PROCEDURE DEVELOPMENT PRACTICES IN FINNISH NUCLEAR POWER PLANTS

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ABSTRACT

Since operating procedures play an important role in nuclear process control by guiding and standardizing how to cope with demanding operational situations, it is important to have a clear understanding of how operating procedures are developed in the nuclear domain. We have investigated procedure development practices in two Finnish nuclear power plants. In this paper, we present a method for the analysis of these practices and some examples of the application of the method. We have interviewed procedure writers and other experts who are involved with procedure development work and explored the results using methodological tools of Practice and Activity Theory. Procedure development activity can be seen as a social practice, loosely supported by methodological guidance. Especially, the early phases of the development project seem to escape from generic characterization. Based on the interview data, some potential tensions and contradictions were identified, and they are discussed through the lens of Activity Theory.

KEYWORDS

Procedure Development, Nuclear Power Plant, Practice Theory, Human Factors Engineering

1. INTRODUCTION

Procedures provide instructions and guidance on how to perform work responsibilities in due manner. Operating procedures play an important role in nuclear process control by guiding and standardizing how to cope with demanding operational situations. The vast majority of accidents in the nuclear domain are associated with use of operating procedures (Marsden, 1996). From this perspective, it is not insignificant how the procedures describe the actions needed to perform a task, which, in turn, is dependent on how the procedures are developed. The development of procedures is a challenging endeavor including several steps extending from planning and writing from validation (Stanton et al., 2010). In safety critical domains it has been argued that a formal procedure development process is required, and rigorous guidance or method must be developed to ensure that the formal process is followed (Stanton et al., 2010). On the other hand, it is well known that any method can never be rigorously adhered to, but it has to be adopted and adapted to the characteristics of each situation (Dittrich, 2016; Fitzgerald, 1996; Laarni et al., 2022). Since it is important to have a better understanding of how operating procedures are developed in the nuclear domain, our aim is to study the procedure development practices in Finnish nuclear power plants (NPPs).

This paper will present the methodology and the first results of the research. It is a continuation of our former paper, in which the methodology was presented for the first time (Laarni et al., 2022). The paper is structured as follows: Chapter 2 introduces a typical procedure life cycle, regulatory and other guidance on procedure development, and the idea of procedure development as social practice. Chapter 3 presents the methodological basis of our research, and Chapter 4 describes the preliminary results of expert interviews. The results are discussed in Chapter 5, and in Chapter 6 we present concluding remarks.

2. PROCEDURE DEVELOPMENT

2.1 Procedure Development Process

The procedure development process and the procedure life cycle in safety-critical domains include a particular set of phases that follow each other. Figure 1 depicts the procedure life cycle, which is based on System Development Life Cycle (Ahmed et al., 2020). There, procedure planning, design and development are subdivided into seven subsections. Procedure development is an iterative process, and the start of a new 'round' may be caused by various reasons, e.g., a new technical system requires extensive changes in process control, or an inventory of a group of procedures signals a need for harmonization of the procedures.

Terms 'design' and 'development' are used interchangeably in the paper, even though they refer to distinct phases in the procedure life cycle.

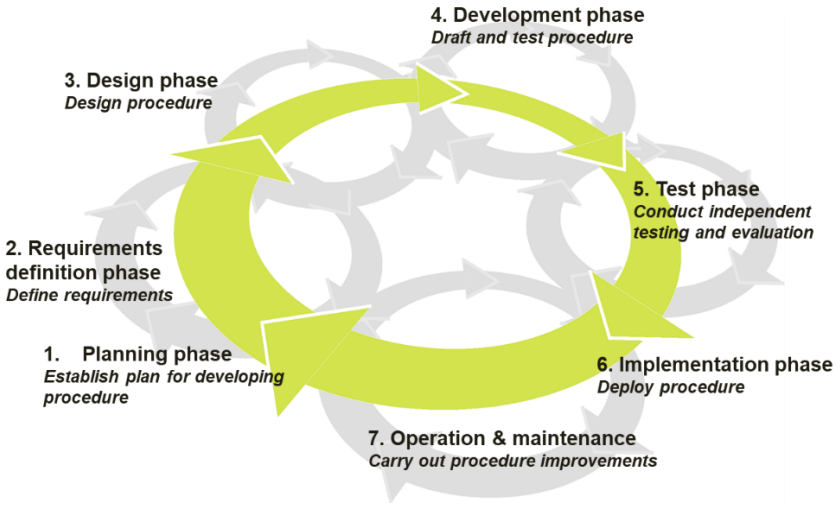

Figure 1. Procedure life cycle (cf., Ahmed et al., 2020). Arrow circles indicate iterations both within each phase and over phases

