

User and Group Behavior in Computer Support for Collaborative Reflection in Practice: An Explorative Data Analysis

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Abstract Although reflection in groups has been shown to be beneficial for many workplaces, there are little insights on how such collaborative reflection can be supported and how users apply the support in practice. This paper aims to diminish this lack by analyzing usage figures and qualitative information from four cases of using a tool supporting collaborative reflection. From the analysis, it derives means to describe individual user and group behavior as well as implications for the design and application of support for collaborative reflection in practice.

Introduction

Reflection is a common activity at work [16], e.g. when workers think about how to improve individual or common work, and when peers help each other to understand and change practice. Reflection can be understood as *going back to experiences, re-assessing them in the current context and learning from this for the future* [3], and has been described as a necessary *attitude* for nowadays' professional practice [29] or as a *mind-set* to be cultivated and spread in organizations [27]. As reflection depends on people's memories of experiences, which may be incomplete or blurred over time, and on the continuation of short-time reflection tools, can support reflection by providing data to reconstruct experiences and sustaining reflection outcomes between phases of reflection [13,24].

It has been shown that groups reflecting together can create outcomes transcending individual reflection results by combining perspectives and implementing them on their own, which makes *collaborative reflection* attractive for change processes in many workplaces [4,12,25]. Despite this potential of reflecting collaboratively, there are surprisingly little insights available supporting such collaborative reflection at work – existing work either focuses on individual reflection or on collaborative reflection in educational contexts. It needs to be understood that collaborative reflection differs from individual reflection: *People engaging in collaborative reflection have to make their experiences explicit, share and compare them with others and collaboratively create insights and ideas for future work*

[12,24,31]. In contrast to individual reflection tools (e.g., [21]) this needs support for communication to exchange perspectives on experiences and discuss insights [6,30]. However, there are little insights on how such support needs to be designed to support reflection groups. In addition, collaborative reflection on work differs from reflection in educational or research settings: In education and research, reflection can be understood and planned as an explicit part of learning or research processes, but in other work settings reflection neither follows directly from tasks conducted nor is a mandatory part of them, causing a shortage of time available for reflection. This means that although many workers recognize that reflection is helpful for them (e.g., [3,29]), explicitly stepping back from the task and taking the time to reflect on it is not possible for them – the importance of other (primary) work tasks often leaves little time for explicit reflection. Reducing reflection to special settings like project debriefings [15] is no solution to this problem, as there are many other settings of collaborative reflection at work [6,24], which cannot be covered by means like debriefings and solutions for them.

This paper aims to contribute to the few insights on tool support for collaborative reflection as described above by taking a closer look at the usage and resulting individual and group activities in a collaborative reflection tool. It analyses four case studies in different organizations with a total of 30 active users. From analysis of these studies, it describes insights on how people use tools for collaborative reflection and how groups work by using these tools. As a result, the paper describes means to characterize collaborative reflection tool usage and design.

Related Work: Collaborative Reflection and Tool Support

Besides *related work on collaborative reflection* in educational and research contexts research on collaborative reflection can also draw from existing work on collaborative work support such as sensemaking or group decision support. While overlaps with these concepts can be recognized easily, collaborative reflection differs from them in certain aspects. For example, work on *sensemaking* or *collective mind* [5,32] emphasizes the need to collaboratively reach an understanding of past events, but sensemaking processes described in this work do not have a clear focus on deriving insights for future work, which is needed for reflection – otherwise reflection leads to common ground but not to change. Likewise, group decision support systems [7] are about exchanging perspectives and arriving at decisions in teams, but focus on the decision rather than other parts of collaboration such as reaching a common understanding [23]. Approaches of collaborative problem solving [28] use joint spaces to solve a problem, but have to deal with the problem that information known to all collaborators from the start tends to be followed more than information of individuals, resulting in a “shared information bias” [1]. Collaborative reflection, in contrast, needs exchange of experiences and critical discourse about members’ perspectives to create a solution for the future.

Recent work takes up reflection as a topic for individual (e.g., [13,22]) and group work (e.g., [24]), but does not analyze group behavior using such support. However, this work shows how supporting people to memorize and get back to experiences helps them learn about themselves [13,22,24] and that we need to differentiate reflection participants by interests in reflection activities (e.g. reporting experiences or commenting on them, [13]). On a methodological level, de Groot et al. [11], Fleck and Fitzpatrick [9] and Bjørn and Boulus [2] recently added analyses of collaborative reflection behavior among groups without technology support. This work shows that groups of reflection participants differ in their communication behavior in terms of being able to articulate problems and assumptions [2] and addressing each others' contributions in reflective communication [11]. It also shows how behavior and actions of individual reflection participants can influence the outcomes of reflection [9].

