

# BEACON: A CSCW Tool for Enhancing Co-Located Meetings Through Temporal and Activity Awareness

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**Abstract**—This paper explores how enhancement of temporal awareness and activity awareness affects co-located meetings’ effectiveness and efficiency. Our focus is meetings happening as part of a project where cooperation is essential for its fulfillment. As a case study, we investigated group work in university projects. In a preliminary study, we found that individuals deviate from topics due to the lack of structure, which results in time wasted on irrelevant discussions. Agendas are essential in order to conduct a productive meeting. In order to investigate this issue, a prototype, “BEACON”, was developed with two components. The first component is a desktop dashboard revolving around creating and managing meeting agendas, as well as having an integrated co-writing noting tool that contributes to temporal awareness. The second component is a status-based artifact that uses color and sound as notifications of defined time limits for different activities in the meeting agenda and contributes to activity awareness. An evaluation with a group of 6 persons was conducted. The findings showed that enhancing temporal and activity awareness through displayed shared notes and a clearly presented agenda during the meeting contributed to generate more ideas and keep the discussions focused. Participants expressed that the artifact’s colors dictated the pace of the meeting positively, influencing them to optimize the available time and reach conclusions. Thus, we conclude that the enhancement of temporal and activity awareness in a workspace-like meeting setting can increase meeting effectiveness and be an incentive of better cooperation within a project.

**Keywords**—awareness meetings; CSCW; temporal awareness; activity awareness; design study.

## I. INTRODUCTION

Organizations nowadays work quite often with project groups, where a set of people come together from different departments to achieve a specific goal. Examples could be the launch of a new product, producing a common report, writing a common document, etc. In these cases, people need to cooperate in order to achieve the final goal. An important part of this cooperation are group meetings. These are used as touchpoints where important things are discussed, and decisions that will push the project forward are made. Meetings are an integral part of the everyday working life of employees who attend approximately 3.2 meetings per week. However, the quality of these meetings is evaluated as poor in 41.9% of the cases [1].

People feel that meetings are not as productive as they would like [2]. They lose track of the context of the topics discussed, resulting in poor decision making [3]. Furthermore, it appeared that agendas have an essential role in structuring group meetings [4]-[7]. Thus, new ways to enhance meeting efficiency and effectiveness are needed as a way of contributing to the cooperation.

Context-Based Workplace awareness [8] was defined as establishing an awareness of the workplace and the activities occurring within it, regardless of distance in space and time. This type of awareness has been studied in situations where

people are distributed and ways to remain aware of others’ activities in the workplace are needed. In this paper, we explore context-based workplace awareness, specifically, its subtypes of temporal awareness and activity awareness in the context of meetings and study how meeting efficiency and effectiveness can be influenced by the enhancement of these types of awareness.

Through an interaction design process, we developed a prototype that we call BEACON. It consists of a desktop dashboard that supports creating and managing meeting agendas, as well as having an integrated co-writing noting tool that contributes to temporal awareness. The second component is a status-based artifact that uses color and sound as notifications of defined time limits for different activities in the meeting agenda.

BEACON was further used to investigate how technology that enhances context-based temporal and activity awareness can affect meeting effectiveness and efficiency?

In Section 2 of this article, we present the conceptual grounding for our work. In Section 3, we present a short description of the design process of the prototype and its evaluation. In Section 4, we present the findings of the evaluation. In Section 5, we discuss our findings in relation to temporal and activity awareness. Finally, in Section 6, we conclude the study and outline possible directions for future work.

## II. CONCEPTUAL GROUNDING

Computer Supported Cooperative Work (CSCW), as defined by [9], is “the field which aims to understand the nature and characteristics of cooperative work with the objective of designing adequate computer-based technologies”. This type of technology has previously been referred to as groupware [10], where the focus was on the group of people working together. However, Schmidt and Bannon [9] argue that the focus should not be only on groups but on cooperative ensembles which can be people or organizations that come together to work on a common goal. These are usually dissolved after the goal has been achieved. Project work fits this description of cooperative work.

Moreover, Schmidt and Bannon argue that cooperative work requires ensembles to be distributed in time and space. This is the case with project work where members work on their own. However, their common encounters in meetings are relevant, which is why we in this paper study meetings as a cooperative work activity in need of technological support.