2.2 Regulatory and Other Guidance on Procedure Development

Methodological guidance used in procedure development in the nuclear domain is based on relevant standards and guides (Laarni et al., 2022). Guidance comes in many forms, and some of it is plant-specific, some of it is national or international. International Atomic Energy Agency's (IAEA) reports (e.g., IAEA-TECDOC-1058, Safety Reports Series No. 48), the U.S. Nuclear Regulatory Commission's (NRC) reports in NUREG- series (e.g., NUREG-0711) and the Electric Power Research Institute's (EPRI) reports (e.g., EPRI 3002004310) are examples of international nuclear guides, and the Finnish Radiation and Nuclear Safety Authority's (STUK) YVL-A.6 is an example of a national guide.

From the perspective of the procedure life cycle, any of the above-mentioned guides does not address all the procedure life-cycle phases. The Procedure Professionals Association's (PPA) AP-907-001 Procedure Process Description is the only document that presents comprehensive guidance for the activities required in procedure development in safety-critical domains. However, as a high-level document, the guide does not provide detailed guidance on any topic.

2.3 Procedure Development as Social Practice

Figure 2 shows our approach for the development of a plant-specific HFE framework for procedure development. National and international standards and guidelines (as described above) have an influence on plant-specific guidance on procedure development. Standards and guidelines also have an impact on the content

of plant-specific programs (e.g., HFE program) and reports (e.g., safety analyses). All these plant-specific documents have an impact on procedure development practices, but they do not completely determine them.

Methodological guidance provides tools for developing a procedure. It specifies what is produced, and processes through which the endpoint is achieved. As proposed by Fitzgerald (1996) and Dittrich (2016), it is a normal state of affairs that methodological guidance is never applied as was originally intended by their developers. Experts in different domains do not typically follow the method closely but utilize only those elements that are relevant to their tasks. Different experts also interpret methods differently, and because situations differ, the same person does not apply the method in the same way in different situations.

According to Dittrich (2016), methods can be considered as practice patterns that have to adapted to the contingencies of each situation. These methods in action are social practices consisting of interrelated activities that are connected through shared teleo-affective structures and shared understandings of what it means to develop a procedure in the nuclear domain (Laarni et al., 2022).

To understand procedure development as a practice we should specify tools and equipment that are used, and the settings in which the practices are actualized (Dittrich, 2016). In addition, as said above, we have to take into account that procedure development practices are flexible so that they can change, develop, and adapt to the characteristics of an ongoing situation (Dittrich, 2016).

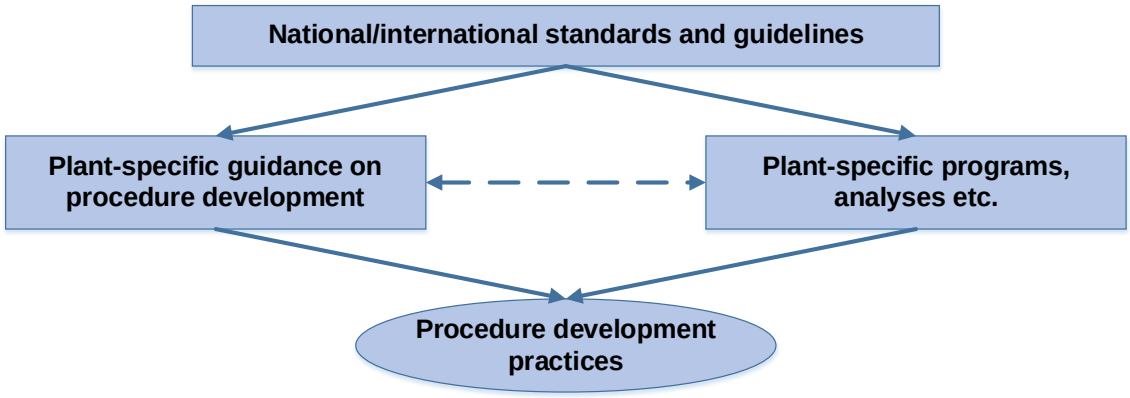

Figure 2. Our approach for the development of a plant-specific HFE framework for procedure development

3. METHODOLOGY

We will investigate procedure development practices by ethnographic methods providing an insider's perspective to understand designers' behaviors, perspectives and experiences (Laarni et al., 2022). The application of the ethnographic approach results in the comprehensive, detailed and contextual interpretation of research data. The ethnographic approach we apply has a special interest in procedure developers' point of view, and its focus is on everyday situations and settings. It is based on an iterative and flexible process of inquiry requiring constant redefinition of the research questions (e.g., Jorgensen, 1989).

