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Digitalization of Whiteboard for Work Task Allocation to Support Information Sharing between Operators and Supervisor

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Abstract: The increase of complexity in modern production systems has put new demands on shop-floor operators. Therefore, proper sharing of information on shop-floors has become more important as means to support operators' cognition. To this aim, the development of Information and Communication Technology has provided new support tools, but many of these tools lack empirical testing in live production. This paper studies how information sharing between operators and supervisor, at a small production company, is affected by the use of one of these tools: namely, replacing a whiteboard for work task allocation with a digital counterpart. In this study, questionnaires, polls, and interviews about the operators' perception towards shared information and its quality were assessed. This assessment was based on the MEET model, which includes both an organizational and an informational perspective for studying various areas that affect meetings and information sharing. The results indicate that, while the information quality was improved by the digital whiteboard, the Organization System supporting the changed Information System need to keep up with the changes. Future practice needs to better match the two systems, and research needs to study the relations of the subcomponents of the two systems.

Keywords: Management of technology developments, Cognitive aspects of automation systems and humans, Management of competences and knowledge, MEET, Information sharing, Shop-floor operators, Digital whiteboard, Information System, Organization System.

1. INTRODUCTION

In current labour-intensive production systems, the increasing demand for product customization also increases the perceived complexity for shop-floor operators (Hu et al., 2008, Davenport and Prusak, 1998). This development can negatively affect quality, production reliability and uncertainty, performance, as well as production time (Mattsson et al., 2016). In this context, improving information quality and information sharing methods can counteract negative effects of increasingly complex work situations (Kehoe et al., 1992) by supporting operators' work (Grane et al., 2012) and building a foundation for strategic consensus possibilities (Edh Mirzaei et al., 2016). Emergent Information and Communication Technology (ICT) can help such empowerment of operators and support a higher level of process understanding (Åkerman et al., 2016).

Both visualization (Lindlöf and Söderberg, 2011) and digitalization (Lee, 2015, Fast-Berglund et al., 2016) are of importance when improving the information sharing methods for operators. An ICT support tool for information sharing that recently has gained more attention for its visualization and digitalization properties is the digital whiteboard, which is the focus of this paper.

To address the issues of information sharing and meetings in industry, previous research has developed the MEET model as a framework for description and improvement of such sharing of information (Fast-Berglund et al., 2014, Gullander et al., 2014). In this paper, the MEET model is used to analyze the implementation and use of a digital whiteboard at a case company, with the overarching aim of evaluating how a digital whiteboard can function as a support tool for information sharing and its effects on the information quality for operators.

2. FRAME OF REFERENCE

Information sharing is of particular interest in this paper. Information itself is different from data or knowledge. While data is discrete facts about events (Davenport and Prusak, 1998), it can become purposeful and relevant information if the data is contextualized, categorized or condensed (Drucker, 1988). Further, information is similar to explicit knowledge but is further decontextualized so that it can be wider applied (Tuomi, 1999). Placed between data and knowledge, information can make individuals into a strong and mutually supportive team, if information is shared and communicated responsibly and multi-directionally (Webber, 1993).

2.1 The MEET Model

The MEET model was developed in 2013 and contains two subsystems, the Information System and the Organization System, with five areas each, as illustrated in Fig. 1. Results from previous studies show that Information System never can store all the knowledge or information needed – there will always be a need for the knowledge that is made available only

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by humans. Furthermore, the Organization System cannot be sufficiently efficient without a good support from the Information System that stores, presents, and handles the information (Gullander et al., 2014). The MEET model has evaluated both subsystems in several case studies (Fast-Berglund et al., 2014, Gudmunds et al., 2015, Asklund et al., 2016, Fast-Berglund et al., 2016, Harlin et al., 2016, Li et al., 2016). Results from these case studies show that it is common to focus on either the Organization System or Information System when establishing new meeting strategies.