### A. Meeting Effectiveness and Efficiency

We live in a world where it is common that workers in service-oriented organizations spend a considerable part of their time in meetings. However, meetings are not as productive as participants would like, and participants often engage in discussions that deviate from the meeting focus. Garcia et al. [4] imply that despite the importance of meetings,

participants often feel that time is wasted because meeting goals could not be reached (low effectiveness), or because the meeting lasted significantly longer than planned (low efficiency). Symptoms of a bad meeting are stated as low group participation, bad decision-making processes, free riders and lack of group attention.

A study by Nixon and Littlepage [11] examined the relationship between certain group meeting procedures and their correlation with the studied subjects' perceived effectiveness of the meetings. The meeting effectiveness was measured by goal attainment and decision satisfaction. The results suggested that among other things; open communication, focus on tasks, exploration of options, analysis of decision consequences, temporal integrity, and agenda integrity might be important effectiveness-related processes. More detailed aspects contained in these processes include (in no particular order); that all members participate in the meeting, that options are discussed before final decisions are made, as well as the consequences of these options, that the agendas are followed during the meeting and that the goals are clear and well defined, being focused and committed to the meeting in terms of time and effort, being prepared for the meeting and having access to the relevant meeting information like, e.g., the agenda, that the meetings are more satisfying than frustrating, that notes are taken of the decisions made during the meeting, and that the meeting start and end on time.

In a study by Davison [2], a method for measuring meeting success was proposed. The factors of this method were quite similar to the procedures explored in Nixon and Littlepage's [11] study, with emphasis on, e.g., communication, discussion-quality and how result-oriented and time-efficient the meeting was. Thus, looking for how many of these meeting procedures are present in group meetings might also give an indication of how effective and/or efficient they are.

### B. Context-Based Workplace Awareness

A largely discussed concept in CSCW is the concept of awareness [10][12]-[14]. Awareness within CSCW was initially discussed by Heath and Luff in their seminal paper, "Collaboration and control: Crisis management and multimedia technology in London Underground" [15]. A relevant definition of awareness comes from Dourish and Bellotti [16]. They described it as "an understanding of the activities of others, which provides a context for your own activity", and outlined the importance of awareness information in coordinating group activities. This definition of awareness has in the CSCW community been referred to as "social awareness".

Bardram and Hansen [8] discussed in their work another type of awareness which they called context-based workplace awareness. They defined context-based workplace awareness as establishing an awareness of the workplace and the activities occurring within it, regardless of distance in space and time. Thus, focusing not only on what others in your immediate surroundings are doing but also having an awareness of the activities that happen in a specific workplace by focusing on the spatial, temporal and activity-related dimensions.

The part "context-based" of the term was used by Bardram and Hansen [8] to define that the awareness they are discussing is often based on context. Their definition of *context* was derived from Dey et al. [17] who defined it as "information that characterizes a situation related to the interaction between users, applications, and the surrounding environment". Dey

et al. [17] also outlined in their paper several categories of context. Of these, status (also referred to as activity) is the most relevant to our study. Status encompasses characteristics of the relevant entity of focus that can be sensed. The entity can here refer to anything from an individual or group of people, to software components or applications. In a separate study, Borges et al. [18] proposed a conceptual framework for analyzing the context in the form of presented information in groupware applications. Of the outlined information types that encompass the context were *scheduled tasks*, defined as identifying tasks through representing their characteristics, and *completed tasks*, defined as providing an understanding of previously completed tasks and their contexts.

Bardram and Hansen [8] argued that context-based workplace awareness is central when attempting to establish coordination in workplaces. Based on the works of Nixon and Littlepage [11] and Davison [2], it is quite apparent that many of the outlined factors that indicate meeting effectiveness and efficiency are related to coordinating the meeting participants around different aspects of the meeting. Thus, coordination is an important factor when discussing meeting effectiveness and efficiency. In this study, we explore how enhancing certain aspects of context-based workplace awareness might be relevant when attempting to improve meetings' effectiveness and efficiency.