3.1 Toolbox Approach

An approach to study practice at work is used (Nicolini, 2012), which is based on a set of stimulating research questions, the answers to which are sought by ethnographic methods of data collection (Laarni et al., 2022). First, we will zoom in on the details of the procedure development practice; after that we will zoom out to enlarge the scope of the study (Nicolini, 2012). In the latter phase, our aim is to focus on connections between practices and their results (Nicolini, 2012). The iterative zooming in and out will continue alternatively until we can provide a feasible account of the practice and its effects on other practices.

Zooming in –questions address topics such as philosophy and strategy on the use of procedures, contributing stakeholders, characteristic features of the design process, tools and artefacts used in the practice guidance used, main constraints of the procedure development practice and main concerns and worries

(Nicolini, 2012). Zooming out –questions address topics such as connections between the procedure development practice under consideration and other engineering practices in the NPP, history of the practice of procedure development, and tensions and contradictions in procedure development practices and their remedies (Nicolini, 2012).

3.2 Procedure Development as an Activity System

By using ethnographic methods and the toolbox approach, we are able to better understand the factors that may contribute to the development of a new procedure. We explore the procedure development project through the lens of Activity Theory and consider the endeavor of procedure development as an activity system. According to the Activity Theory framework, the main elements of procedure development activity are the following: procedure designer (Subject), process control activities requiring proceduralization (Object), new procedure (Outcome), design guides (Rules), NPP personnel (Community), engineering vs. operating personnel (Division of Labour) and modelling tools and simulators (Tools) (Engeström, 2005). In applying the Activity Theory framework, we aim to identify potential tensions and conflicts emergent in attributes of the activity system and between different activity systems (e.g., between different engineering domains or between suppliers and power companies). According to the Activity Theory, these contradictions are not necessarily harmful, but they may stimulate learning and the development of the whole activity system.

3.3 Data Collection

We have conducted a couple of semi-structured interviews by interviewing experts of two Finnish NPPs. Seven experts participated in the interviews, which were conducted at different moments of time during a period of about ten years.

3.4 Data Analysis

Audio recordings of semi-structured interviews were transcribed. The interview transcripts are coded to identify main themes and important concepts. Some main parts of the transcriptions of the discussions are analyzed in a more detailed fashion.

Data analysis is based on a dialectical strategy, according to which data is broken down into elements and components, and they are analyzed further to identify patterns and relationships (Nicolini, 2012). When an interesting topic has been identified, the data is again put together, providing an interpretation of a question of a particular problem. The synthesis is then assessed and critically examined. This zooming-in – zooming-out process can be repeated several times. Finally, the results of the interviews are carefully documented.

4. RESULTS

4.1 Procedure Development Process in Finnish NPPs

Next, we will present preliminary answers to the above-mentioned zooming-in and zooming-out topics. Our answers sketch a Finnish way to develop operating procedures in nuclear domain.

4.1.1 Procedure Development Process

The procedure development project varies much depending on the extent and size of the technical project to which it is associated. The project is much larger and longer, if it is related to an extensive automation renewal project than to an update of an individual procedure. The project is also more extensive if the aim is to harmonize all procedures or to change the format of a large amount of procedures. The process is also different depending on whether there is an existing procedure on the topic or not.

The interviewees agreed on the main steps in procedure development. The following steps were identified: 1) Identification of the initial event and reflecting the plant's response to it; 2) outline of the strategy and specifying the safety functions; 3) analyzing by modelling tools how the strategy actually works; 4) preparation

of the first draft (shift supervisor's version); 5) performing additional analyses and testing the draft at the training/development simulator in order to identify the critical details; 6) involvement of operators and testing the procedure at the full-scope training simulator; 7) development of possible operator-role specific procedures (i.e., versions for reactor operator and turbine operator); 8) development of background material and additional information; 9) verification/staff reading review of the procedure; 10) validation planning, incl. determination of criteria for the technical acceptance of a procedure and determination of the safe limits for critical parameters; 11) preliminary simulator validation; 12) final validation; and 13) final check-up and approval.