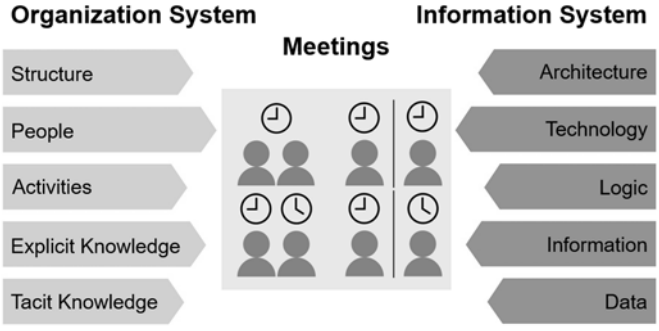

Fig. 1. The MEET model with areas of Organization System (left), areas of Information System (right), and time-place flexibility of Meetings (in between).

2.2 Time-Place Flexibility of Meetings

Two different dimensions, a time dimension (same or different time) and a place dimension (same or different place) can be used to create a combined matrix of four different meeting types (Baecker, 1993), visualized in the centre of Fig. 1:

- same time - same place; a number of people meet to share information and knowledge in the same environment
- different time - same place; information is saved for later used by others, for example on a whiteboard (digital or analogue)
- same time - different place; the meeting is performed for example via telephone, live video, or remote guidance
- different time - different place; electronically stored information, such as information stored in a computer system that can be accessed by others on the other platforms, e.g. phones, tablets, and computers

These four different situations represent various contexts where a company may communicate.

2.3 The MEET Model in this Use Case

Although the development of meetings and information sharing may consider all of the ten areas of the MEET model, this case study focuses on the Information System areas of Technology, Logic, and Information in particular.

3. THE CASE COMPANY

The case company, LaRay AB, provides surface finishing for their customers with different types of coating methods; wet painting and powder coating. The case company is considered to be a small Swedish production company, with circa 20 employees and a flat hierarchy. Previous studies at case company have explored meetings at-large and visualization in general (Asklund et al., 2016, Li et al., 2016). In this case study, the scope is to study digital visualization of one of the meetings.

At the start of this study, there was one face-to-face meeting that concerned daily production planning between shop-floor operators and production supervisor; an information meeting at 14:00 (2 p.m.). Due to the different starting times of morning shifts, informal meetings between individual operators and supervisor existed, mainly concerning work task allocation. Therefore, a whiteboard for work allocation (Fig. 2) was used to convey simple information and reduce the amount of these face-to-face meetings. Using the whiteboard, the supervisor assigned each available operator (left column) work tasks from a high priority 1 to a low priority 3 (three right columns). When an operator finished the high priority work task, the operator moved on to the next work task in order.

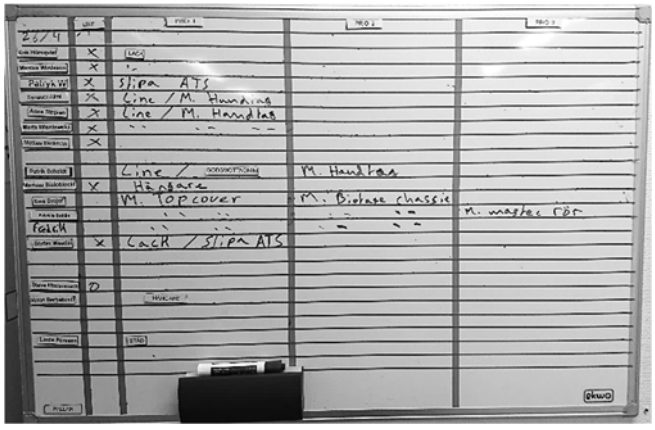

Fig. 2. Whiteboard for work task allocation, with a list of operators (left column), and a work task priority for each of the operators (three right columns).

However, despite the whiteboard's purpose of reducing time and effort spent on conveying information about work task allocation, the informal meetings continued. Purposed reasons for this phenomenon arose from the difficulty of understanding the written information due to illegible writing, accidentally erased information and non-standardized shorthand instructions.

