Reflecting Aloud with ReflectPal: Engaging Users in Individual Reflection on Collaborative Activities

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ABSTRACT

Digital assistants have the potential to aid individuals in various domains and have proven beneficial in supporting natural ways of communicating. However, tools to assist individual reflection on collaborative activities have received little attention. To explore how digital assistants can be used to support this purpose, we developed ReflectPal, an application deployed through Google Assistant. ReflectPal was tested through a two-week in-situ deployment. The results showed that digital assistants are suitable and capable of supporting individuals in reflecting on their own behavior in collaborative activities and that structured reflection patterns can lead to deeper and more meaningful reflection. Although purely voice-based interaction to promote reflection still seems like a remote objective from a technical point of view, we show promising results in using this technology to support reflection, for example, by employing text-based input as a fallback option for how to interact.

Author Keywords

Google assistant; digital assistants; speech-based intelligent agents; voice user interface; reflective HCI; reflection; meta-reflection; reflection-on-action; group collaboration; collaborative activities; university context.

CCS Concepts

•**Human-centered computing** → **Empirical studies in HCI;**
Please use the 2012 Classifiers and see this link to embed them in the text: https://dl.acm.org/ccs/ccs_flat.cfm

INTRODUCTION

Tools to support cognitive processes and well-being in collaborative activities have received little attention [2, 25]. Although studies have focused on work-related reflection in correlation to increasing well-being among employees [20, 25], few have focused on exploring design measures and integrated solutions for invoking reflection through self-assessment [3, 44]. In this study, we explore how reflection can be used to solve challenges related to group collaboration without applying

measures that focus on visible feedback and concrete end-results. This motivation stems from a concern expressed by Baumer et al. [3] who state that most studies treat reflection as a means to an end by measuring outcomes related to reflection and not the act of reflection itself [3]. We pursue to stray away from the goal-oriented paradigm of measuring outcomes of reflection, and instead focus on the experience of reflecting. As we see it: If reflection leads to a desired outcome (e.g., performance, behavioral change, or goal-reaching), it should only be viewed as a personal achievement and not used to indicate a more successful reflection. To conceptualize reflection in this paper, we utilize Schön's [48] definition *reflection-on-action.* Schön [48] describes this as a retrospective act, where the practitioner reflects on an event that already has occurred, while reconsidering the situation and what needs changing in the future [48].

We explore the potential of using digital assistants (DA) to enable reflection. According to research, DAs are capable of aiding both reflection and well-being [26]. The technology supports natural ways of communicating and has proven beneficial in individuals' willingness to disclose and self-assess [33, 51]. Individuals have reported that they feel less vulnerable and do not fear being judged or viewed negatively when interacting with machines [33]. Moreover, DAs have shown to possess several beneficial traits for everyday use, such as: neutral ways of presenting information, handsfree use, high accessibility, and the ability to influence collaborative interaction positively [33, 42, 43]. The capabilities of DAs have evolved rapidly over the years, and the technology has adopted and refined facets such as speech-recognition [38] and human-like features [11, 41]. At the same time, problems concerning the technology have also been raised, indicating usability issues, and a gulf between user expectation and experience [34, 41]. Although research have highlighted both problems and opportunities with DAs, there is reason to believe that the rapid improvement of the technology means that shortcomings are being addressed and gradually resolved [38].

We developed ReflectPal, an application in Google Assistant, to examine how DAs can be used to guide and support individual reflection concerning behavioral patterns in collaborative activities. To gain a comprehensive understanding of which challenges occur in collaborative activities, we examined existing literature and conducted a thematic analysis. The thematic analysis was based on 126 student reports concerning university students' self-assessments of their collaborative group activities. Through the thematic analysis, we identified

common challenges related to behavioral dynamics, such as: opposing values and personality traits; underlying hierarchical positioning amongst individuals; and unequal participation. We tested ReflectPal in a two-week in-situ deployment with 19 university students.

The contributions of this work include: 1) A collection of challenges concerning group collaboration and collaborative activities. 2) The design of ReflectPal, an application in Google Assistant that guides and supports individual reflection on collaborative activities. 3) Findings from an in-situ deployment showing that DAs are capable of aiding reflection and that structured reflection patterns have the potential to lead to deeper and more conscious reflection. However, results also indicated that participants needed to rely on textual input at times, highlighting that the current state of the technology still needs to be improved. Lastly, this study identified that DAs to support reflection is a promising research area that could benefit from more examination by the Human-Computer Interaction (HCI) community.

RELATED WORK

In the field of HCI, different technologies to support collaborative activities have been widely explored over the years. As quoted by Licklider in 1960: *"[...] there is a continuing interest in the idea of talking with computing machines."* [31], and today, many years later, this shows to be an extremely relevant observation. Products are no longer solely tied to the handset, which gives reason to believe that spoken dialogue interfaces are the future of many key services [34].

Collaborative Activities and Technology

In collaborative activities, the concept of feedback has been used to increase individual and team performance. DiMicco et al. [10] developed a tool to indicate standards of appropriate group behavior to support individual reflection. The study looked into how a shared display could impact the behavior of individuals in groups during collaborative tasks. Findings revealed that behavior in the extremes was affected by the presence of the display [10]. To detect social interactions, promote behavioral change, and provide feedback to enhance group collaboration, Kim et al. [24] developed the Meeting Mediator. The aim was to bridge the gap amongst distributed groups by detecting, communicating, and visualizing social signals on group members' mobile phones [24]. Contrary to the distributed feedback, Tausczik et al. [50] examined a real-time feedback system to monitor communication patterns among students in co-located groups. The results showed that the system was able to improve group performance, but only in the groups that were dysfunctional [50]. Leshed et al. [29] aimed to stimulate reflection on language use and collaborative behavior [29]. For this objective, they developed a chat-based system to present visual feedback on group members [29]. Findings revealed that feedback in collaborative work settings affected social interactions and caused people to alter their communication patterns [29]. The examples above highlight how technology can be used to support feedback in collaborative activities. However, it has been proven that feedback alone struggles to make a difference [44]. Instead, the condition that enables change is not determined by the feedback, but the reflective action based on the feedback [44].