From the perspective of the procedure life cycle (see Figure 1), steps 1-3 are included in Planning, Requirements development and Design phases of the life cycle, and the rest of the steps are included in Development and Test phases. The steps in the early stage of the development process partially overlap each other, and there are iterations both within steps and across several steps.

Typically, HFE issues play an increasing role at later developmental phases. The amount of modelling and testing in the early stage of the development process is highly dependent on the scope of the project: in new-build and large modernization projects more extensive testing and modelling is needed than when developing a single procedure for a well-analyzed task.

Next, in sections 4.1.2-4.1.8 we present the most important zooming-in topics; in sections 4.1.9-4.1.10 two zooming-out topics are described.

4.1.2 Perspectives Taken on Procedure Development

We first analyzed what positions and perspectives were taken on development work. Procedure philosophy is materialized in a procedure strategy. Regarding emerging operating procedures (EOPs), the procedure strategy can be defined as a description of the main steps to achieve the safe state of the nuclear power process. Typically, designers cannot define the strategy at their work desk. Instead, they have to conduct tests and monitor the plant response, and based on the test results, they can finally settle the strategy.

A Concept of Operations (ConOps) was another term that was used to describe the starting point for the procedure development process – especially for the development of EOPs. A ConOps can be defined as a high-level description of how the proceduralized activity is conducted in a particular situation in order to achieve the safety goals (Fairley and Thayer, 1997). The ConOps, thus, describes the general structure of the procedure, and it is further specified throughout the development process.

In one of the two NPPs, the interviewee had a very practical attitude towards the designers' work: the procedure designer sees him-/herself as a member of the operative unit, and by developing good procedures for operators his/her work contributes to plant operation. Procedure development is also seen as a part of configuration management process, in which functional and physical characteristics of plant systems are controlled based on plant knowledge.

4.1.3 Contributing Stakeholders

We were interested to know who are involved in procedure development. Typically, the total number of practitioners involved in the development work varies much depending on the size of the project. In one Finnish NPP, the typical number is 20-30. Often, there is one person in charge and another one acting as a deputy. The core team also includes, for example, the head of the procedure design department, the main simulator trainer, some people from the safety department, and some heads of divisions. Their role varies depending on the expertise needed in various phases of the development project. Typically, they provide background information, review drafts of the procedure and participate in the verification, validation and approval of the final versions.

In another NPP, there is the core group, which is responsible for the development work itself. In addition to that, a group of experts conducting modelling and testing is involved as well as a group of operating personnel (e.g., operators) from the plant who play an important role in procedure development, because they have an overall view of the state of the process in a particular situation. They present comments on the first drafts, based on which a revised version is drafted. Operators also participate in the validation of a new procedure.

As a whole, it was thought that procedure design is a collective activity. The procedure development group jointly considers alternative solutions in different phases of the development process. Review events at the NPP in which several process experts from relevant domains participate play an important role in the development work. In these events, procedure designers tell the operating personnel that a particular kind of

procedure is on the way, what the strategy and the end state will be etc. The aim is to receive early feedback from process experts and get confirmation about whether the development work is proceeding on the right path. There is also collaboration with the safety-engineering group. Safety engineers are able to tell what process changes may occur, and the procedure designers' task is to determine how the effects of the changes should be taken into account in the procedure.

Operator feedback is received through different events: Feedback is based on operators' experiences in simulator training, when they read and familiarize themselves to the background material of the procedure, and when they prepare themselves for the license exam or participate in refresher training.

4.1.4 Characteristic Features of The Design Process

Regarding timing and schedule of the procedure development practice, one interviewee thought that the design process is often rather long: it may last for one year or even longer. Sometimes, there is a fly in the ointment, and the design work has to be started anew from the beginning; sometimes, several partial iterations are needed.

The share between independent work and teamwork varies from one phase to another. Some interviewees thought that the design work is a solitary grind in the early phases of the project: you prepare a draft version alone, and then you submit the draft to reviewers and wait for their comments. Interestingly, it was also considered as creative work: the procedure designer is like an artist, who designs the draft from all bits and pieces (raw material) he/she has. Especially, creativity is needed in the early phase of the design process and also in the development of a totally new procedure. The designer has to overcome the 'white paper fear' and make the first guess, because there is no earlier version from which he/she could copy the first ideas. Typically, the designer can prepare the first draft in different ways: there are several degrees of freedom, and there is no one right answer how to solve a particular problem and present the solution in a procedure.