4. METHODS

This case study was centred around the implementation of a digital whiteboard and it refrained from influence the work method and process.

Before the implementation of a digital whiteboard, a workshop was held together with operators. In conjunction with this workshop, the operators and the management filled out the MEET self-assessment questionnaire individually. The status quo was measured on a daily basis for seven days using opinion terminals, and the new state was measured for nine days by using the same opinion terminals. At the end, the same self-assessment questionnaire was filled out. The general

outline of the applied methods is chronologically visualized in Fig. 3.

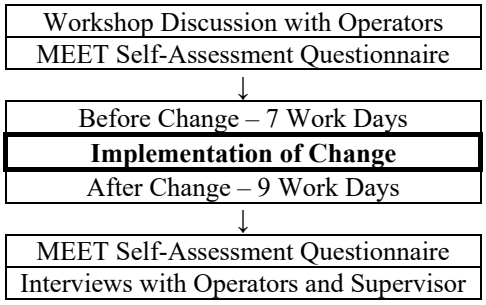

Fig. 3. Chronologic visualization of applied methods.

4.1 The Implemented Change: Digital Whiteboard

The whiteboard from Fig. 2 that became disused was replaced by a digital whiteboard. The digital whiteboard was a mobile interactive display connected to a computer with internet access and logged on to the case company's Content Management System server.

The spreadsheet used for work task allocation on the digital whiteboard was designed to mimic the previous whiteboard since it was not desirable to explicitly change the work method. The change itself is impacting the Information System areas of Technology, Logic, and Information the most. A screenshot of the spreadsheet, as used at the end of the case study is captured in Fig. 4.

Fig. 4. Screenshot of the spreadsheet on the digital whiteboard for work task allocation.

The change was first introduced to the CEO and the supervisor, spanning these topics:

- status of the current situation
- reasons for the digital whiteboard as an improvement
- functionalities and how to use the digital whiteboard
- plans for the near future and the case study

In turn, the supervisor introduced the functionalities of the change to the operators and explained their intended use.

4.2 Workshop Discussion with Operators

Introductory workshops were organized for, and attended by, all operators. During the workshop, the participants were given information about this study, including:

- time and place flexibility of meetings, and examples of such meetings
- group discussion on the questionnaire results and ideas for change
- information about the purpose and execution of this case study

In addition to being aware of the study, the outcome of the workshop affected the design of the digital whiteboard (Fig. 4). The operators volunteered suggestions on what type of information was desired for the meeting. These answers were recorded and contributed to the formation of the implemented change. It included some novelties, such as a comments field, time stamp, and list of abbreviations of commonly written work tasks.

4.3 MEET Self-Assessment Questionnaire

The MEET self-assessment questionnaire helps assess a specific meeting. The result from the questionnaire shows the improvement potential for each of the ten areas in the MEET model – either low, intermediate or high level of potential improvement (Li et al., 2016):

- high level of improvement potential; short-term focus for development of meetings and communication should be prioritized to these areas
- intermediate level of improvement potential; when prioritizing focus these areas are less urgent, but still important
- low level of improvement potential; areas are under control to a larger extent than previous areas

The questionnaire consists of ten questions with multiple choices, and these questions are mapped to the ten different areas of the Organization System and Information System of the MEET model. The questions of the questionnaire and the mapping to the various areas are appended in Appendix A.

Previous studies at the case company have indicated that this questionnaire can give a general picture of the state of the meetings (Li et al., 2016).

In this study, the questionnaires were filled out before the change, in conjunction with the workshop, and also after the change, in conjunction with the interviews. Then, the results were compared.

4.4 Opinion Terminals

The daily measurements were conducted via opinion terminals, where the operators entered the response. This measurement system was anonymous and aimed to reflect the operators' subjective perception of the situation. The operators were asked two questions:

Q1: Do you have enough information to do your job today?

Q2: How do you perceive your work today?