Supporting Reflection with Technology

Positive changes in behavior require that individuals assess their own experiences before they can reach new understandings [4]. Reflection has shown to be a beneficial tool to reach this understanding and has moreover shown to give insights into various contexts and domains (e.g., education, health, and work [26, 36]). Plenty of technologies have been developed to inform design on reflection for everyday practices and personal informatics, for example, through self-tracking [46], lifelogging [6] and digital diaries [32]. However, tools to support reflective actions outside the everyday-domain are modest [25]. Isaacs et al. [21] developed Echo, an Android application designed for users to record and systematically reflect on their daily activities [21]. Findings showed that Echo produced improvement in participants' well-being after only using the application for a month [21]. Kocielnick et al. [28] developed Reflection Companion, a mobile conversational system that supported reflection on personal sensor data, specifically physical activity data collected with fitness trackers [28]. Findings suggested that mini-dialogues were successful in triggering reflection and led to increased motivation, empowerment, and behavioral change [28]. When designing for reflection, Baumer et al. [3] defines: *"[...] sometimes the goal of reflection is not only to increase self-knowledge but to take action based on this increased awareness. Systems of reflection vary as to the extent that they support taking such action."* [3]. Therefore, it is important to design systems that acknowledge reflection as an ongoing process, thus supporting an increase in self-knowledge as well as granting room for taking action based on the increased awareness.

Speech-Based Technology: More than Entertainment

Cho et al. [8] revealed that speech-based agents need to provide more practical core values, rather than just entertainment. Today speech-based agents are gaining popularity, and it is clear that the technology offers new and innovative opportunities for engaging in collaborative activities [38]. However, it is not entirely clear how this technology can be used to deal with challenges characterized by shared work environments. In the work domain, there has been an emphasis on using agents or chatbots to deal with subjects such as personal organization, administrative tasks, or management of to-do lists [26]. Cranshaw et al. [9] presented a digital assistant that provided fast and efficient scheduling through structured workflows. Liao et al. [30] conducted a field study with a personal agent software to help employees detect work-related information. Their findings showed that agents created more interruptions, primarily when used by employees who were generally averse to interruptions at work [30]. McGregor et al. demonstrated how agents could be used to monitor spoken dialogue in group settings, and pro-actively detect useful actions, and carry those out without any specific commands [35]. These examples show that speech-based technology has made its entry into the work domain by assisting workers in organizational and structural assignments. Few studies have examined how DAs can be used to support workers in processes related to cognition and personal well-being. Kimani

et al. [25] developed Amber, a conversational agent that supported workers with work-related goals to explore the potential of using conversational agents to improve workplace productivity and well-being [25]. Findings indicated that participants enjoyed Amber's work-related suggestions and that workers became more mindful about their work practices to the point where they would make changes to increase productivity and become healthier [25]. Kocielnik et al. [26] developed an agent with chat-based communication through a personal device to examine how voice-based and chat-based interaction affected workers' reflection and supported self-learning [26]. Findings indicated that voice interaction might enable users to step back and reflect on their work [26].

IDENTIFICATION OF CHALLENGES

In order to identify design directions, we conducted a literature review where we studied a vast number of research articles containing suggestions on how to support collaborative activities and design for reflection. In addition, we conducted a thematic analysis to identify and reveal which challenges individuals face when participating in collaborative activities. These challenges played a pivotal role in the design of our application, as it helped us understand which challenges it should be able to incorporate and accommodate.

The thematic analysis was based on 126 reports authored by university students from Aalborg University (AAU) in Denmark. This university utilizes the problem-based learning model, which encompasses a high degree of group work and collaboration between students [12]. The student reports included self-reported assessments of group work in semester projects and were written cooperatively in groups, generally consisting of 4-7 individuals. Each report included a description, analysis, and evaluation of the collaboration and work processes within the group, as well as collaboration with external partners and supervisors. The reports were extracted through an exhaustive search in AAU's Digital Project Library. The search was carried out with specific selection criteria and sought to retrieve a 100% recall of the documents that met these criteria. Based on the search, all student reports from the period of 2015-2019 containing subject headings such as 'group work', 'work processes', and 'group collaboration' were collected to form the basis of the dataset in the analysis. The choice of basing the thematic analysis on university student reports allowed us to focus on a group of individuals with similar and well-defined requirements for collaboration and group work, who still engaged in different types of collaborative contexts.

Thematic Analysis: Procedure and Findings

Thematic analysis is a widely used method to process qualitative data, but there is no explicit agreement on what a thematic analysis entails and how to carry it out correctly [5]. We guided our analysis following Braun's [5] step-by-step guide on how to conduct a thematic analysis. The process began with noticing patterns of meaning and identifying challenges of potential interest in the reports [5]. On account of this, we generated two extensive inspection lists after having read and re-read the reports while noting down initial ideas [5].