In one of the two NPPs, meetings with other design team members are arranged about once a month. The progress of the work is discussed, and it is also checked if additional modelling is needed. Nowadays, remote electronic meetings are preferred. Participants are better prepared for them, it is easier to focus on the subject matter, and there is no additional small talk. For many team members working at the plant area, it is also easier to participate in electronic meetings. Remote work during the COVID 19 pandemic has become a part of a normal routine and changed the work practices. In general, the change was considered positive: The interviewee thought that working at home is more suitable for creative work than working in an open office.

One critical question is how the procedure development practice is kept on track. The proverb 'well planned is half done' holds good in procedure development. The procedures must be rigorous enough, and the administrative procedure plays an important role by providing basic guidance about the process. The correct order of progress is that you first familiarize yourself with the topic, after which you can recruit other people to participate in the design work. It is also important that meetings are arranged in a regular fashion.

4.1.5 Tools and Artefacts Used in The Practice

In order to take into account the process effects of plant changes, modelling and simulations play an important role. According to one interviewee, modelling plant processes by Apros (Advanced Process Simulation Software) or other modelling software is very important and nearly obligatory, because the designer cannot take into account everything when he/she is working at his/her desk. Their wish to Father Christmas was a part-scope simulator with which it would be possible to develop and test the procedure with the laptop. According to the interviewee, they do not use specific graphics programs in their work. MS Word and Visio are the most important tools, and they also have a graphical template for the design of flowchart procedures.

4.1.6 Guidance on Procedure Development

High-level administrative guidance on procedure development provides an overall structure for the development work in both Finnish NPPs. In one of the two plants, according to the interviewee, it is the only administrative document providing guidance on procedure development work – more detailed administrative guidance, e.g., in the form of a procedure writer's guide does not exist. In another NPP, there has been intensive collaboration with foreign companies, which have provided guidance on the development of EOPs over a period of about two decades.

As noted in Introduction, there is little detailed regulatory guidance on procedure development in Finland. The interviewees in one of the two NPPs said that international guidance is not utilized, and it is not known very well. Instead of reading documents, discussions with experts from other NPPs are preferred. They receive

advice, backup and useful material from their colleagues in another plant. They had also participated in a Nordic project in which plant-specific best practices were shared and compared. Procedure formats were found quite similar in Nordic NPPs.

4.1.7 Main Constraints of The Procedure Development Practices

A constraint means anything that is preventing the designer to achieve the goal. How much the development process is constrained depends on the type of procedure: there are more constraints in the development of EOPs than normal operating procedures. Typically, there is detailed guidance on the development of flowchart-based procedures, incl. general principles, writing and drawing guidelines and guidance on crew behavior. Guidance comes in different levels of detail.

New procedures may be necessary if some equipment having significant process effects is renewed. In this case, the equipment supplier may have a large role in revision of the procedure, since only it knows how the new device functions. For example, it has to be decided with the supplier whether it is possible to test the new system at the factory and whether it can be tested before the launch of the procedure.

The designer has also to incline his/her ears to the opinions and preferences of safety engineers and of operating personnel. Safety analyses place constraints on what direction the development work should take, and as already mentioned, operators take a close look at the usability of new procedures, when they comment on the draft versions and participate in verification and validation activities.

Procedure changes are informed to the Finnish nuclear authority. Principally, the designer has to take into account the nuclear authority's guidance and its remarks but, in general, the authority only keeps a watch that plant changes have been considered in procedure development. As said, the guidance provided by the YVL guides is quite cursory. Overall, the nuclear authority is not much interested in the procedure design process or the contents of the procedures as such.

4.1.8 Main Concerns and Worries

Typically, the designer hopes that the whole process will proceed smoothly and as scheduled, all critical information has been gathered and all critical issues are taken into account so that there is no need to return to previous phases of the development process.

One of the designers' main concerns is whether they properly understand how the new device works and whether all critical process effects of plant changes have been taken into consideration in the design work. In the beginning, there is a discussion on what boundary conditions have to be taken into consideration, what consequences a particular event may have, and what human errors may occur. A special challenge may be that the coverage of a procedure may be difficult to determine beforehand complicating the identification of critical source information. Furthermore, it must be kept an eye on consistency with other procedures, which may turn out to be difficult, if the pool of procedures is big.