The operators answered the questions by pressing one out of four selections for the two questions: very dissatisfied,

dissatisfied, satisfied, or very satisfied. The operators were instructed to enter their response once a day for the terminals respectively.

4.5 Semi-Structured Interviews

During the week after the conclusion of opinion terminals measurements, semi-structured interviews were held. The interviewees were grouped to three operators in each interview. The interviewees were asked questions about the implemented changes with regards to their impression of the information quality attributes and not the overall perceived quality in general (Kehoe et al., 1992):

- relevance
- timeliness
- accuracy
- availability
- comprehensiveness
- format

Out of the six attributes of information quality, the availability attribute was not used as an interview topic because availability as an attribute in this case study was not affected to a significant extent.

Besides the interviews with the operators, an interview was also conducted with the supervisor with topics covering the same information quality attributes as the group interviews with the operators, but from a supervisor perspective.

5. RESULTS

Three types of results were obtained from this study:

- results from MEET self-assessment questionnaires, both before and after the change (section 5.1)
- results from opinion terminals, two questions, both before and after the change (sections 5.2 and 5.3)
- results from interviews, after the change, with both operators and supervisor (sections 5.4 and 5.5)

5.1 MEET Self-Assessment Questionnaires

The questionnaire was completed by operators before the change (i.e. the workshop participants) and 15 responses were recorded. After the change, the questionnaire was filled out once again by the operators (i.e. the interviewees) and 6 responses were recorded.

The aggregated results of the questionnaires, with the number of respondents and improvement potential for each area, are displayed in Fig. 5 and Fig. 6. Both Fig. 5 and Fig. 6 show the outcomes at the start of the study (top panel, in both figures) and at the end of the study (bottom panel, in both figures), for the three levels of improvement potential; low (white), intermediate (grey), and high (black), for the five areas of the Organization System (Fig 5.) and the Information System (Fig. 6), respectively.

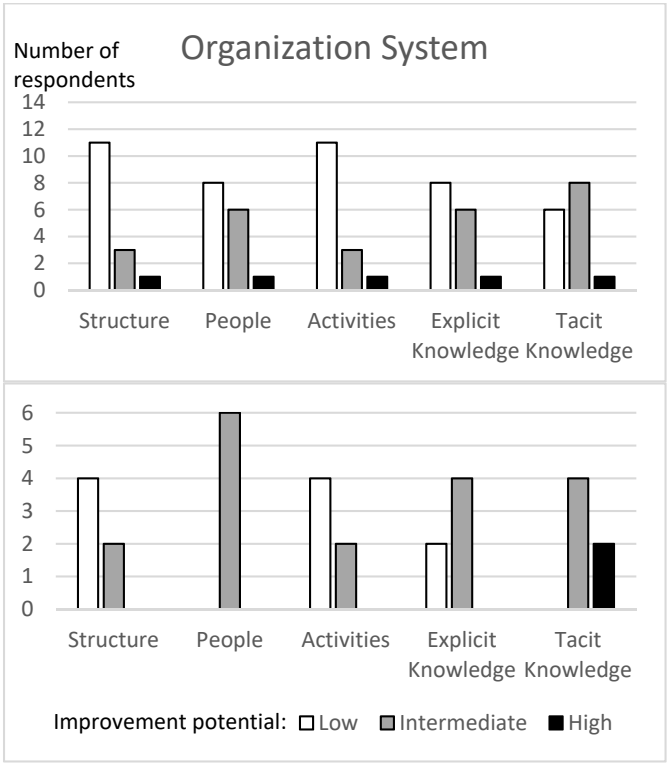

Fig. 5. Aggregation of the questionnaires result at the start of the study (top panel) and at the end of the study (bottom panel) for the five areas (x-axis) of the Organization System and the number of respondents (y-axis).