The inspection lists encapsulated all identified instances related to collaborative problems mentioned in the reports and contributed with a low-level initial coding [5]. Through collating the two inspection lists, a thorough selection of potential themes took place [5]. Here, 17 themes showed repeated occurrences, identifying these as the most pressing challenges for students. Subsequently, the themes were checked in relation to the coded extracts in the inspections lists and meticulously categorized and organized into thematic maps based on their interrelationship [5]. Lastly, we generated clear definitions and names for each theme and map, to ensure association between our selected candidates and to identify how individual reflection could support them [5]. The 17 themes are visible in Figure 1.

	Challenges	Number of mentions
1	Insufficient time management	53
2	Insufficient discussion management	44
3	Insufficient decision-making	44
4	Non-work related discussions	44
5	Unequal participation in discussions	43
6	Insufficient use of ICT-tools	30
7	Insufficient project management	29
8	Missing work ethics	28
9	Insufficient agenda management	26
10	Insufficient meetings management	26
11	Failing to match expectations in advance	25
12	Insufficient conflict management	20
13	Insufficient break management	19
14	Failing to meet as scheduled	17
15	Insufficient management of interruption	16
16	Domination and hierarchy issues	15
17	Written agreements not complied with	10

Figure 1. Findings from thematic analysis: identified challenges.

From the thematic analysis, it was noticeable that the challenges reported by students concerning group collaboration and collaborative activities were predominantly consistent with the challenges identified through existing literature. Although some challenges concerned project related problems stemming from the university-based context, most were related to collaborative dynamics in general.

Beyond confirming the contemporary relevance of challenges and establishing a well-grounded collection of common challenges in collaborative activities, this analysis also gave rise to a prioritization of these. The number of mentions in the reports indicated the rate of occurrence for each challenge, signifying which appeared to be the most common. Thus, we could adjust our focus to the most prevalent challenges. We derived four main challenges that were considered relevant to focus on in this study. These were: Unequal participation
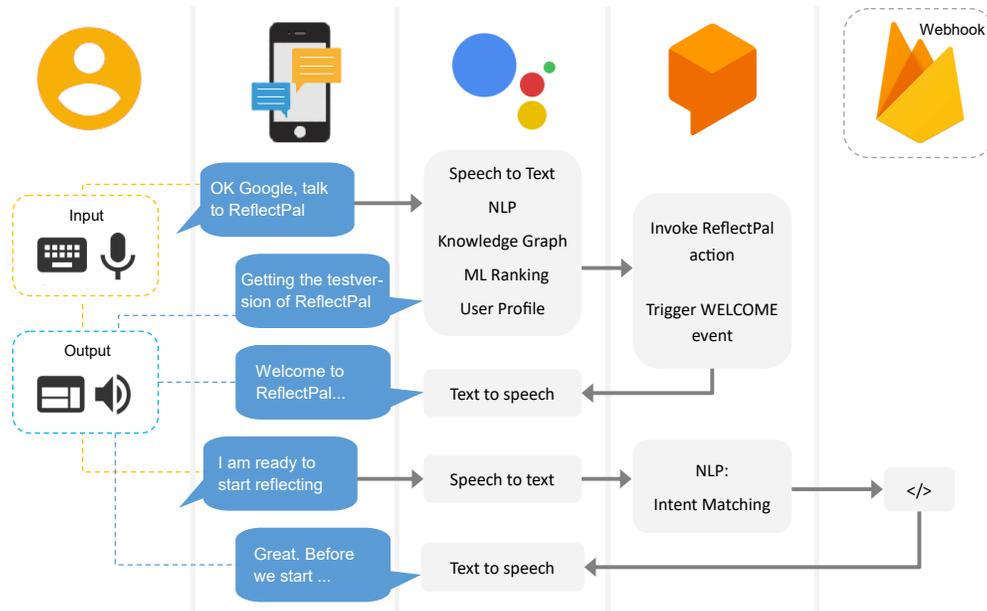
Figure 2. Visualization of ReflectPal's system architecture.

in discussions; Domination and hierarchy issues; Insufficient decision-making; and Non-work related discussions. We identified these as the main challenges, based on the number of mentions in combination with an assessment of which were most inclined to benefit from individual reflection. These four challenges later came to be momentous in designing our application, ReflectPal.

DEVELOPING DIGITAL ASSISTANTS FOR REFLECTION
Following the thematic analysis, we examined how ReflectPal could be designed to address the challenges identified. It was decided that the goal should be threefold. ReflectPal should: 1) provide users with questions promoting individual reflection through a guided dialogue; 2) be able to encapsulate all collaborative challenges identified through the thematic analysis; 3) be supported by mobile devices and afford easy access as well as both visual and auditory output. These three goals were considered essential in order to reach the overall objective as we strove to develop an application that supported individual reflection on own behavior in collaborative activities.

System Design and Infrastructure
ReflectPal was developed through an integration of Google Actions and Dialogflow. This allowed us to exploit built-in language processing AIs, such as natural language understanding (NLU) and machine learning [1]. In Dialogflow, we implemented the core logic of the conversation structure. We applied Firebase as a webhook fulfillment and created additional logic through external coding with JavaScript, using Visual Studio [18]. We developed the application in English and utilized Speech Synthesis Markup Language (SSML) to enable additional intelligibility by emulating a natural linguistic context. ReflectPal was deployed through Google Assistant, and Figure 2 illustrates its core architecture.

Users interacted with ReflectPal via their personal smartphones, using Google Assistant. User inputs were registered through voice and text-based inputs over the phone's microphone or keyboard, and outputs were generated by text on the screen and audio from the phone's speaker. Although Firebase supports the use of real-time databases, it was decided that ReflectPal should not preserve user data. We assessed that the storage of data would have a more significant negative impact in terms of possible hesitation to disclose and mistrust compared to the expected value gained from being able to save user data.

