

Human performance (HU) tools are a diverse set of good working practices or error-reduction techniques that originate from various industrial contexts. They are usually applied in the operational context by shop-floor workers (especially maintenance and control room workers). Meeting-based HU tools *pre-job briefings* and *post-job reviews* involve holding meetings with task participants to prepare for the task or to reflect on it after it has been completed. (Teperi et al., 2022). Pre-job briefings and post-job reviews are in use in the Finnish nuclear power plants.

During the development of the video-based method it was considered and suggested that meeting-based HU tools could be supported by video sessions. Hypothetically, the results of video session would feed input to pre-job briefing, and on the other hand, the post-job review could be strengthened by separate post-job video session, in which input from post-job review could be reviewed collaboratively. Table 4 presents the hypothetical process.

Table 4: Process for integrating video method and meeting-based HU tools.

Video session (pre-job)	**HU tool: Pre-job briefing**		**HU tool: Post-job review**	**Video session (post-job)**
Result: Checklist for pre-job briefing.	Review of checklist.	**Work task performance**	Result: Comments and ideas for video session.	Result: Items for next pre-job video session and / or pre-job briefing.

The suggested process remains hypothetical, since it was not yet realised in practice. Based on the feedback from nuclear power plant personnel, the suggested connection between the video method and meeting-based HU tools was not entirely straightforward. It was seen that the video method generates discussion and observations, which are more about problems, habits and skills related to the actual work task performance. It was pointed out, that these are not the main topics of discussion especially in pre-job briefings. The method could possibly support post-job reviewing, but the video session should be organised separately from the actual post-job review (HU tool), afterwards in a more peaceful moment and situation (as it was originally suggested). In summary, the video method supports pre-task and post-task activities, but a clear connection with meeting-based HU tools seem to be currently difficult to establish.

7. Simulator training and video-based method

The project also involved a discussion on the usage of a lifting simulator in training. Based on the discussion, which involved maintenance workers (lifting crew) and digitalization developers, it is possible to make contrast between three different training modalities, that is, 1) simulator training without video-based training, 2) video-based training based on real situation (without simulator) and 3) simulator training combined with video-based training. Table 5 presents the results of this comparison.

Certain issues in Table 5 have been addressed above already, such as, the time-consuming video-editing involved in video-based training as well as the quality challenges. Assumedly, with the simulator, the environment is easier to control, thus allowing better sound quality. Additionally, the trainer, if one is involved, could put the video recording on only during the most challenging phases of the simulator training session: thus, there would only shorter snippets of video, reducing the need for editing.

In the discussion, the issue of privacy was voiced out: The operators might not want that their performance used for training purposes. This is an ethical issue that should be carefully discussed with the operators—they should provide consent and they should be allowed to withdraw the video data upon request. Additionally, the question of the influence of video on performance was mentioned: *"It is a situation that may make you nervous and videoing may add to that"*. This, in turn, is an issue to be further studied and discussed with the operators.

The distinctive benefit of the video method versus simulator training only is in the capability to compare operator teams. Some teams might have good working practices that might be beneficial for others. However, the heavy lifting operation is highly procedural—the operator does not engage in decision-making during the process but follows the guidelines very precisely, as expressed by one discussion participant. However, the operator teams might nevertheless have different styles by which they actualize the procedures. One issue is the amount and appropriateness of communication, which was found to be a point of development within this study. It was added that development has taken place on this issue. In principle, other similar style differences could be identified with the video method. On the other hand, a good trainer might be able to identify working styles during the simulator training as well.

In principle, the benefit using a simulator is that the training session can be halted whenever needed and deemed suitable. Thus, it is possible to train in short sessions, which allows flexibility. The sessions may also be halted for pedagogical reasons: the trainee might want to discuss certain issues, or the trainer might lecture or test the trainee during the session, for example.

Overall, there are strengths and weaknesses in both using video and simulators. It seems that the best results could be obtained by using both appropriately. Unlike using the simulator, videoing is not yet part of the training culture in Finnish nuclear power plants.

Table 5. Comparison between three training modalities

Strengths, weaknesses and threats	**Simulator training without video-based training**	**Video-based training based on real situation (without simulator)**	**Simulator training combined with video-based training**
Cross-team comparison	No	Yes, but limited benefit in highly procedural activities	Yes, but limited benefit in highly procedural activities
Pedagogical interventions during performance	Possible	Not possible	Possible
Time consuming video editing	[does not apply here]	Yes	Yes, but less than without simulator (the simulator scenario may involve challenging phases that are cued for video recording)
Can be done flexibly, when suitable for the operator	Yes	No – have to wait until the videos have been edited	No – have to wait until the videos have been edited, but easier than without simulator
Quality of the video	[does not apply here]	Worse quality (challenges with voice recording and camera angles)	Better quality
Privacy considerations	Non-issue	To be considered and discussed.	To be considered and discussed.
Impact on performance	Non-issue	To be considered and discussed.	To be considered and discussed, but not so relevant.

8. Summary and conclusions

This report presents the description of a video-based method for collaborative learning and development in a nuclear power plant's maintenance activities. The purpose of the method is to enhance maintenance workers' skills, knowledge and resilience during safety-critical operations. The report gives practical guidance and examples on how to design and implement the video-viewing sessions. The case study provides information and results on using the method concerning lifting activities in the reactor hall during the outage of the power plant. Furthermore, the report provides insights onto how to utilise the video-based method in simulator training and in combination with meeting-based human performance (HU) tools.

The video-based method can serve a number of useful purposes in maintenance activities. The video viewing session should be designed according to its main purpose and goal. For the successful implementation of the method, it is important to select suitable task to be video recorded. The task should be complex, communicative, involve physical activities, and have safety-critical relevance. Furthermore, careful selection of video material is essential.

The video-based method provides a clearly new way to prepare for work and to learn from previous activities. The method provides viewpoints that possibly cannot be acquired anywhere else. The most significant challenges are related to the responsibilities and usefulness of the method, and to the selection and editing of the actual video material. To be recognized as an official method in the nuclear power plant it needs to be included in the power plant's existing guidelines and procedures.

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