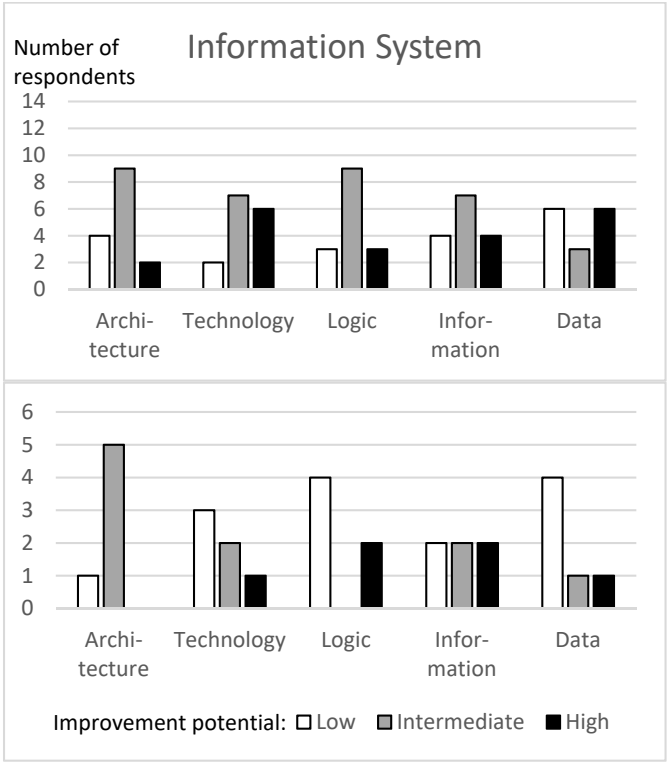

Fig. 6. Aggregation of the questionnaire results at the start of the study (top panel) and at the end of the study (bottom panel) for the five areas (x-axis) of the Information System and the number of respondents (y-axis).

Overall, at the start of this study (top panels of Fig. 5 and Fig. 6), there seemed to be more improvement potential among the areas of Information System than the Organization System, where Technology (Fig. 6, top panel) was the area with the most improvement potential (more black and grey, less white). The Data area (Fig. 6, top panel) was the most polarizing area, where the participants' views differed the most (more white and black, less grey).

Examining the changes for each area at the end of the study for the Organization System, the areas of People, Explicit Knowledge, and Tacit Knowledge have increased their improvement potential (Fig. 5, comparing bottom panel with top panel). For the Information System, improvement potentials in the areas of Technology and Logic have decreased, as intended (Fig. 6, comparing bottom panel with top panel). The decreased improvement potential for Information System and increased improvement potential for Organization System mean that since the introduction of the digital whiteboard, the need for better technology and logic has been satisfied to some extent, but the need for better organizational structure to support the use of the digital whiteboard as increased.

5.2 Opinion Terminal: Question 1

The poll question at the first opinion terminal was: "Do you have enough information to do your job today?". The daily variations from terminal 1 can be viewed in Fig. 7.