The design of ReflectPal was guided following Google Developers' personality design guidelines [17] and the design guide by Kim et al. [23] for consistent personality manifestation. Our first design consideration included deciding which personality traits were considered desirable to mirror in the application. Here, we decided to focus on: calm, trustworthy, neutral, rational, and subtle. In addition, we decided that the voice of ReflectPal should be a medium-to-high pitched male voice to separate it from the default voice in Google Assistant. Moreover, the selected voice matched the chosen personality traits. Thus, it contributed to greater consistency in ReflectPal to better support the users' mental models when interacting. Another design choice that was made was implementing slow-paced speaking using SSML in order to support comprehension and induce a calm experience.

ReflectPal: An Application for Reflection
To initiate use of ReflectPal, users had to say aloud or type "talk to ReflectPal" in Google Assistant. This action invoked a welcome intent that introduced users to ReflectPal by explaining the purpose of the application and the benefits of using it. After users expressed that they were ready to commence the reflection session, they were asked to find a comfortable
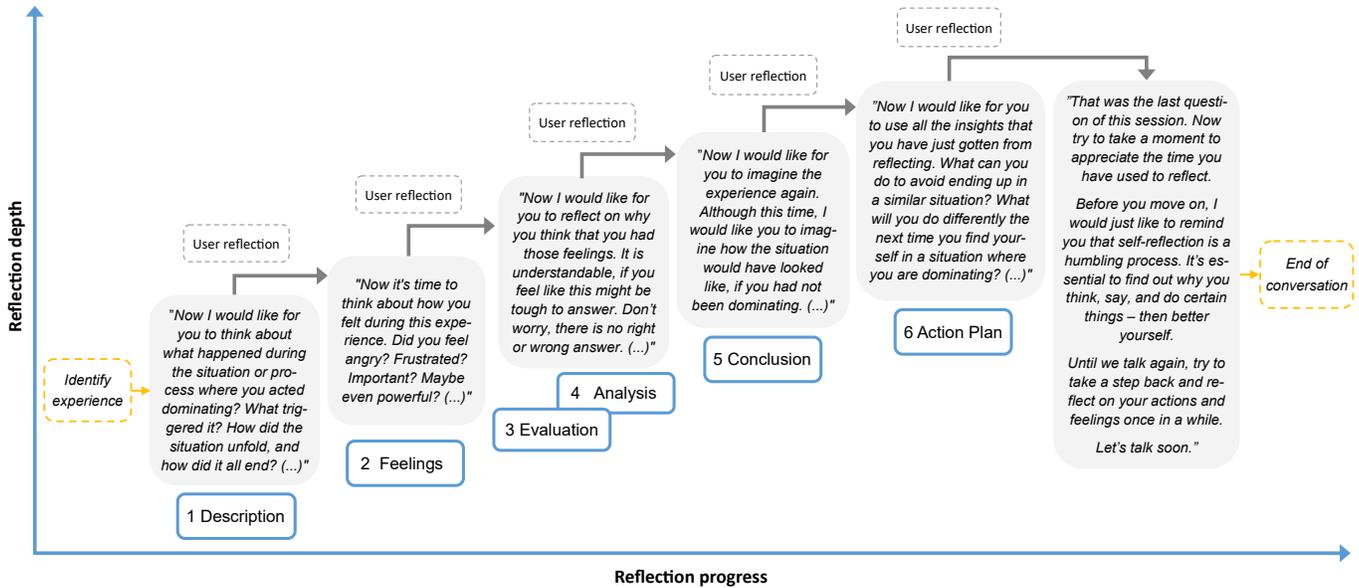
Figure 3. Sample dialogue from ReflectPal related to the reflection point 'decrease your domination on group work', visualizing the connection between reflection levels and conversation structure.

place to be seated to avoid interruptions while reflecting. Once the users expressed that they were comfortable, five reflection points were presented to them. Out of the five points, users were instructed to choose one as the focus for the session. Four out of the five points referred to the main challenges derived from the thematic analysis, but since we also wanted to accommodate more context-specific challenges, an option for users to pick a self-chosen topic was added. This counted as the fifth reflection point. Reflecting on a self-chosen topic made ReflectPal more flexible, enabling reflection on a broader range of challenges. Although our choice of topics for reflection did not encompass challenges related to group management and regulatory issues due to the low degree of individual influence, the self-chosen topic still allowed users to reflect on matters like these. The five reflection points users could pick from were as follows:

1. Better your contribution in group discussions
2. Decrease your domination in group work
3. Get better at decision-making
4. Get better at not engaging in small-talk during group activities
5. Pick a self-chosen topic

Once users had picked a focus for the session, they were guided through six stages. The stages were specifically designed to promote reflection. After having gone through the six stages and before ending the sessions, users were presented with a closing remark, a quote about reflection, and prompted to occasionally take a step back to reflect on their actions and feelings, aiming to encourage reflection in their everyday lives.

As time has been pointed out as an essential condition for enabling reflection [28], this dimension was also taken into account when designing the flow of how users should interact with ReflectPal. Users were provided with the time they individually needed to reflect and would indicate when they were ready to move on. This was considered significant for the flow of the conversation to create a pleasurable and unrushed interaction.