Concerning *tool support for reflection*, most tools proposed and evaluated in existing work primarily serve *individuals*, including learning diaries or portfolios [10,30], tools to take pictures of events for later reminiscence or reflection [9] or capturing events with multimedia content and periodically reminding people of these events to foster reflection [13]. In line with our understanding of collaborative reflection as described above, by *collaborative reflection tool support* we mean tools that support activities such as reporting and sharing experiences, communicating about them and drawing conclusions together. However, among the few examples of such tools mentioned in literature are either generic tools such as shared whiteboards (e.g., [35]) or expert tools such as process model displays (e.g., [19]). To the knowledge of the authors, analyses of tools supporting collaborative reflection at work for different groups are not available. Given this lack and contrasting it with the potential of collaborative reflection at work, this paper aims to provide insights on the design and usage of collaborative reflection tools. It is aligned to research questions derived from the state of the art described above:

- How do people use tools supporting collaborative reflection at work?
- Which factors influence which types and situations of usage at work?
- How can we design tools supporting user groups in reflecting together at work?

Four Studies of Collaborative Reflection Support at Work

The Talk Reflection App was build to support workers in reflecting collaboratively on their communication and social interaction skills, which is a common and underrepresented learning problem [24]. The app is based on intensive research including ethnographic studies in different workplaces and participatory design workshops with potential users [24]. It was trialed in four different work settings.

The Talk Reflection App for Collaborative Reflection

Recognizing the lack of available tools to support such collaborative reflection, we built the Talk Reflection App as a prototype for tools of this kind. In our work, we found that workers recognize reflection as a valuable means to deal with stressful interactions, but that it was hard for them to find the time to reflect together, resulting in little improvements stemming from their reflection and in ideas from the few and brief collaborative reflection sessions not followed up on.

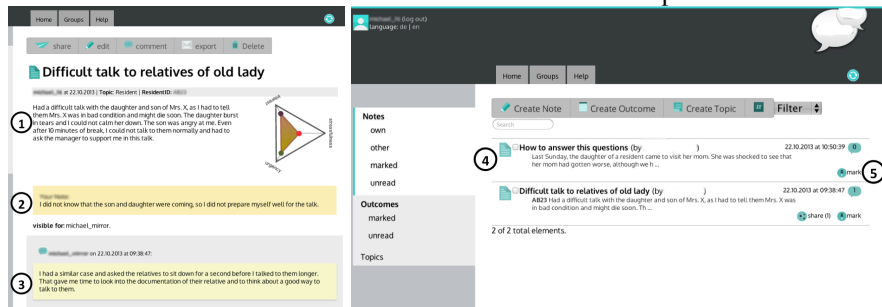


Fig. 1. The Talk Reflection App for collaborative reflection on social interactions.

The Talk Reflection app supports the documentation of conversations and the articulation of individual and collaborative reflections on them by commenting on documented experiences. This, in line with related work [6,12,30,31,33], helps workers to explicate, share and reflect on experiences from conversations. The app supports multiple steps of collaborative reflection as described by [24]:

- **Creating experience reports:** The app supports users in documenting experiences by writing them down. This includes a description of the experience and personal reflections. Writing down experiences triggers individual reflection (e.g., [30]) and provides a basis to later remember the situation [24]. Fig. 1 (left) shows a resulting report (no. 1) with a personal reflection annotated (2).
- **Sharing experience reports:** Experience reports remain private to users initially, but can be shared with others. Once they are shared, other users can find them as shown in Fig. 1 (right, no. 4). Sharing reports can be understood as asking others for comments on the experiences.
- **Reading shared experience reports:** Users can read shared experience reports as shown in Fig. 1 (left) and mark them for later reflection (no. 5). To make users aware of available reports, the app shows unread reports on its landing page and sends digests to users. Reading others' reports may be based on curiosity, but also on impression of interest and willingness to support others.
- **Commenting on experience reports:** To engage in reflection on shared experience reports users can create comments on shared reports as shown in Fig. 1 (left, 3). Comments may contain similar experiences of a user, suggestions for acting in the situation described or other reflective content. They may contain articulations of similar experiences, new perspectives or proposals for change.