As methods of how context can be utilized in applications, Dey et al. [17] proposed the concept of context-aware functions in the form of three categories. The first category, *presenting information and services*, contains two functions, the first is displaying context information to the user and the second is proposing a set of relevant actions to the user based on the current context. The second category, *automatically executing a service*, is described as applications that will perform certain commands or reconfiguring the system for the users triggered by context changes in the system. The third and last category, *attaching context for later retrieval*, is defined as applications that tags relevant context information data, in which the users can later retrieve. These three proposed functions are thus useful when designing a technological solution that aims to enhance context-based workplace awareness.

While the aim of the study was to look into how meeting effectiveness and efficiency was influenced when enhancing workplace awareness, we should as well state that as meetings happen in co-located places (different from the study setting Bardram and Hansen [8]), the influence of context-based workplace awareness has not been studied before in a meeting "context". Thus, this paper also contributes as an example of discussing context-based workplace awareness in settings where participants are indeed seated together, but cooperation can still be enhanced through context-based elements.

Bardram and Hansen [8] described several types of awareness as part of context-based workplace awareness. Of these, we thoroughly present temporal awareness and activity awareness below, as well as their relation to the contexts of status, scheduled tasks, and completed tasks.

### C. Temporal Awareness

Temporal awareness is defined as an awareness of the progress of activities over time in terms of past, present, and future and outlines the importance of schedules for coordination, as well as being aware of events in the past, which often can be important when making decisions in the present or

planning the future [8]. This is very relevant to group meetings as they often have a limited timeframe. Planning and managing the tasks/activities according to the available time is, therefore, important in order to avoid problems, such as those highlighted by Garcia et al. [4] and achieve the meeting's objective(s).

As stated above, our context is a "meeting" where people come together to discuss issues that relate to a cooperative project. In order to increase the temporal awareness in meetings, we investigate the concept of agendas. According to the Cambridge dictionary [19], an agenda is described as "a list of matters to be discussed at a meeting". In other words; An agenda can implicitly be used as a method of describing the activities and establishing the structure of a meeting. Multiple studies have concluded that the use of agendas is essential for improving the effectiveness and efficiency of group meetings [4][5][7][20]. Furthermore, a study [21] in the area of Group Support Systems (GSS) discussed that meeting structure has a positive influence on information sharing between group members in decision-making situations, and highlighted how group members need cues and indicators, e.g., boldfaced text to be able to share initially unshared information. Using the context of scheduled and completed tasks, presenting such agendas by describing upcoming and completed activities during the meeting can be used as a method for increasing temporal awareness.

Yamane [22] conducted a study in the context of his lectures where students were given "course preparation assignments" aiming to prepare them prior to the lectures in order to establish thoughts and opinions on the course matter. This was an attempt to increase the effectiveness of the discussion in the lecture, which was documented to be very successful. Thus, presenting meeting information in a way that allows group members to prepare thoughts and opinions about the discussion topics before the meeting, might be a good method of promoting discussions.

#### D. Activity Awareness

Activity awareness is defined as an awareness of specific activities and their surrounding context, irrespective of who is performing them [8]. As group meetings naturally contain several different activities, e.g., in the form of tasks, this type of awareness becomes quite relevant. In our study, to simplify the types of activities in a group meeting, we group them to three levels of abstraction; high, medium, and low. We define high-level as the activity of conducting the meeting as a whole, medium as activities related to the meeting's overarching goal (e.g., topic discussions), and low-level as any activity contained within a medium-level activity, such as communication and discussion within a specific topic.

In a study by Haller et al. [23], a digitally enhanced meeting room was developed to promote group creativity by combining digital and paper media through pen-based interfaces. The results indicated that having digital tools simulating pen and paper helped improve group collaboration. Integrating a note system where group members can make notes and share with the rest of the group, might, therefore, have a positive effect on how the members collaborate as well as increase the awareness of low-level activities.

In a study by Janicik and Bartel [24], it was discussed how temporal planning affects coordination and task performance in groups and found that temporal planning had a positive relationship with task performance. In another study [25], different

design strategies for supporting collaborative activities were proposed. Among these, deadlines were suggested as a method of enhancing activity awareness and prompting coordination by presenting progress, specifically as a status reminder. Another study [26] that revolved around patterns in group interaction when regarding time limits and task types on the quality and quantity of the group performance, suggested that sessions with short time limits generate ideas at a higher rate despite a reduction on the quality of such content produced. Based on these studies, having a method of planning the meeting's activities in terms of time and presenting the time limits as a status reminder during the meeting might make a positive impact on the meeting's effectiveness.