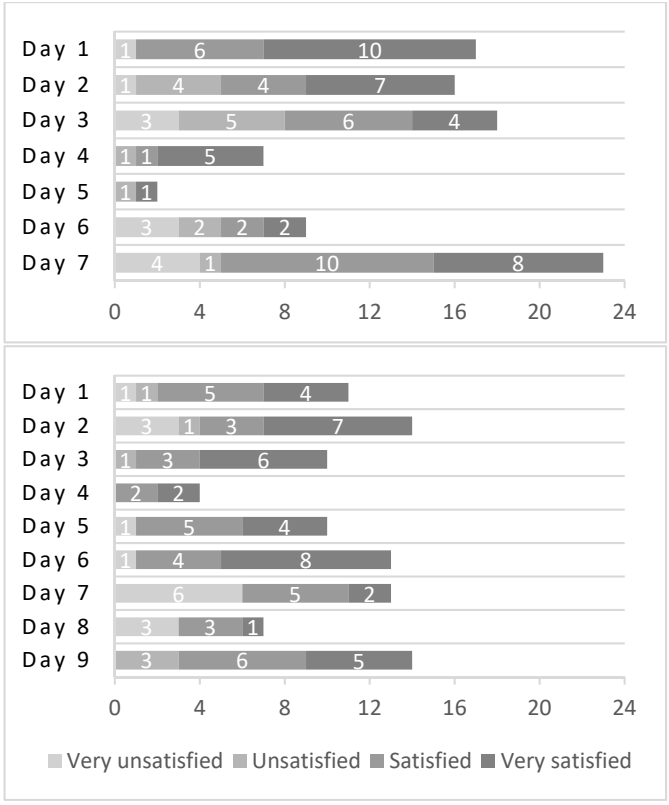

Fig. 7. Results from terminal 1 before (7 days, top panel) and after (9 days, bottom panel) the implementation of change, with the bars (divided into four segments) representing the number of votes (x-axis).

Aggregating the 7 days before the implementation of the digital whiteboard (Fig. 7, top panel), 40% of the operators' answers were very satisfied, 32% were satisfied, 15% were dissatisfied, and 13% were very dissatisfied, totalling 72% positive responses and 28% negative responses, over 92 responses.

Aggregating the 9 days after the change (Fig. 7, bottom panel), 41% of the operators' answers were very satisfied, 38% were satisfied, 6% were dissatisfied and 16% were very dissatisfied, totalling 78% positive responses and 22% negative responses, over 96 responses.

Thus, generally, comparing before and after the change, a slight improvement was observed, from 72% to 78% positive responses, concerning operators' perception of themselves receiving enough information to perform their work.

5.3 Opinion Terminal: Question 2

The poll question at the second opinion terminal was: "How do you experience your workday today?". The daily variations from terminal 2 can be viewed in Fig. 8.

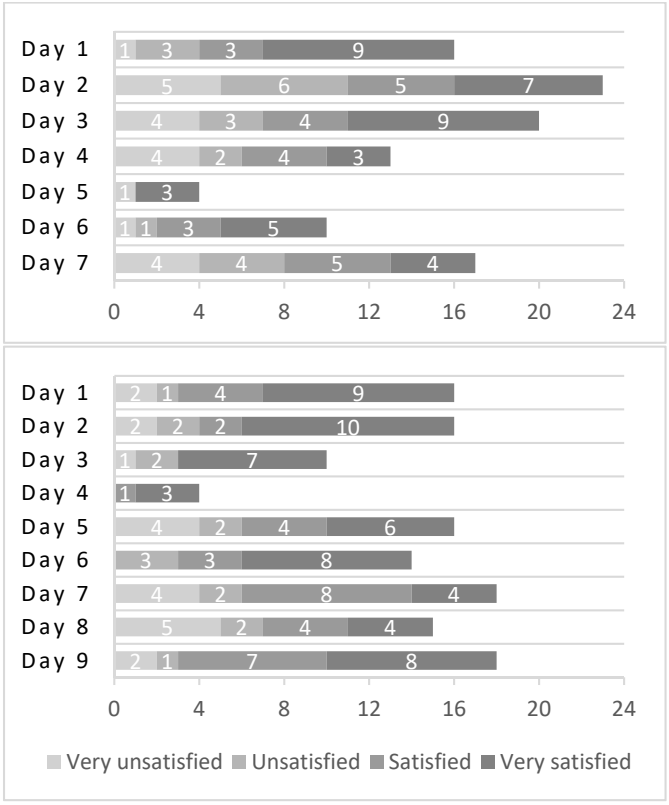

Fig. 8: Results from terminal 2 before (7 days, top panel) and after (9 days, bottom panel) the implementation of change, with the bars (divided into four segments) representing the number of votes (x-axis).

Aggregating the 7 days before the implementation of the digital whiteboard (Fig. 8, top panel), 39% of the operators' answers were very satisfied, 23% were satisfied, 18% were dissatisfied, and 19% were very dissatisfied, totalling 63% positive responses and 37% negative responses, over 103 responses.