Four cases of Support for Collaborative Reflection

The Talk Reflection App was used in four different cases to study the adoption and usage of tool support for collaborative reflection (see **Table 1**). In each of the cases, the focus of reflection was different, although all were closely related to social interaction and communication. The number of initial participants varied from 23 to 6 and the duration of studies varied from 32 to 63 days (see **Table 2** below).

	Context	Objective(s)	Participants
Case 1	Public administration, UK	Learning about professional interaction in internships	22 interns, 1 manager
Case 2	Public administration department, UK	Support for merging two departments by practice reflection	11 staff, 1 manager
Case 3	Care home, UK	Improving interactions with residents, relatives and others	8 staff, 1 manager
Case 4	Hospital, GER	Improving conversations with relatives	4 assistant physicians, 2 senior physicians

Table 1. Cases of using the Talk Reflection App in practice.

Cases 1 and 2 were conducted within the administration of two districts of a city in the UK, whose management wanted to support their employees in learning at work. **Case 1** included the interns working for the district for one year. Management wanted to support them in their new and oftentimes stressful experiences at work and to enable them to learn how to act in professional environments even after the internship. The interns knew each other from partly from introductory courses, but worked in different departments. **Case 2** featured participants from the same department in the two districts in order to enable workers to learn from each other beyond departmental boundaries, as they were doing similar work. Workers were located partly in the same buildings, and some knew each other. Thus, some of them had the opportunity to talk to each other frequently, but conversation opportunities across districts or with the overall manager were rare.

Case 3 was conducted with care staff in a UK care home dealing with residents suffering from dementia. In such homes medical aspects of care are covered by registered nurses, while staff doing the major part of care throughout the day is not highly educated. The manager wanted care staff to reflect on interactions with residents, relatives and other parties in order to increase service quality in the home.

Case 4 was conducted with physicians working in a German hospital. The participants worked on a neurological ward and dealt with emergency patients. Thus, they were highly educated and specialized in this work. The aim in case 4 was to use reflection to support assistant physicians in learning about conversations with relatives, which is a stressful and important part of their work. In both cases, the participants worked together in the same unit and talked to each other every day.

In all cases, at least one group member took responsibility for promoting and ensuring app usage. In cases 1, 2 and 3 this was done by the respective managers

and in case 4 the two senior physicians took charge. It needs to be noted that there were differences in spatial proximity between the user groups: while in cases 3 and 4 (and for some participants also in case 2) the participants could talk to each other every day during work, in case 1 (and for many participants also in case 2) participants worked in different buildings and departments and thus communication was mainly possible via the tool.

Methodology, Tools and Data

For all of the four cases we used a similar scheme to run the studies. Before we introduced the app, we conducted a workshop with potential users of the tool to understand the needs of (collaborative) reflection in the respective organization and to create a frame for the study, including consulting on the possibilities to use the app in different work situations and to adapt it to the needs of the study partner. To introduce the app, we gathered the participants in a workshop and trained them to use it for collaborative reflection. For each case, we created a closed group in the app to enable them to share and discuss experiences only with participants of the test. During an introductory session the participants were asked to create accounts, to add experience reports to the app that described some of their recent experiences and to share the content. They were also asked to look at shared reports and create comments. Based on this, the additional features were walked through as well. Finalizing the training, we discussed with each group of participants questions on the usage and opportunities to use the app during work. Besides this introduction we did not impose any other constraint for using on the participants and left the way of using it to them and those responsible for the respective case.

To analyze the studies we used log files, content analysis and focus groups after the studies. Log files were used to analyze experience reports created, comments created and reports read according to their overall and average numbers. We complemented this usage analysis with qualitative information from two focus groups (cases 2 and 4) and interviews in the other cases. To make sure to analyze only experience reports and comments containing reflective content, we used a coding scheme derived from [9,11] to analyze whether content in the app was part of reflection and excluded non-reflective content. In particular, *documents* were excluded if we did not find traces of reflection in the document or comments on it (that is, if they did neither contain nor cause reflective content), while *comments* were judged per item. In addition, we found that some users had not used the app again after the introductory sessions without giving notice or reasons. We excluded the activities of these users and analyzed usage of the tools only for *active* users, who had *at least* created one document or comment after this session. Content of excluded users stayed in the data set, as others had commented on it. In the cleaned data set shown in **Table 2**, we only excluded a few content items but reduced the number of (active) users to 30 (as compared to 50 participants in total). Despite the loss in participants, this gives a better impression on how the app has

been used for reflection. In addition, to cope with the different timespans in the cases (32 days in cases 1 and 2 and 49 or 63 days in cases 3 and 4 respectively), we calculated the average numbers of items created per day and the average number of items created per user in the table. We will mainly refer to the figures for active users unless mentioned differently.