### III. METHODS

As mentioned in the introduction, we chose student projects as a case study. The study was conducted in a university college in Norway.

We took a design process approach for our research [27] and went through the four phases of *Informing*, *Visioning*, *Prototyping*, and *Evaluating*. Initially, we conducted research for design to design the prototype and then we conducted research through design by using the prototype to answer our research question. In the first part, we collected data that showed the need for a digital tool that could support meeting efficiency. We then designed and developed a prototype based on these needs and conducted a thorough investigation into relevant literature as a means for answering the research question through an evaluation. Hence, we shortly present our design journey and explain in detail the evaluation process and its respective findings.

#### A. Informing and Visioning

In order to understand the students' needs in a meeting situation, an observation of a group meeting was conducted early on. Additionally, the informing-phase included individual interviews with two students and one expert. Collected data were analyzed with a qualitative interpretive approach [5] from a CSCW perspective, where we tried to identify the groups' needs in relation to the cooperation among participants and the overall meeting efficiency.

Findings showed that there was a lack of a consistent flow in the activities discussed despite having a good leader that stimulated the discussion. Decisions were made by just a few of the participants without being documented. However, when they utilized a collaborative writing platform on the common display (google docs), the participants seemed to be more active in discussing and expressing ideas based on what the activity required. The fact that the group's discussions were lacking in structure seemed to reduce the quality of the meeting, but the use of a common medium for information sharing and collective decision-making notes seemed to improve it.

The findings presented above were, through an initial literature investigation, associated with "awareness" as a major concept in CSCW. Further investigation in the CSCW literature regarding awareness brought us in the context-based workplace awareness and the respective sub-types such as temporal and activity awareness as closely related to the needs for increasing meeting efficiency that was our initial aim. Thus, our aim became designing a digital solution that supports context-based workplace awareness and investigates how that would influence meeting effectiveness and efficiency.

Based on our findings in the informing phase both from the empirical data and the look at the literature, we took the role of designers and had a brainstorming session, and a design workshop [27] where various design concepts for possible prototypes were discussed. Through different sketches and use of different materials, we explored how the solution would look and what kind of features would promote temporal and activity awareness. Based on the final sketches we built a prototype that we named “BEACON”. The name was inspired by the concept of a beacon, a light set up in a high or prominent position as a warning, signal, or celebration [28].

**B. Prototype**

The prototype Beacon consists of two components, a desktop Dashboard and an Artifact. Figure 1 illustrates the prototype in a meeting setting.



Figure 1. Stylised illustration of how the prototype is intended to be used.

1) *Desktop Dashboard*: This component utilizes the first context-aware function, *presenting information and services*, as described by Day et al. [17]. It presents to users medium-level meeting activities in the form of an agenda, as well as their descriptions and time durations. It also utilizes the third context-aware function, *attaching context information for later retrieval*, through an interactive co-writing noting tool for each activity that allows the participants to later retrieve previously recorded low-level activities. Adobe XD was used to create the dashboard with four base pages:

- **Home screen**: Shows recent projects, current group members, and meetings that have been conducted. Users can create a new meeting agenda from here.
- **Agenda creation**: Includes a form section for the creation of agendas, such as agenda title, description, date, as well as the agenda’s activities that each has a title, description, and priority (1 - 5). The higher the priority, the more time will be allocated to the activity.
- **In-session screen**: Shows which activity is active, in addition to the noting functionality. This is shown in Figure 2.
- **Meeting review screen**: Gives the users the ability to review the activities they have discussed in a structured manner, with the option to edit the notes of each one.