Conversation Design to Enable Reflection

ReflectPal's conversation design was based on a theoretical framework, aiming to encourage reflection and guide users through a developmental process [16, 28]. The conversation structure was guided by Gibbs's reflective cycle, which proposes a design approach for reflection-on-action based on six reflective stages [16]. The six stages related to: Description, promoting to recall what happened in the experience; Feelings, identification of thoughts and feelings; Evaluation, evaluating whether the experience could be deemed good or bad; Analysis, relating to which sense could be made from the experience; Conclusion, relating to which actions could have been better to take; and Action Plan, prompting to identify what to do in a similar experience in the future [16]. Figure 3 illustrates how the reflection levels related to the dialogue in ReflectPal. Additionally, we directed our focus on ways to design and phrase questions to support reflection. Here, we applied Moon's levels of learning [37], which entailed a comprehensive collection of tools for how to support reflection.

FIELD DEPLOYMENT

In order to examine if ReflectPal was capable of supporting individuals in reflecting on their own behavior in collaborative activities, we tested the application in a two-week in-situ deployment [47]. The purpose of field deployment was to examine ReflectPal both in terms of usability, but also in terms of its situated use [47].

Participants

To test ReflectPal, 26 participants (M=13, F=13) were recruited through purposive sampling on Facebook and recruit-

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ment emails forwarded to university students from AAU. After being recruited, the participants received information about the test period, instructions for how to interact with Reflect-Pal, and step-by-step installation guides for iOS and Android. During the installation phase, seven (M=4, F=3) out of the 26 participants were forced to leave the study either because of personal reasons (N=5) or problems related to the installation of the application (N=2).

Before interacting with the application, participants were asked to sign a declaration of consent and fill out a questionnaire to collect demographic data and previous experience with technology. Data from the questionnaire showed that participants had a mean age of 25,16 years and consisted of university students from various educations. Out of the 19 participants, 15 were Danish, with the remaining being from Bolivia, Ecuador, and Romania. 16/19 noted their English skills as being either advanced or expert. Moreover, 15/19 participants rated their expertise with technology as advanced or intermediate, with 4/19 describing themselves as experts. 9/19 participants described their previous experience with voice-based assistants to be at a novice level, 6/19 described their experience level to be intermediate, and 4/19 described their experience level to be advanced.

Procedure

Participants were divided into two test groups, where all were instructed to use the application for two weeks. The usage of ReflectPal happened based on the participants' desire to use the application, albeit participants were instructed to use it at a minimum of two times per week. The reason for not forcing a more frequent use upon the participants had to do with the fact that prior studies discovered reflection to be a time-consuming process that does not necessarily happen all at once [2].

Following the test period, participants were asked to partake in an evaluation of ReflectPal. The evaluation included a post-deployment questionnaire and an interview, which aimed to gather feedback from the participants' experiences when interacting with the application. The questionnaire comprised of 14 questions on a 7-point Likert-scale and was distributed through SurveyXact. The questionnaire was formulated with inspiration from agent rating scales presented by Kimani et al. [25] and Olafsson et al. [40], as these studies had a similar goal of encapsulating user feedback based on DA interactions. In parallel with these studies, we aimed to explore dimensions of: usability, user enjoyment, trustiness, and if the application supported the primary purpose of aiding participants in reflecting. These dimensions were chosen to provide indications on: how favorable and uncomplicated the application performed; if users enjoyed such an application; if users trusted such an application; and if the application was capable of prompting reflection in the chosen context. The interviews were semi-structured with an exploratory character and all conducted in English. The interviews aimed to gather a comprehensive collection of qualitative feedback indicating strengths, weaknesses, and opportunities for the application. A selection of the interview questions can be seen in Figure 5.

RESULTS

The data from the post-deployment questionnaire were analyzed, and descriptive statistics (i.e., mean response rate and standard deviation (SD)) were calculated. We calculated the individual rating average per participant, by averaging scores from all 14 questions in the Likert-scale questionnaire. This served to indicate the application's ability to perform satisfactorily and to identify the variability of the scores. The interview data were processed through an initial coding and a subsequent qualitative categorization of themes using NVivo. We operated with an inductive approach [7] by interpreting the raw textual data and abstracting common themes based on the extensive understanding of the interview contents. We chose this approach as opposed to employing a deductive approach [7], since the nature of this exploratory study caused that no predefined themes were identified before initializing coding.

Quantitative Findings

Data from the post-deployment questionnaire indicated general satisfaction with ReflectPal. Figure 4 presents a boxplot of the 19 participant rating averages from all 14 questions in the Likert-scale questionnaire.
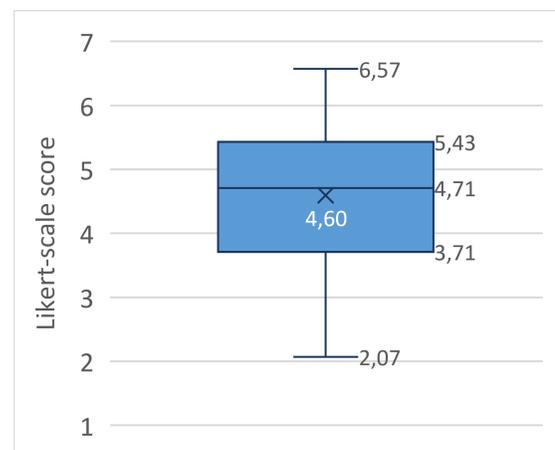

Figure 4. Overview of the 19 participant rating averages from the 14 Likert-scale questions, visualized in a boxplot.