Measuring (collaborative) reflection activity in tools

The lack of studies on tools to support collaborative reflection at work goes along with a *lack of measurements for analyzing collaborative reflection activity* in such tools. To cope with this lack, we combined means to analyze collaboration and insights from a literature analysis on collaborative reflection analysis in other contexts to create an own set of measurements for our analysis.

- **Adoption:** Collaborative reflection relies on participants well articulating experiences and sharing them with others [14,30,31,33] as well as communicating about them, i.e. sharing their insights, perspectives and ideas to critically reflect on the experiences [8,12,24,34]. Therefore, an initial measure of **adoption** of collaborative reflection tools can be found in the *number of experiences articulated* and shared as well as the *number of comments* made in the tool.
- **Activity:** For collaborative reflection to happen participants need to show interest in and give feedback on shared experiences articulated and shared with them [6,9,11,18]. As a measure of such **collaborative activity** we therefore use the *number of experiences read by individuals* (measure of interest) and the *amount of shared experiences commented on* (measure of feedback given).
- **Quality:** In addition, **collaborative reflection quality** improves if participants engage in discussions rather than providing single comments (e.g., [11,26]). The *average length of threads* created by comments in the Talk Reflection App was used to measure this quality (as also proposed by [20]), assuming that more items in a thread enable better discussions among participants.

These measures are related only to what happened in the tool, thus showing only digital reflection activity. We consider this view to be valuable as it shows the impact of the tool, especially for users who cannot talk to each other frequently or who cannot be present when others reflect face to face. Complementing this view with data on reflection outside tools on the same level of data quality would be valuable but creates an observer problem that we will tackle in further work.

Results: Usage of Reflection Support in the Cases

Concerning the **adoption and individual usage** of our app, **Table 2** shows that most experiences were documented in case 2, and that (despite a usage period

twice as long) users in case 3 produced least experience reports. Looking at the average figures shows that per user least reports were created in case 1 (1.4), and that cases 3 and 4 are in between (2.4 and 3.2 documents per user). Case 2 shows the highest daily productivity for experience reports (1.7 per day), cases 1 and 4 (0.5 and 0.4) show about twice as much activity as case 3 (0.2).

	Case 1	Case 2	Case 3	Case 4
Participants (active / all)	11 / 23	8 / 12	5 / 9	6 / 6
Duration (days)	32	32	63	49
Experience reports (active / all users)	15 / 26	45 / 51	12 / 15	19 / 21
Experience reports per user (active / all)	1.4 / 1.2	5.6 / 3.9	2.4 / 1.7	3.2 / 3
Experience reports per day (active / all)	0.5 / 0.8	1.4 / 1.6	0.2 / 0.2	0.4 / 0.4
Comments on experiences (active users)	35	53	18	28
Comments per experience documented	1.3	1	1.2	1.3
Comments per user (active users)	3.2	6.6	3.6	4
Comments per day (active users)	1.1	1.7	0.3	0.6

Table 2. Usage figures for the cases, differentiated by items created by active users (first figure in cells) and items created by all users (second figure), including drop-outs after introduction.

The figures for comments go along with the figures for documented experiences: Case 2 produced most comments (55 in total, 6.6 per user), while case 3 created least comments (18). Case 2 was most active per day (1.7 comments), and in case 1 users more frequently created comments (1.1 day) than in cases 3 (0.3) and 4 (0.6). Looking at comments per report, however, we can see that cases 1, 3 and 4 outperform case 2, suggesting that overall there was more communication activity in these cases. It has to be mentioned that although the usage numbers look low (given the timespan) at first sight, one needs to understand that although stressful interactions create sustainable harm, they do not happen every day. The figures also suggest that case 2 is a (positive) outlier¹ in terms of usage, and that the figures for the other cases represent average cases.