2) *Status-based Artifact*: This component is a 3D printed artifact (shown in Figure 3) designed to present the status of defined time limits of high- and medium-level activities in the meeting. The artifact has a built-in speaker and two

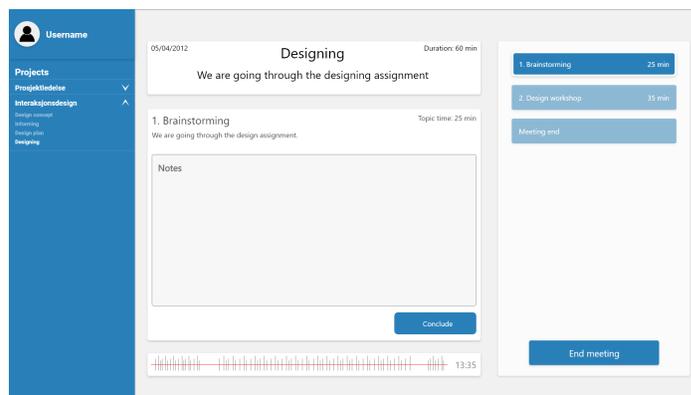


Figure 2. Screenshot of the desktop dashboard in the “in-session” phase.

light sources that each can display different colors. The top light source represents the time left of meetings’ high-level activities (the meeting as a whole), and the bottom light source represents the time left of medium-level activities (e.g., topic discussions). The speaker is used to audibly notify the participants when different time limits have been reached. Figure 3 illustrates the artifact component of the prototype. The defined colors of the light sources indicate the following:

- **Green**: More than half of the activity’s allocated time remains.
- **Yellow**: Half of the activity’s allocated time remains.
- **Red**: Only about 10% of the activity’s allocated time remains.
- **Blue**: The activity’s allocated time has been used up and any further time spent on this activity is considered *overtime*. The speaker sounds a notification when this phase is reached.

The choice of colors is inspired by a study on the relationship between color and emotion [29]. The transition between colors occurs instantly. When high and medium-level activities are concluded the relevant light source resets to green. This is especially relevant for medium-level activities.



Figure 3. The artifact component of the prototype.

The second context-aware function, *automatically executing a service* [17], is the core concept of this component. The component will dynamically change its colors based on context changes, such as the time duration of the activity. These changes are both triggered by time events and user input. E.g., the allocated time of remaining medium-level activities can increase if the current activity is concluded before the time

is up, or the allocated times can be reduced if and the more the current activity is spent in overtime. These increases of reductions in allocated times are calculated based on defined activity priorities and the remaining time of the high-level activity.

### C. Evaluation

We will refer to this subsection as “Evaluation” to adhere to the interaction design process phases. However, the evaluation in this paper relates to the testing of our prototype, collecting data about the testing and further analyzing it. The evaluation phase helped us explore the research question raised in this paper.

Due to limitations in time and resources, we conducted the evaluation with a small group of people as a pilot study. The evaluation was conducted in the form of a usability test in a controlled setting involving users [27]. We investigated how users utilize, interact with, and feel about the prototype, and how the presence of the prototype impacted the efficiency and effectiveness of the meeting.

We observed a group of 6 students having a meeting in a university group room. The observation was followed with a structured interview in which each participant in the meeting was asked about his/her experience of using the tool in the meeting.

The process of the evaluation started with the researchers explaining how the evaluation would be completed, with an explanation on how the artifact and desktop dashboard operates. They were informed that the researchers would manually control the artifact’s colors and sound notifications (Wizard of Oz approach [27]) based on their time used during the meeting and that they should try to pay attention to these types of changes. Since Adobe XD could not support writing directly in text boxes in the prototype tab, we utilized a google docs document mimicking the desktop dashboard. They were however told to use the desktop dashboard when they needed to read the activity titles and descriptions, and when concluding medium-level activities.

*Task enactment:* The subjects were beforehand given four activities in the form of discussion topics, with additional instructions for how to interact with the prototype. As described in Subsection C, the desktop dashboard can be used to assign priorities to the activities, which the group leader was told to do before the meeting.

*Observing users’ reaction:* During the task enactment, all four of the researchers took notes on how the users reacted to certain predicted scenarios and other unexpected reactions to the prototype.

*User satisfaction structured interview:* An interview including nine structured questions were created for understanding how the participants felt about using the prototype and how they perceived the prototype to influence meeting efficiency and effectiveness through enhancing context-based workplace awareness. Questions related to the prototype were therefore mostly stated as “How did you feel...?”. Questions related to awareness was more investigative without using CSCW terminology as that would most likely just confuse the interviewees.