At the time the designer makes the first guess, he/she does not know all the details; so, his/her guess may be wrong. Something surprising may happen that the designer has not been able to anticipate, for example, related to a particular process parameter or the functioning of the automation system. It is also very difficult to ask others' opinions, when you do not have drafted anything – you only have the white paper. When the first guesses have been made, discussions with other stakeholders can be started.

Sometimes it is found in testing that the new procedure does not seem to work. The simulation freezes, it has to be interrupted, and it must be analysed what went wrong and why. It is also possible that some experts raise an issue that has not been properly addressed, and therefore the whole process must be started again from the beginning. Experts from different domains notice different things, and the procedure designer can become blind to the details. Sometimes the procedure may be so complicated that the reader is not able to understand it correctly. However, it is not only a matter of facts, but also opinions may differ. In that case, experts have to find a compromise, which all can agree on.

Resistance to change is sometimes a problem - especially in a case of upgrading existing procedures, which operators have used for years. Active operator participation throughout the process is the best remedy for that.

4.1.9 Connections Between the Procedure Development Practice Under Consideration and Other Engineering Practices

Procedure development is linked to several other processes. As was already said, often procedure changes are linked to plant changes: a new device is installed, which has implications to the nuclear process, to monitoring

and control activities, which in turn requires changes to the procedures. Therefore, several groups of experts must be consulted in the design phase, such as HFE and training personnel as well as members of the safety analysis team and the operation manager. It is challenging to take into account all the possible implications of other engineering activities on the procedure development practice.

One issue that was raised in the interviews was the relationship between the HFE program and procedure design activities. Both plants have recently developed their HFE practices which also has implications on procedure development activities. Some new requirements have been laid down, stating, for example, that operator training must be arranged before new systems and procedures are taken into use.

Especially, in new-build and extensive modernization projects, the orchestration of interactions between several engineering practices involving practitioners from different organizations is a challenging task.

4.1.10 History of The Practice of Procedure Development

Procedure design is also considered from the perspective of how it has changed and developed over years and decades. The designer sees him-/herself as one link in a chain of historical development. In one NPP, much improvement has been seen: for example, previously, there was no administrative guidance on procedure development. The lack was justified by saying that the development practices were built-in to the courses of action.

In another NPP, in the early 2000's, a decision was made what direction and approach will be taken in the procedure development. International collaboration has played a major role in the development of the procedure development practices. Philosophy of use and ergonomics were 'bought' from a foreign organization and adapted to the Finnish context. There is still intensive ongoing collaboration with foreign stakeholders in procedure design.

4.1.11 Summary

Procedure design activity is still a mystery: after several interviews, we still know quite little about the development process – it seems that the designers are not able to verbally describe the process in a detailed fashion. This is understandable if procedure development is considered as creative work – then, the details of which are understandably difficult to verbalize. Another, not exclusive reason can be that the procedure design can proceed in various ways, depending on the scope of the procedure and perhaps also on the person who leads the process.

An additional problem is that the design process is not addressed in existing administrative guidance in detail. Due to this, it is not possible to compare the design practices to guidance; such guidance just does not exist, and the existing Finnish guidance documents are in such a general level that it does not support procedure development in practice.

Rigorous guidance is a necessary but not a sufficient prerequisite for a good product. On the other hand, high requirements for the product shape the process to a certain mould. Even without strict guidance we can, thus, end up with rather uniform practices.

4.2 Description of The Example Case

Next, we present briefly an example case of a procedure development activity in a Finnish NPP. The aim is to demonstrate how a fluent development process evolves. It was found that there are different opinions on what good communication is in accident situations. Therefore, it was decided to make changes to some procedures regarding communication and change the administrative procedure addressing operative personnel's tasks and duties. There are potential benefits of more detailed guidance on communication practices. First of all, it can promote team situational awareness in more complicated situations (simulator runs) so that the operator has a better understanding of what other operators are doing.

A group of experts was established to conduct the work, including outage coordinators, heads of divisions and shift supervisors (SSs). Their task was to define what good communication is in accident situations. The interviewee was asked to update some procedures from this perspective.

First, an annex of an administrative procedure addressing expectations on communication in accident/incident situations was designed. Topics included are, among others, what has to be verified and who should do that. Two-way communication is typically required, and exceptions must be communicated immediately. Guidance was provided on how the information should be presented in a procedure.

Simulator testing of the new procedures with communication related instructions was conducted in spring 2022. Simulator trainer and head of divisions discussed the progression of the run and the impact of the change of the procedures. They were quite satisfied with the new procedures and thought that the procedures have been improved: the amount of communication was increased, and the crews' performance was more consistent.