Table 2 also shows that between the groups there are differences in the frequency of experiences and comments created. We may therefore ask what caused these differences and whether they had an influence on collaborative reflection in the cases. Looking at such **collaborative reflection activity** (using measures as defined above, see Table 3) shows differences between the cases other than expected from the figures discussed above. *First*, while case 2 is the most active case overall in terms of attention to experiences documented in the system (421 experience reports read in total) and an average length of communication threads of 2.24, the data also shows that case 2 has low percentage of experiences being commented on (45%): In cases 1 and 4 the coverage of comments for documented experiences is twice as high (81% and 86%). This suggests that in these cases

¹ It will be shown below that case 2 is an outlier mainly because of massive activity of one user.

there was a *different balance of interest* in content. In addition, it means that for case 2 more than half of the documented experiences were not commented on, which may discourage users from sharing their experiences with others. *Second*, the cases differ in the average length of threads created by comments made on documented experiences. Cases 1 (2.05 comments per document commented on) and 2 (2.24) show longer threads than cases 3 (1.5) and 4 (1.37). This indicates that reflective discussions were held more intensively in cases 1 and 2. This may be explained by the spatial context of these cases: As described for the cases above, in case 1 and (partly) case 2 participants could not talk to each other face to face frequently, while this was possible for cases 3 and 4. Therefore, users in cases 1 and 2 may have seen more value in communicating via the tool. Participants of case 4 approved this during the focus group by reporting that they had not created many comments but rather talked to each other directly. We can thus see that *spatial proximity of users* makes a difference in reflection tool usage.

	Case 1	Case 2	Case 3	Case 4
Experience reports read	284	421	144	153
Experience reports read per active user	25.8	52.6	28.8	18.9
Experience reports read per day	12	14.3	2.4	3.1
Experiences commented on (percentage all)	21 (81%)	23 (45%)	11 (73%)	18 (86%)
Experience reports read per comment	8.1	7.8	8	4.7
Average length on threads	2.05	2.24	1.50	1.37
Threads including originator of experience	6 (29%)	16 (70%)	3 (27%)	0 (0%)

Table 3. Collaborative activity in the Talk Reflection App. To show the collaboration during the test, the table shows only data of *active users* in the cases.

We can state that the reflection group in case 1 was *most active*, as it had a good coverage of documented experiences commented on and longer conversation threads. In contrast, the group in case 2 also discussed intensively, but on a smaller percentage of experience reports. In cases 3 and 4 users commented on many experiences, but discussions were shorter. In addition, for cases 1 to 3 we see a similar number of read events per comment (about 8), while in case 4 it took users to read more than three experiences less to create a comment (4.7). Differences in groups can therefore also be seen in the *responsiveness* to reports shared and in the *intensity of discussions*. They may affect the impact of collaborative reflection, as less communication lowers the chance to create insights together.

Analysis: Individual Roles and Group Characteristics

The discussions above show that our measures on experiences documented, comments created and shared experiences read help to describe and analyze reflection group behavior, but also that this does not fully explain group performance. Con-

cerning **individual roles**, this raises the questions how the basic activities relate to each other in terms of groups using collaborative reflection tools. A Pearson correlation among all participants of the cases (n=30) for these activities shows that there is a strong correlation ($r > 0.8$ for all pairs) between them (see Table 4).

Pair	r	P
Experience reports created & comments created	.919	<0.01
Experience reports created & experiences read	.841	<0.01
Comments created & experiences read	.815	<0.01

Table 4. Correlation of reflective activities in the studies (n=30, all participants of all cases).

The correlations suggest that for the average user the basic activities go along, meaning that the more one reads the more comments one makes etc. The diagrams of user activity in the cases (Fig. 2) shows good examples for this: for users such as U1.3, U2.1, U3.1 and U4.2 high figures for all activities can be found, while U1.4, U2.8 and U3.5 show how low figures for all activities.