The whole observation was video recorded to prevent data loss. The interviews were audio-recorded and further transcribed. Figure 4 shows the evaluation setup with the prototype in a group room.



Figure 4. Evaluation observation in process.

The data collected was then analyzed with a qualitative interpretative approach [30] in two phases. Initially, all the researchers looked at the video-recording and the notes taken during the observation. The aim was to reflect on meeting efficiency by interpreting participants’ behavior in relation to the features of the prototype. The first round of interpretations was then refined with the data from the interview transcript. That helped us in refining the initial interpretations, finding contradiction among what was said, and what was observed and further explore behaviors with uncertain interpretations. The results of this first analysis are presented in Section 4.

The second phase was a qualitative interpretative analysis of our findings from the perspective of context-based workplace awareness and its subtypes, such as temporal awareness and activity awareness and their influence in the meeting efficiency and/or effectiveness. The data from the interview was in this phase primarily used for interpretation and sense-making. Iterative rounds of discussions with all researchers concluded in what is presented in Section 5.

## IV. FINDINGS

Our selected group of participants found the prototype interesting and were generally excited about the opportunity to test it. Participants agreed that knowledge of the content of the discussions presented in a structured manner prior to the meeting helped to form ideas and express opinions with ease. The participants also agreed that the colors of the artifact had an impact on how the discussion dynamic played out.

One thing to note is that the participants never naturally used up the allocated time suggested from the dashboard. As a result, the artifact’s function for indicating overtime (blue light) was not activated due to the early conclusions of the activities. To test the function for overtime, an additional topic (“bonus activity”) was added, with a stricter time constraint than what the participants thought to be necessary.

The findings are separated into two sections, the artifact and the dashboard, where we elaborate on the specific results of the evaluation.

### A. Dashboard

1) *Agenda:* As mentioned at the start of this section, knowing the activities beforehand and having the activities and their descriptions structurally listed was agreed by all participants as being helpful with forming ideas, which made it easier to state their individual opinions. It was also expressed by participants 1, 2, 3, and 6 that knowing the activity sequence within the meeting had a similar effect of helping them prepare

their opinions. It was observed that the participants would often reread the activities' titles and descriptions. Participants 1 and 5 said that the option to reread the activity's titles and descriptions was helpful in reminding them of what the initial discussion was about. They also said that this additionally helped them to keep their thoughts and opinions relevant to the topic.

2) *Noting*: The participants frequently used the noting function of the prototype during the activities for multiple purposes. Generally, they used it to record each participant's take on the topic. It was also observed that the fourth activity was controversial for all participants as the atmosphere seemed to become more tense and focused as they had strong and partially biased opinions on the topic. To overcome this the group used the recorded data in the noting tool to systematically exclude the less agreed upon opinions, until a consensus by majority vote was reached. At the end of each activity, the group would analyze what was written in the notes and continued to the next activity when all members agreed to do so.

3) *Meeting review*: As described in the Prototype-section, the desktop dashboard also provided a meeting review of the completed activities at the end of the meeting. It was observed that the group used this feature briefly to review the contents and conclusions of the meeting's activities, as well as confirming that nothing was missing and that the conclusions should remain. One of the participants suggested after the evaluation that "It could be helpful to have some sort of agree/disagree button to click on each activity to make the process faster".

## B. Artifact

1) *Colors of the Artifact*: Participants 1, 3, and 5 expressed the colors made a positive impact on controlling the pace and engagement of the discussion. Participant 4 said it made them more aware of the time left. It was also mentioned by participants 1 and 5 that the time-pressure made them feel that things moved faster, and a conclusion had to be met regardless of incidental disagreement between participants. These views coincided with what was observed by the researchers, who noted that the members actively responded to the color changes even in the middle of discussions. For instance, when the color of the activity status was green; the discussion was perceived to be relaxed and open. When the participants noticed the color of the activity status had changed to yellow; they became more focused on moving towards a conclusion without becoming stressed. The color change to red was perceived to make the participants stressed to reach a conclusion.

However, it was expressed by almost all of the participants that the color red was thought to be indicating the end of an activity, even though they were explained beforehand that red is meant to represent a low amount of time before a recommended activity change. Another observation was that the participants only seemed to express notice of the color change after about 1-2 minutes after it had changed. In the "bonus activity" it was observed that the participants became aware of the activity running on overtime when the color changed to blue and asked the researchers if they had to stop working on the activity. The researchers told the participants to continue their discussion if they wished to do so, which they chose to do for a few minutes.