Aggregating the 9 days after the change (Fig. 8, bottom panel), 46% of the operators' answers were very satisfied, 26% were satisfied, 12% were dissatisfied and 16% were very dissatisfied, totalling 72% positive responses and 28% negative responses, over 127 responses.

Generally, comparing before and after the change, an improvement was observed, from 63% to 72% positive responses, concerning operators' feeling of work satisfaction.

5.4 Interviews with Operators

The semi-structured group interviews on the operators' impressions of the change were based on the different attributes of information quality and the results are summarized with regards to the five applicable attributes.

Relevance: The information on the digital whiteboard was perceived as relevant for distributing work tasks. Several operators thought that it helped them start-up faster. However, most of the interviewees would have liked even more work-task related information.

Timeliness: Operators perceive that the digital whiteboard has a better update rate than the previous whiteboard. However, some technical issues impair the impression, e.g. sometimes it is not automatically updated via the Content Management System. If there is an urgent change, the supervisor gives the information directly to operators, leaving the information on the digital whiteboard inaccurate.

Accuracy: The operators agreed that the information has become more accurate than before, but the perception of how much more accurate it is differing. Sometimes it is difficult to know from whom the information originates, which may impair the accuracy.

Comprehensiveness: Sometimes more information is desired but at the cost of clarity. For some operators, information on the digital whiteboard is enough. However, for others, it is not enough to get started on working with specific work tasks.

Format: Operators were still a bit unfamiliar with the digital whiteboard, but experience a general improvement. The comment fields were not used, because of a technical error, but some operators expressed that they also did not have the familiarity or courage to use it anyways in this short time it has been available.

In general, the operators expressed an increase of information quality and a positive experience of the digital whiteboard, which was in accordance with the opinion terminal results. However, more information is desired and more time may be required for this new method to work well.

5.5 Interview with Supervisor

In general, the implemented change was considered as positive by the supervisor because of a reduced self-perceived workload since operators became more independent. From an information quality perspective, the supervisor received similar questions as the operators.

Relevance: The supervisor thinks that the type of information is relevant for the operators. However, continuous dialogue with operators may change the content if the perception of relevancy changes.

Timeliness: The information is mostly updated on an as-needed basis. The supervisor arrives before the shift starts and updates the information.

Accuracy: The supervisor thinks that the information has become more accurate than previously. However, when information is changed on a short notice, written information is combined with the supervisor instructing the operator directly on the shop-floor.

Comprehensiveness: The digital whiteboard presents what, when, and by whom the work tasks should be performed, but not how. However, the supervisor observed that operators have increased their use of the Enterprise Resource Planning system that holds more information concerning how work tasks should be performed since operators already came near the digital whiteboard-adjacent computer.

Format: The digital whiteboard was considered easy-to-use by the supervisor.

6. DISCUSSION

This research was carried to explore if this kind of ICT, a digital whiteboard, can support operators. With respect to the responses from the opinion terminal polls, the overall implication for the case company is that the work situation is better after the implementation of the digital whiteboard. The interviewed operators at the case company conveyed improved satisfaction over daily information exchange and overall work situation.

In general, the operators expressed positive impressions about the implemented change thanks to an increase in information sharing. However, the perceived impressions of the operators varied depending on the required amount of information to perform the work tasks. Operators with more complex information-intensive work tasks wanted more information, while operators with less complex repetitive work tasks expressed indifference. Overall, the increased sharing of information seems to have a positive social aspect and makes the operators feel more appreciated by management.

The results from the self-assessment questionnaires show that the improvements of Technology and Logic seem to have come at the cost of some of the Organization System areas. An explanation may be that the Organization System is not stable, and changes to the Information System may have caused alterations in the Organization System. However, the number of respondents to the second round of self-assessment questionnaires was smaller, and therefore the questionnaires were complemented with qualitative semi-structured interviews. These interviews confirmed that while the information quality is perceived to have been increased, more improvement efforts are needed.