Looking at individual behavior more closely reveals that there are other types of users, for whom the basic activities do not predict each other. Naturally, one would assume that users comment more than they document experiences, as there are more of opportunities to comment than difficult situations to write down, and that they read more experiences than they comment on, as usually not every read event will result in a comment ($\#documented\ experiences < \#comments \ll \#documents\ read$). As Fig. 2 shows, this shows for most users in the cases, but there are also users who created more content than they read (e.g., U4.1 and U4.6), who created more experience reports than comments (e.g., U2.1 and U3.1) or who showed high activity in creating content (documents for U4.1, comments for U4.6) despite little reading activity. The other way around, other users (e.g., U1.11, U3.4) show low activity in creating content but higher attention to shared content than others in their group. Looking at individual user behavior, we suggest four types of users for reflection support:

- **(Typical) Reflection participants:** For most users activity levels in creating experience reports, commenting and taking notice of shared reports (reading) go along. As a general pattern, increasing awareness for or activity in one of these activities is therefore likely to result in increase activity in general.
- **Documenters:** Some users mainly create experience reports, but create little or no comments (e.g., U4.1, U2.1 and U3.1 – the latter created more documentations than comments). As one reason for this U4.1 told us that he had mainly wanted to share experiences that he found relevant for his colleagues, but did not see value in commenting on shared reports.
- **Commenters:** Some users (e.g., U1.1, U2.3, U3.3 and U4.6) mainly commented on experience reports. In the focus group we found that, as an example, U4.6 had taken the role of an advisor in case 4, mainly advising the assistant physicians. Users of case 2 reported it had been easier to comment than to “get things going”, meaning to get feedback on their reports.

- **Readers:** Users such as U1.11, U2.6, U3.4 and U4.4 read many experience reports but contributed little experience reports or comments. These participants thus form the periphery [17] in the app. From focus groups and interviews, however, we found that they were as active as others in face-to-face conversations on the documented experiences.

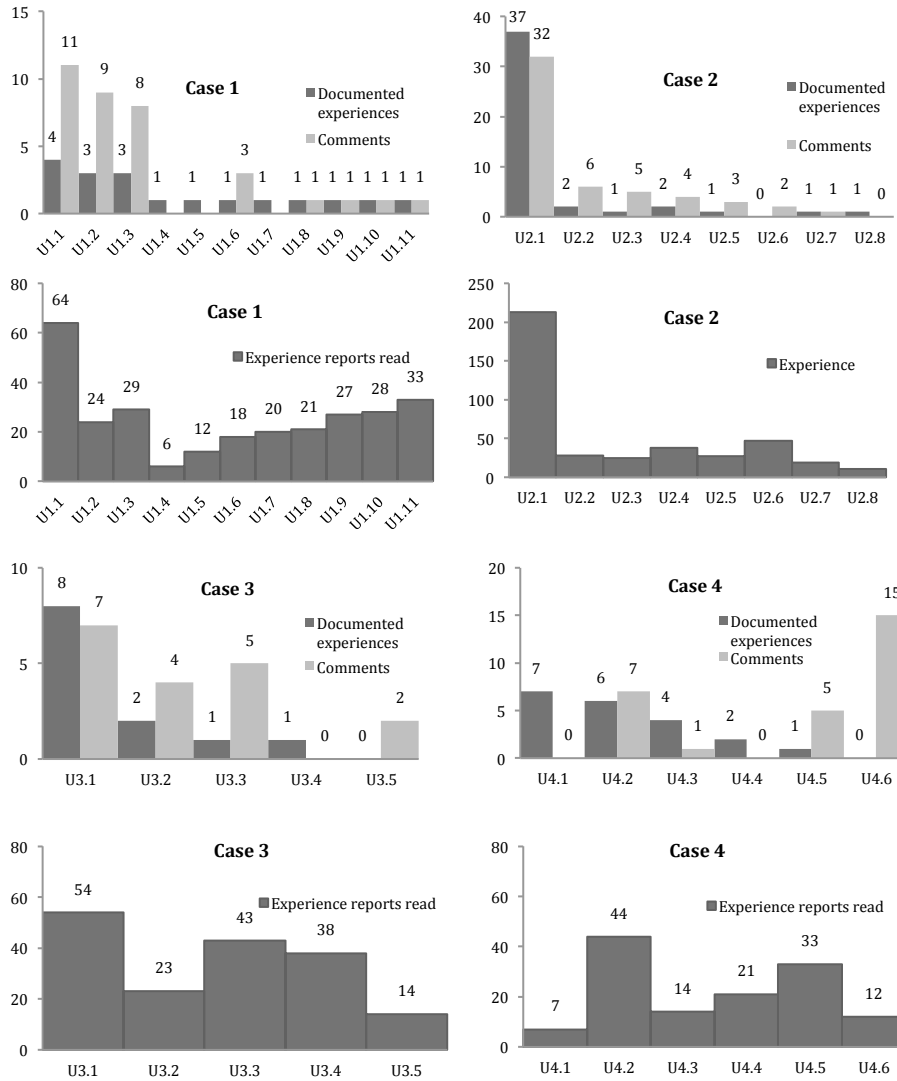


Fig. 2. Usage of the Talk Reflection App in the cases per active user and grouped by case. Documented experiences and comments created shown in the upper half of each quadrant, the number of documented experiences read is shown in the lower half of each quadrant.