Shift supervisors have to make several announcements in accident situations, and previously they typically preferred these announcements over other activities (such as asking information about the process situation from other operators). It was found in the simulator tests that they now inquire other operators before they send the announcements.

There still was some need for improvements, since all the details of the new procedures were not adopted by operators. Some crews delivered too big chunks of information in one utterance, which was not the original idea. It was also found that even though operators should notify that they aim to turn the page, they did not do it in a regular fashion. According to the interviewee, the run proceeded a bit slower than normally, which is understandable, since adoption of anything new takes time and effort.

In the beginning, there was quite much resistance, but it quieted down after the simulator test. The new administrative procedure was submitted to the shift personnel, and also some example procedures were delivered to them. These were discussed in training days in spring.

Regarding SS's briefings, a special form has been developed; it is expected to be filled in at a suitable moment of time during the simulator run. SS determines when there is a suitable time for a briefing.

The work is in progress, and some issues are still open: For example, it must be decided whether there will be communication boxes in all accident/incident procedures. If yes, it will be a very laborous task to realize. The next step is to update the new procedures based on comments. Then, heads of division will once again check them, and after that, it is monitored how the crews apply the new guidance. Human performance simulator runs will be conducted in the following year, in which special attention will be paid to crew communication.

This is an example of a rather simple case, in which existing procedures were improved. Instead of computer modelling, a couple of simulator runs were conducted in a training simulator. Overall, the development work seemed to proceed quite fluently, and the project was kept well on track.

5. DISCUSSION

5.1 Tensions and Contradictions in Procedure Development

In Methodology chapter we described the procedure development process capitalizing on Activity Theory. Figure 3 shows an activity triangle for procedure development demonstrating the interactions between the main attributes of the procedure development activity. According to Activity Theory, if we think backwards, the Outcome may change if one of the corner elements changes (e.g., new rules or tools are introduced). For example, new administrative guidance may be launched, new tools such as part-scope simulators and virtual meeting tools may be taken into use and division of labour may also change. Let's take as an example the effects of COVID 19 pandemic on procedure development work. One of the main dilemmas in the era of COVID 19 was, on one hand, the requirement to continue normal work arrangements and, on the other hand, the prevention of infections by reducing face-to-face contact. One solution to this contradiction was to introduce new work tools and new ways of working based on virtual remote work, which, in turn, challenged one of the fundamental principles of the work in nuclear industry, that is, the principle that all critical work activities are performed inside the fences of a NPP. Apparently, new guidance is needed to orchestrate both individual and collaborative work in the new situation.

It is also possible that new tools (e.g., virtual conferencing tools and part-scope simulators) will challenge the existing division of work between the procedure developer and those practitioners conducting modelling work, which, in turn, may put pressure on skills requirements. Furthermore, these changes may have implications for guidance, and possibly new rules are needed to address the new ways of conducting development work.

Contradictions may also emerge between activity systems. For example, in a new-build project or in a large modernization project typically a group of suppliers is involved, of which some may also be active in procedure development. This may have implications to all attributes of the activity system, for example, through the fact

that Community includes not only practitioners from the power company but also from supplier organizations. Some tensions and contradictions between the attributes were identified in expert interviews, and they are illustrated by lightning bolts in Figure 3.