In the 7-point Likert-scale spectrum, we described the ratings as: 1-3 = low rating; 4 = neutral rating; and 5-7 = high rating. Based on the rating averages for each participant, it was evident that the majority of participants (14/19) rated the application as being above the midpoint of the scale (>4). It was noticeable that the Interquartile Range (IQR) ranged between 3,71 and 5,45. This signified that all but one from the top 75 % of the participants rated ReflectPal above midpoint of the scale (>4), indicating a predominantly successful interaction. However, the more extreme data-points indicated that the experience of interacting with ReflectPal had not been entirely uniform. In Figure 5, a selection of questions from the post-deployment questionnaire is shown with calculations describing the mean response rate and SD.

Items	Rating	Mean (SD)
Usability		
It was **easy** to interact with ReflectPal	1.Not at All, 7. Very Easy	5,27 (1,64)
I felt the interaction with ReflectPal was **comfortable**	1.Not at All, 7. Very Much	5,00 (1,53)
It was **clear** for me how to interact with ReflectPal	1.Not at All, 7. Very Clear	5,58 (1,61)
I felt the conversation with ReflectPal was **natural**	1.Not at All, 7. Very Natural	3,53 (1,84)
Enjoyment		
I **enjoyed** interacting with ReflectPal	1.Not at All, 7. Very Much	4,37 (1,22)
I liked the way ReflectPal **presented information** to me	1.Not at All, 7. Very Much	4,64 (1,58)
Trustiness		
I **trust** ReflectPal	1.Not at All, 7. Very Much	4,74 (1,60)
Supporting assistant purpose		
ReflectPal **helped me reflect**	1.Not at All, 7. Very Much	4,58 (1,68)

Figure 5. A selection of post-deployment questionnaire questions and responses.

Regarding usability, 13/19 participants reported that it was easy to interact with the ReflectPal. Similarly, 11/19 rated the interaction as being comfortable, with only 3/19 participants indicating a modest degree of comfortableness. 14/19 found it clear how to interact with the application, while 3/19 indicated a lack of clarity. In terms of how natural the conversation felt, only 4/19 participants indicated that the conversation felt natural, whereas 12/19 did not find the conversation with ReflectPal natural. Regarding the enjoyment of the application, participants reported different sentiments. 7/19 reported to enjoy the interaction, 8/19 were neutral in their rating, and the remaining 4/19 did not enjoy it. In terms of how the information was presented, it was visible that only 7/19 participants were satisfied, whereas 6/19 indicated a neutral stance, and 5/19 indicated low satisfaction. In terms of trust, 9/19 rated that they had high trust in ReflectPal, whereas a small number of participants (3/19) indicated low trust. With reference to supporting application purpose, 12/19 participants reported a clear indication that it helped them reflect, and 6/19 gave a middle to lower rating, indicating that ReflectPal somewhat helped them reflect. Only 1/19 participants gave a rating of 1, indicating that the application did not help them reflect whatsoever.

Qualitative Findings
From the interview data, it was clear that ReflectPal worked well in evoking individual reflection on collaborative activities. The participants generally reflected more during this period, not only regarding collaborative activities but also in regard to everyday life issues. In the following sections, the main themes from the coding are gradually presented and expounded on. The themes that arose from the qualitative categorization were: ReflectPal's support and overall experience; Reflection on collaborative contexts; ReflectPal's structure; and Changes in reflection patterns.

ReflectPal: Support and Overall Experience
Using a DA was a new experience for most participants. Several had not interacted with voice technology, let alone a DA, before. This, along with the fact that the application was in English, made for a fairly steep learning curve at the beginning of using ReflectPal. Some participants adjusted to this interaction, some liked that the use of ReflectPal was so vastly different than their other interactions with technology, and few did not get past the feeling of ReflectPal being divergent and somewhat intrusive. Nevertheless, results showed that the majority of participants were positive in regard to DA technology as well as using it to reflect on collaborative activities. The flexibility in communicating via both text and speech was mostly well-received and viewed as one of the core strengths of ReflectPal.

For all participants, ReflectPal managed to invoke reflection in one way or another. The majority of participants reported that they felt the DA supported them in reflecting on individual behavior in collaborative activities and that they had reflected in a more structured way than they normally would. It was also reported that most participants experienced a substantial increase in how frequently they reflected and that the sessions led to additional reflection on other parts of their lives.

Reflection and Collaborative Contexts
This study was formulated to demonstrate the feasibility of DAs in the context of individual reflection on collaborative activities. However, ReflectPal was only covering a subset of the areas identified through the thematic analysis and was therefore not sufficient in covering all contexts of collaborative practices. Regarding the coverage of reflection points, the participants' opinions were divided. The five points which ReflectPal was able to accommodate, were by some considered to be adequate. Others wished for a more personalized experience, encapsulating a bigger list of reflection points, and a third group requested a more generic way of reflecting, which could also be applied to their everyday problems that were not related to collaborative practices.

As the identified reflection points stem from the identification of university students' challenges in collaborative activities, the sessions with ReflectPal have mainly been focused on reflecting on past situations that did not go well. A few participants pointed out, they wished for more emphasis on positive experiences and to identify what led to the positive experience:

> *P26: "[...] my experience with the questions was that they kind of had a negative outlook from the start. [...] of course, I understand that reflecting is to make yourself better, but I felt that "oh, I have done something wrong, so now I need to reflect on it," and it is only when I have done something wrong that I can reflect on it."*

It was noteworthy that the usage of ReflectPal had varied in terms of when participants reflected and what they reflected on. Some reflected mostly on experiences that took place years ago, and others preferred to reflect on their most recent experiences with collaborative group activities. Furthermore, the environment in which participants reflected also differed. Some reported that they used ReflectPal directly after a collaborative activity; some used it as an intermediate activity between their work tasks; some used it at the end of the day as a way to review it; and one reported that she used it before meetings, to identify how she could improve her actions from the last meeting.