2) *Sound Notifications*: As mentioned in Section 3.B, the artifact had the function of playing soundbites as an indication of, e.g., activity change. Activity change was only reached in the "bonus activity" and it was observed that the sound notification was not immediately noticed by the participants. The sound was also not significantly mentioned by any of the participants in the interview answers. The melody that was played after the participants agreed that the meeting was over, was observed to make them uplifted as they laughed and smiled in reaction. The group also mentioned in the interview that a helpful implementation could be a short ping when the color of the activity status would change to keep the awareness present. One participant mentioned the possibility of integrating a voice that informs users how much time is left. The use of vibrations was also suggested by another participant in a casual discussion after the meeting.

## V. DISCUSSION

### A. Temporal Awareness

As mentioned in Section 4, the participants stated that knowing the activities and their sequence before and during the meeting, helped them prepare by generating thoughts/ideas, which made it easier to express them in the discussions. In other words; The temporal awareness of knowing about activities in the future was helpful for preparing in advance, and that in the moment of the activities these past preparations made it easier to contribute. This appeared to make the discussions more effective and/or efficient by reducing the time spent in generating these thoughts/ideas during the activities. This seems to coincide with what Yamane [22] suggested in his study. Being prepared before meetings in terms of role and information was also listed by Nixon and Littlepage [11] as a procedure that might be related to meeting effectiveness and efficiency. Backing up this argument; The evaluated group meeting, in regard to this, certainly seemed more efficient than the group observed in the informing phase, where several minutes were used just acquiring knowledge about the task at hand.

An interesting and unexpected observation made by the researchers was one of the ways the participants used the prototype's noting tool. In the fourth activity, the discussions between the participants were quite heated and there was a significant amount of disagreement and differing opinions on the discussed topic. To solve this the group, without any guidance from the researchers, wrote down each participant's opinion. This could potentially have given the rest of the group members a cue [21] to discuss why some of the opinions were more "valid" than others in regard to the discussed topic. One could argue that providing these cues "forced" the members to defend their argument by presenting initially unshared information about their opinion, which could have resulted in other members adjusting their opinion/stance and therefore, led to a more thorough exploration of options. The participants then proceeded to systematically narrow down the opinions until a conclusion was made by the majority vote. This is a small example of temporal awareness as the recorded opinions can be considered records of past low-level activities used to solve the task in the present. Somewhat similarly, the meeting review feature was also used briefly by the participants as a method of control checking if what was previously concluded was still agreed upon. This is another example of how the notes can contribute to temporal awareness by allowing the participants

to view what had previously been discussed. Coincidentally, exploring different options properly before a final decision is made is outlined by Nixon and Littlepage [11] as something that might indicate meeting effectiveness and efficiency.

We argue that removing the common noting tool would reduce the quality of the discussions as the participants would have fewer means of properly exploring options. It could, however, be argued that the group leader was the primary reason for the noting tools good use, meaning that the noting tool's efficiency might be depended on how well the users can apply it. Regardless, it seemed that when the noting tool was put to good use, it enhanced the awareness of the low-level activities in the discussion. This could confirm our assumptions made in the conceptual grounding on the basis of Haller et al. [23], that group collaboration could be enhanced by integrating a noting system where participants can share their thoughts with the rest of the group.

### B. Activity Awareness

During the meeting, the information about the high- and medium-level activities presented through the agenda appeared to help the participants to stay on track in the discussions. Specifically, the opportunity to reread the title and descriptions of activities appeared to be useful, as participants 1 and 5 expressed that this helped them remember what the initial activity was about. This could be an indication of something that improved the effectiveness and efficiency of the meeting, as Garcia et al. [5] specified that lack of group focus is a sign of a bad meeting, and Nixon and Littlepage [11] mentioned how participants being focused and committed to the meeting might be a factor indicating meeting effectiveness and efficiency.