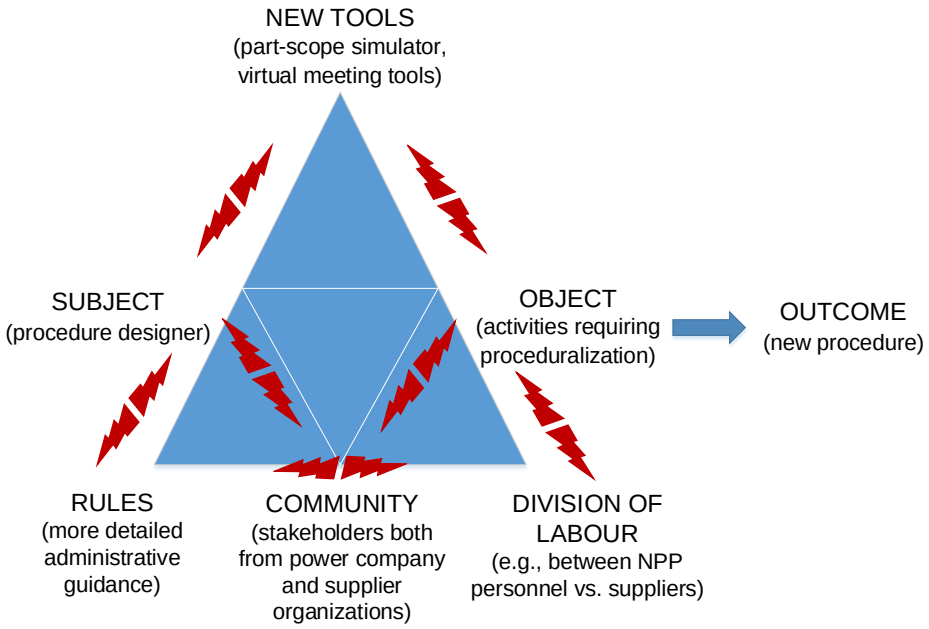

Figure 3. Activity triangle for procedure development (Engeström, 2005). Some tensions and contradictions between the attributes are shown with lightning bolts

5.2 Procedure Development Practices

Is there a need for methodological guidance on procedure development, and if yes, what information should the guidance include? In a general level, the procedure development process follows a particular path, which is well described in several handbooks and guidance documents. In a more specific level, it depends on what kind of procedure we are talking about. There are quite detailed instructions for the development of EOPs, providing guidance both on the process and the format of the procedure.

A plant-specific administrative guidance on procedure development can provide a general framework for procedure design work. Our analysis of one plant-specific guidance showed that the some topics are well addressed in detail in the Finnish administrative guidance such as review of the procedure draft, and approval of the new procedure. On the other hand, some topics are not addressed in the Finnish administrative guidance such as formal procedures for the management of the procedure change request (e.g., evaluation of the request, determination of the request's priority) and formal procedures for planning the development of a new procedure (e.g., determining the workflow for the alteration, detailed description of the development process and finalization of the development process and implementation of the change management process).

Let's assume that we have practical guidance on procedure development. The next question is how the guidance is followed. As was suggested by Dittrich (2016), procedure development practices are flexible so that they can change and develop and adapt to characteristics of an ongoing situation. This means that the activity of designing a new procedure is itself an object of development that can evolve.

What we have found is that it is quite difficult to proceduralize the early phases of the design process, which are an indication of collective creativity and collaborative learning. This kind of collective creativity is especially needed in the planning, requirements specification and design phases of the procedure lifecycle, when the work is still searching for direction and firm basis.

Even though the procedure development is a collective enterprise, there is always the designer in charge, who writes down the first guess and who has to overcome the white paper's fear. As one of the interviewees said, after drafting the first guess, it is easier for others to contribute to the design work.

As was suggested earlier, procedure development can be considered as a social practice: There is the shared intention to design and develop a new procedure, shared understandings what it means to develop a new procedure, explicit rules and principles providing guidance on the work and tools and artefacts that are important in accomplishment of the practice. Implicit in the conceptualization of procedure development as a social practice is the idea that there is always a possibility to do things differently: methods have to be adopted and adapted, and in some way always constructed on the fly in actual implementation.

5.3 Further Work

This paper only scratches the surface in understanding the procedure development practices in nuclear domain due to the fact that our results are based on interviews with a small group of practitioners. To paint a richer and more nuanced picture of the development process, a more versatile selection of ethnographic data collection methods should be included into the methodological toolbox. For example, we should participate in virtual meetings in which the procedure developers take part. Ethnographic observation of these meetings provides insight on how a procedure is drafted, how decisions are made, what drives and guides decision making and how it is implemented.

6. CONCLUSION

In order to create a better understanding of the procedure development process, a new methodological approach is needed, aggregating elements from both rigorous HFE analyses and an ethnographic case study approach. Since the type and scope of projects varies much, there is no universally applicable method for procedure development, but only quite general guidance can be presented. This is especially true in the early phases of the procedure development process, which seems to hide from detailed characterization. On the one hand, it is an individual endeavor, on the other hand it is a collective enterprise of several teams; on the one hand, it is a strictly proceduralized, analytical activity, on the other hand, both individual and collective creativity is needed. According to our interviewees, the periods of individual and collaborative and analytical and creative work typically follow each other in a quite regular fashion.

We have explored the procedure development through the lens of Practice Theory. But in order to be able to specify in more detail the understandings, rules, intentions and usage patterns of tools and technologies we must dig deeper into the implementation of procedure development practices. Only this way we are able to see the full potential of the ethnographic approach.

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