Structure and Reflective State
The structure of ReflectPal, moving gradually from superficial to deep reflection, was particularly empathized as a novel way of reflecting for many, which generally led to a deeper and more conscious reflection, compared to their usual ways of reflecting. *P1: "[...] ReflectPal helped me reflect in an organized way, so with ReflectPal, I went deeper and deeper into the specific situation [...] usually when I reflect, I am not that organized about it.".* Although ReflectPal showed useful in evoking reflection, three participants experienced that the challenges were left unresolved at the end of the sessions:

> *P7: "Maybe I don't think about the negative stuff very much as a person, but when you are asked a question about the bad stuff, of course, something is going to come along and then I was kind of stuck with ReflectPal."*

Due to the short period of using ReflectPal, many did not reach the point where they could apply their reflection to resolve collaborative challenges in future scenarios. Thus, the accomplishment of taking action based on the obtained self-knowledge and increased awareness was not apparent in all experiences.

> *P7: "You are already down the narrow path of all the bad stuff that happened, but I think that I kind of got left behind with the bad emotion afterward. If it makes sense. I was thinking about something that went wrong, but I could have used some inspiration on how to change it into something positive. Maybe how to keep working on yourself in the future, so I don't kind of get left behind afterward."*

It is possible that prolonged use could have resolved this feeling of being left in the reflective state.

Changes in Reflection Patterns
Out of the 19 participants, only three reported that ReflectPal did not support their reflection on collaborative activities in profound ways. One person already had a reflection routine in place and did not feel that ReflectPal was creating additional value. The two other participants found the situation of using technology to reflect too artificial: *P5: "[...] reflecting with a program or a screen, technology, is not something I am actually that fond of. So, I guess that is the overall conclusion of how I felt with using this system.".* For these participants who did not see a clear outcome in terms of reflecting on collaborative activities, all still reported that they experienced a change in their reflection patterns. These participants reported

that they compared ReflectPal's structured reflection to their own reflection patterns. Thus, they evaluated their way of reflecting from a meta-perspective, implementing segments from ReflectPal's step-wise structure into their daily reflection. This tendency was mentioned by multiple participants during the interviews, hence indicating that this acquisition was common.

DISCUSSION
Results from the field deployment have provided insights into university students' reflection on their individual behavior in collaborative group activities, using a DA. For most participants, reflecting with a DA was a new experience that differed vastly from their regular uses of technology. The majority experienced benefits from being assisted by a DA while reflecting, since the technology offered support and structure.

Reflection and Motivational Factors
Research has uncovered that DAs are capable of supporting goal-oriented interactions and interventions to help users achieve goals by self-assessing [26, 49]. Our goal was not to examine if the reflection could lead to a desired outcome, but instead to have the reflection as the overarching indication of a successful experience. The results significantly indicated that DAs were successful and beneficial in supporting individual reflection on collaborative activities. However, results also showed that some participants requested the opportunity to create solutions, e.g., by writing down conclusions for how to act in future scenarios. Participants desired to use this logged information as visible feedback to produce more motivation for using the application. This demand is consistent with results outlined by Zhou et al. [52], which describes visible feedback as one of the most useful and effective parameters for users to achieve goals and maintain motivation by comparing past performances to current ones [52]. It could be argued that the reflective act needs to be supported with additional functionality and information to enable more motivation to use the application, as objective outcome measurements, self-monitoring, personalized feedback, behavioral goal-setting all prove beneficial in maintaining user participation and motivation [52]. Although motivation is essential when developing applications, we greatly stress the importance of remembering the reflective act as being the most significant parameter when developing for reflection. Thus, not to treat reflection as a means to an end, but instead, make sure that the reflective act is paramount [3].

The Choice of Voice Technology
During the development of ReflectPal, we made a proactive choice of accommodating both voice-based and text-based inputs, as the study included participants from four different countries, counting none of them as native English speakers. We chose this, as findings from Kocielnik et al. [26] indicated difficulties with voice-based input, mainly emerging from participants' different accents as well as from participants' overestimation of DA capabilities. Even though 16/19 participants noted their English skills as being either advanced or expert, the voice-based input still made for a troubled interaction. Some participants reported that the speech-recognition improved over time, while others instead utilized the text-based

input. The option of allowing participants to dynamically switch between voice-based and text-based inputs generally showed to be a successful way of alleviating frustration and provide alternative ways to interact. Despite this, there is still reason to ruminate if the troubled interactions could have been alleviated by testing ReflectPal with native English speakers or if the trouble mainly had to do with users overestimating the DAs capabilities. One thing that is clear, is that multiple studies formerly have pointed out, that in terms of speech-recognition, DAs are still in its infancy [34, 41]. A seamless purely voice-based interaction appears to be an ambitious but remote objective. For now, text-based input remains relevant as a fallback interaction when interacting with DAs. In countries with low DA familiarity, an implementation with both text and voice-based input would furthermore serve as an intermediate step towards utilizing DAs. This entails that users slowly would be able to accustom to utilizing voice-technology while still having the familiarity of text-based input as additional support.