Technology-wise, even though the use of the digital whiteboard has been perceived as positive both in the questionnaires and the interviews, it may not be necessary to use a digital whiteboard. While the previous whiteboard had the possibility to be used as a two-way communication tool, it was used for one-way communication. Similarly, the digital

whiteboard enables two-way communication but was used for one-way communication from the supervisor to the operators. Based on this use of the digital whiteboard, a monitor for one-way communication, providing the same information, is enough – and more cost efficient.

In addition, a while after the end of the study, the case company introduced monitors, as in Fig. 9, to convey the information previously displayed on the whiteboard and tested on the digital whiteboard. This aftermath lends support to the notion that the Organization System and the Information System are closely interlinked, where the work methods should be supported by ICT and not the other way around.

Fig. 9. A later introduced monitor for conveying information about work task allocation, with a similar design as the previous digital whiteboard as of Fig. 4.

7. CONCLUSIONS

Overall, this study suggests that there are some implications for both the activities of the case company and considerations for future research.

For the case company, a mapping of required information content for performing specific work tasks should be conducted. After such mapping, the digital whiteboard, or other support tools, can be designed or customized to better accommodate different operators' cognitive needs. Furthermore, as an Organization System effort, education of impacted operators in their role and use of newly introduced support tools could lead to improved perception of their work situation.

Using ICT to transfer information is preferable as it adds clarity to the communication in comparison to non-digital alternatives. However, an organization's technology and work methods should be harmonized with each other in order to maximize the added clarity. In a broader sense, in order to support sharing of information, the development of Information Systems should take the development of Organization Systems and its implications into consideration, and vice versa. Future research needs to consider this co-dependency carefully.

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Appendix A. THE MEET QUESTIONNAIRE

The questions from the MEET self-assessment questionnaire, with subsequent selectable answers, are:

Q1: Is there an expressed standard for the meeting?
- Yes, clearly expressed
- Yes, in development
- Yes, but no one knows about it
- No

Q2: Are appropriate competencies attending the meeting?
- Yes, always
- Yes, mostly
- To a certain extent
- Rarely

Q3: How often do the participants use their opportunity to speak during the meeting?
- Almost always
- Often
- It could be more often
- Rarely

Q4: Is it only the experts that are speaking during the meeting?
- Yes, and no one is questioning
- Yes, to a certain extent
- Yes, but everyone is an expert
- No, we have a good dialogue

Q5: Are there good technological support tools for presenting previous decision, processes and/or events during the meeting?
- Yes, and they are working properly
- Yes, but we are rarely using them
- We can do more
- Technological what now?

Q6: Are there good technological support tools for documenting information about previous decisions, processes, and/or events during the meeting?
- Yes, and they are working properly
- Yes, but we are rarely using them
- We can do more
- Technological what now?

Q7: Is it clear how information from the meeting should be saved?
- Yes
- No

Q8: Is it easy to find information relating to the meeting from other activities?
- Yes, never any problems
- Yes, I often ask an expert
- So-so, our information system is complicated
- No

Q9: Is it clear how information from the meeting is relevant to the daily work?
- Yes, it is clear
- Yes, but sometimes repetition is necessary
- No, it has to be repeated frequently
- No, the information seems to not be reaching

Q10: Are the used technological support tools at the meeting compatible toward the organization's overall information system?
- Yes, everything is integrated
- Yes, but further integration is possible
- To a certain extent
- No, nothing is integrated

The questions-to-results relationships are clarified in Table 1. Each question affects two or three OS or IS areas and vice versa.

Table 1. Questions-to-results relationship of the MEET self-assessment questionnaire, indicated by x.

	Questions									
Organization System	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Structure	x								x	
People		x		x						
Activities	x								x	
Explicit Knowledge		x	x							
Tacit Knowledge				x				x		
Information System	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Architecture							x	x		x
Technology					x	x				x
Logic					x				x	
Information			x			x				
Data						x	x			