Our list of user types described above is not exhaustive, especially given the small number of examples for the latter three special user types. However, given that reflection tools (in contrast to most other communication tools) need to differentiate between experience reports and communication content articulated, this list provides a novel and unique user description, which together with other insights described below can help to provide support for collaborative reflection by supporting or inhibiting certain roles to foster collaborative reflection in a group (see Table 5). It also shows that inside or outside apps, each user type has a role in collaborative reflection, providing content of certain types and/or being informed about experiences of others and potentially active in discussions outside tools. In practice, of courses, roles are combined: we also found some users with aspects of two types, as described above.

Besides differences in user types, Fig. 2 also shows differences in the **group activity and performance**. Breaking discussion activity down to the participants in the groups, we can see from Fig. 2 that in cases 2 and 4 more than half of the comments (U2.1, U4.6) and in cases 2 and 3 more than two thirds of experience reports were created by one user (U2.1, U3.1). In the focus groups of cases 2 and 4, this turned out to focus communication on these users: in case 2 users told us it was hard to get feedback to own experiences, indicating communication was centered to reports created by U2.1; in case 4 we were told that the presence of U4.6 had prevented some participants to create more comments. A participant from case 3 reported that U3.1 had taken the role of being responsible for organizing reflection in the care home, which had resulted in her providing most of the content. These cases show how a *dominant user* may shape the structure of a group using collaborative reflection support tools, including positive (e.g., a push for activity) and negative (e.g., communication focus) consequences. The clarity of dominance in case 2 (the activity of U2.1 is more than five times higher than other users' activity) explains the outlier position of case 2 as discussed above – without counting in U2.1 the usage figures of case 2 are similar to the other cases.

Concerning user types and homogeneity of the groups, we can see that in cases 1 and 2 the group was more homogeneous (i.e. many users created documents and comments), while in case 3 and especially in case 4 user types were more heterogeneous, with a weight on creating comments in case 3 (except U3.1) and a clear role division between commenting (U4.5, U4.6) and documenting experiences (U4.1, U4.3) as well as reading more (U4.2, U4.4, U4.5) or less (U4.1, U4.3, U4.6) in case 4. Given these differences, we can identify three aspects describing participation in the technology-supported reflection groups in our cases:

- **Self-organized, broad reflection:** Case 1 shows the most homogeneous distribution of reflection activities among users. This can be interpreted as a self-organized reflection group without a clear leader, which discusses most experiences shared in the group intensively.
- **Lead user driven reflection:** Cases 2 and 4 show the strongest influences dominant users concerning documented experiences (case 2) and comments (both cases). This creates a reflection group mainly focused on this user,

- **Reflection with separated roles:** Case 4 shows how participants of a reflection group can take different roles and thereby keep the group running with documenters ‘feeding’ commenters with content to comment on.

These differences in the groups’ behaviors can also explain some differences in group performance. For example, the activity of the *dominant user* (U2.1) in case 2 mainly caused the high percentage (70%, see Table 3) of discussions in which the originator of an experience report was involved – U2.1 was involved as documenter *and* commenter in 13 of the 16 threads. However, the activity of U2.1 also resulted in a low percentage of experience reports created by other users commented on: among the 23 reports commented only three were not created by U2.1. This was also reported in the focus group of case 2, in which people reported they felt others were less interested in their experiences due to a lack of comments as response to their reports. As a result, for successful usage of collaborative reflection support we need to *control dominance effects*. While the *role division* in case 4 resulted in a high coverage of experience reports with comments, the figures also suggest that it has a negative effect on communication, as case 4 has the lowest average length of threads. In a small group with role division the originator of a report is often not part of the discussion group, resulting in a lack of a *critical mass of users* willing to discuss: In contrast to all other cases there was *no thread at all in case 4 that involved the originator of an experience report* (see Table 3). This was also reported during the focus group, as users felt others were not willing to create comments.