In the interview, several of the participants expressed that the colors of the artifact made them more aware of the status of the meeting in terms of activity time limits and encouraged them to come to a conclusion before the time was up. This aligns with the researchers' observations that the participants seemed aware of the status of medium- and high-level activities even when predominantly working on low-level activities. Raising activity awareness through presenting the status of activity time limits using colors seemed to be effective as the participant 1 explicitly mentioned that the pace of the meeting was controlled positively by this feature. This was also implicitly mentioned by participants 3 and 5. It was also observed that the participants would not recognize the status change before 1-2 minutes had passed, which likely changed the current pace as soon as it was identified. It could, therefore, be argued that the state of the color changed too quickly, and a gradual change over time could facilitate the pace even more.

In terms of the sound notifications of recommended topic changes, this was never naturally observed during the meeting, as the participants concluded the topics before this notification could initiate. The only time this was observed was during the "bonus topic", where the participants at first did not notice the notification until the sound was replayed by the researchers with higher volume. This gives the indication that such a notification sound should be clear and easily identifiable, in which the sound used during the evaluation apparently was not. However, the fact that the topics were always concluded before the recommended time was up, and thus the meeting was also ended with time to spare, could be an indication that the meeting was efficient. This coincides with both Nixon and Littlepage [11], as well as Davison [2], who both outlined the

potential importance of temporal integrity. The time allocated to each topic was also indirectly defined by the participants themselves through giving each topic a priority, as described in Section 3.C. This aligns with the study by Janicik and Bartel [24], who proposed that there is a correlation between specific time duration and task performance. As also described in Section 5, Kelly and McGrath [26] suggested that having short time limits results in a faster pace but might lead to lower result quality. As mentioned earlier in this section, the participants perceived the awareness of activity status to result in a higher pace, which coincided with what the researchers observed. The quality of conclusions/results, however, were not significantly investigated.

## VI. CONCLUSION AND FUTURE WORK

Our findings, based on the observation and interviews compared to the conceptual grounding, indicate a positive effect on decision making in group meetings when temporal and activity awareness are enhanced. Specifically, The participants came prepared for the meeting, and it seemed that the foreknowledge of activities was beneficial for the effectiveness and efficiency of the discussions. A central focus for increasing the awareness of the meeting structure was the agenda, and especially the topic titles and descriptions, which were reread several times by the participants during the discussions. They expressed that this helped them keep the discussions relevant to the ongoing topics, which in turn might have made the discussion more effective and/or efficient. The most impactful observation for the awareness of discussion was the use of the noting tool. The tool was often used as a common area to record thoughts and seemed to be useful and effective in that the participants could keep track of the explored and, therefore, unexplored options/information until a conclusion was reached. In addition, the status-based artifact seemed to be dictating the pace of the meeting. For instance, the activity status colors of yellow and red were perceived to motivate the group to move towards a conclusion at a quicker rate compared to green, which seemed to have a more relaxed atmosphere.

Hence, our findings show promising results on how the prototype can aid group meetings in terms of effectiveness and/or efficiency through enhancing temporal and activity awareness in the meeting. The responses from the participants were generally quite positive.

While the findings of the study seem promising, the prototype was only tested in one meeting. In order to gain more insight into its true effects on group meeting efficiency and effectiveness, the prototype would have to be tested in several meetings of different settings, as well as with different participants. It would be especially relevant to investigate the prototype in the setting of an organizational meeting, as this would provide more insight into how generalizable the prototype is in more and less professional settings. The effectiveness and efficiency would also have to be measured with a more reliable method, and the findings of meeting participants using the prototype would have to be compared with the findings of participants not using it in order to see if there is a significant difference. The prototype should also be further developed, so all of its features are fully functional and not controlled through a "Wizard of Oz"-approach. This should make for a more natural experience, and thus produce more accurate results.

Beyond this, we also collected more data during the evalua-

tion regarding insight into possible improvements to the design of the prototype. One such improvement could be looking into design alternatives for the artifact, as it was observed that it was not naturally visible at the center of the table due to being low in height. This is suboptimal as it can prevent the participants from receiving the presented context information, and thus not generating awareness. We also believe that gradually changing the colors of the artifact is another possible improvement for enhancing awareness, as this would give a more accurate feel of the status of activities, as opposed to instant color change. Lastly, adding more functionalities to the noting tool could be beneficial.

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