Discussion: Implications for Socio-Technical Reflection Support

The analysis given above shows how groups using reflection tools differ from each other and which factors can explain these differences. These factors already consider environmental constraints: for example differences in spatial arrangement of participants in the cases most likely caused users in cases 1 and 2 to communicate more in the app than users in cases 3 and 4, who worked closely to each other and had many opportunities to talk to each other personally. Our insights – though preliminary – also allow an initial characterization of reflection groups and their participants to support such groups specifically:

- **Egalitarian reflection group:** Well-balanced group in terms of reports, comments and attention to shared content (main example case 1, also case 2 except lead user). Such groups show good collaborative reflection behavior, shortcomings can be found in the amount of reports created (as exemplified by case 1).
- **Leader-based reflection group:** Seemingly very productive group driven by a dominant user (main example case 2, but also cases 3 and 4). Advantages are high amount of content and communication; the disadvantage is a focus on the dominant user and consequences for impact and motivation of others.

- **Polar reflection group:** A group with role division between commenters and documenters (main example case 3). Advantages are higher certainties in reports and comments being created, resulting in higher coverage of reports with comments and better response rates. Disadvantages are low communication intensity and little overall impact on the group.
- **Underdeveloped reflection group:** In some groups, the reflection group characteristics may not be pronounced enough to support reflection (main example case 3). This results in low communication and little acknowledgement of experience reports shared.

This differentiation overlaps with the three types of participation in collaborative reflection groups as described above. It explores these types deeper by discussing advantages, disadvantages and possible success of each model, including a fourth category describing a group setting in which reflection may not work.

As we illustrated, these different factors have positive and negative aspects on group performance – for example a dominant user may push activities in a reflection group, but may also reduce reflection quality. In addition, interventions concerning these factors may allow groups reflecting collaboratively to reduce disadvantages and benefit from certain advantages: For example, in underdeveloped groups it may be helpful to establish a leader to push reflection activity or in order to raise activity one might want to push polar groups more into egalitarian behavior by encouraging documenters to also comment. Table 5 shows an initial list of such factors as well as potentials for intervention.

Factor	Description	Intervention
Content creation and attention to shared content	Little content production, communication or attention to content harms performance	Motivating the creation of experience reports to motivate comments and read events
User type effects on group behavior	Specific roles may foster activity in a group, role division may reduce interaction	Foster activity of specific user types when needed (e.g., push documenters to also comment to push communication)
Critical mass for reflection	Users groups with little active users may fail in reflecting	Activate readers in groups by encouraging them to create reports and comments
Responsiveness and discussion activity	Low responsiveness and little discussion decrease impact of reflection	Make users aware of relevant content and prompt them for comments; create awareness for reading reports (interest)
Lead user push	Support for activity in the group, e.g. pushing discussions	Supporting dominant user effects in the beginning of group activity
Lead user flaws	Focusing attention too much on lead use activities	Limiting the focus on the lead user by pushing other content and users forward

Table 5. Factors and interventions influencing group performance in reflection.

Implementing collaborative reflection and applying the interventions as mentioned above is not only a matter of setting up reflection processes and supporting them by tools, but also of change in management (see also [26]). This means that in order

to set reflection in practice there is a need to have one or more persons promoting reflection, being responsible for reflection in an organization and implementing it.

Besides these insights, our analysis showed that the activity we measured was not the only activity triggered by the use of the app – besides this, also a social practice of reflection among the group participants emerged where this was possible in terms of spatial arrangements. To understand collaborative reflection as it happens in practice also needs an understanding of these activities: Exploring them and combining them with the analysis of reflection in an app may give us a more comprehensive image of how reflection tools are used in practice and how we can design for socio-technical practices of collaborative reflection. Although difficult to achieve, as daily practice is hard to observe, this will be the next step of our work. Further work on understanding groups using collaborative reflection support may draw from our insights, characterization and interventions, but need to continue and adapt them. Such work needs further studies as presented here and may also benefit from qualitative analysis of the content created in apps.

Finally, besides an analysis as described in this paper, there is a need to analyze people not using tools supporting (collaborative) reflection. While this is more difficult in terms of accessing users, it may provide valuable insights for constraints to be met by such tools. Further work will need to take this into account.

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