Reflection and Collaborative Contexts

ReflectPal incorporated four out of the 17 challenges identified in the thematic analysis, as we set out to explore whether using DAs in this context was a valid proposition. These were extracted from the prioritized list of identified challenges. However, not all challenges were deemed suitable for individual reflection. This entailed that several of the highest-ranked challenges were not directly represented in the application. Although this study has focused on individual reflection patterns and own behavior, there is no denying that group-based reflection also plays a significant role in collaborative environments. Individual reflection was described as beneficial for the majority of participants, yet several also expressed an interest in applying the structured reflection plenary with their group members. We see a potential in leveraging both individual and group-based reflection in collaborative contexts, to accommodate a larger area of collaborative challenges. In continuation, it could be relevant to explore the dimension of reflecting with DAs in collaborative activities in groups compared to individual reflection.

Generality Versus Specificity

Addressing only a subset of the collaborative challenges identified through the thematic analysis, entailed that some participants could not relate to the challenges presented in the application. In contrast, others did not have enough content to reflect on. We created an option for participants to choose a self-chosen topic to reflect on, to enable reflection on challenges that were not already provided by ReflectPal. However, data from the interviews indicated that some participants found the self-chosen option too generic to support their reflection. Our results did not state if the generic reflection guide was to prefer over the specific ones. Although, results did suggest that the generic guide enabled reflecting on broader topics, whereas the specific guides only granted room to reflect on the one selected challenge. The generality and specificity of the reflection guides have been a source of discussion multiple times during this research, as both carried a risk of making ReflectPal rigid and possibly irrelevant to participants. From

the start, we strove to find the balance, although this has shown to be a difficult task due to the participants' subjective opinions and preferences in how they preferred their individual reflections to be. This has formerly been pointed out as being ascribed to differences in personalities, perceptions, and preferences [22, 39]. To accommodate these differences amongst users, we suggest to turn the attention to personality-targeted design [22, 39], and to grant room for customization of systems that strive to support reflection. Customization would provide flexibility, thus enabling a more adaptable and relevant application to more individuals. In continuation, it is important to stress that this might carry the risk of creating incorrect and inconsistent content, thus impede meaningful reflections and, in turn, lead to contradicting experiences [26]. It is feasible that some domains would benefit from a generic design that supports a broader reflection, while other domains would benefit from more a specific design. We suggest that when designing for reflection, both the domain-specific context and user perspectives are taken into consideration.

Reflecting on How to Reflect

Throughout this study, it became increasingly evident that the reflection which ReflectPal offered was not only limited to the intended usage regarding reflection-on-action in collaborative experiences. Rather, participants started reflecting on their own ways of reflecting and implementing the step-wise and conscious reflection into their daily lives. This use of ReflectPal we refer to as *meta-reflection*. This type of reflection-on-reflection was overall mentioned by several participants throughout the interviews and served as an unanticipated outcome of this study. It became apparent that the meta-reflection arose, as the sequence of the questions, following Gibb's six stages of reflection, became a means to skills gathering and personal development for several participants. For these participants, ReflectPal thus served as a learning tool to increase their own awareness of how they reflect on their own actions. The fact that DAs appear adequate to be introduced as a learning tool to meta-reflection creates a host of additional questions in relation to how to design DAs for this matter. As for now, the field of meta-reflection is an underexplored area within the HCI field, as the body of research covering design guides for this is close to non-existent. Research has focused on related areas such as meta-cognition [14, 15], self-reflection [19, 27], or reflective practice [13, 45]. Although overlaps are present between these research areas and meta-reflection, none of the mentioned areas entirely covers the specific act of reflecting on one's own reflection and accustoming to deeper and more structured reflection patterns. We see potential in further exploring the practice of meta-reflection, as this study has indicated that this could lead to a more meaningful reflection, by being able to monitor, assess, and adjust the act of reflection itself. In continuation, it is notable that the sequential presentation of questions is taken into account when assessing meta-reflection, as this way of imitating a conversation seems vital to enable the meta-reflection. By presenting little information at a time, participants are only granted room to reflect on the information presented to them, thus enabling a more in-depth reflection before moving on.

Limitations and Future Work

This study related to a few limitations that are significant to address. One limitation concerned the study's small scale and sample size by only having tested the application with 19 participants over a two-week period. In future work, scalability should be of priority, as an extended test period and a larger and more wide-ranging sample would increase both validity and generalizability to indicate long-term effects of reflecting with a DA and thereby provide a more general picture. Limitations towards the generalizability of the results are relevant to address, as this work solely examined challenges induced by collaborative activities in a university context, specifically in a Danish setting dominated by problem-based learning principles [12]. We thus position this study as an initial exploration to deploy and test an idea as a proof of concept. In future work, efforts should be made to uncover if similar applications as the one presented in this study are relevant and applicable to other domains (e.g., work or everyday life) in which collaboration is important.

The motivational factors related to the utilization of ReflectPal were not explored in this work. Results showed that few participants did not feel motivated to use ReflectPal at all, and others were only motivated to use it in proportion to the agreed minimum requirement. Moreover, the usage of the application did not represent a realistic situation, as a realistic situation would not necessitate instructing individuals on how and when to use it. It is unknown if participants would have felt motivated to use the application outside of this test-setting, and until this is explored, we can only ruminate about motivational factors. Results in this study showed that some participants preferred to reflect instantly after having experienced a collaborative challenge, where others preferred reflecting later in the day or week. In continuation of this, results also showed that some participants preferred to reflect on newly experienced situations where others reflected on situations that had happened years ago. From this, it was evident that participants had vastly different personal motivations for when they preferred to reflect. Undoubtedly, reflection can help alleviate challenges in collaborative contexts, but personal motivation is necessary for this to happen. Therefore, when designing for reflection it is significant to include motivational factors, especially to support long-term use. This could be done by implementing notifications to remind individuals to reflect or through nudging to explore how reflection could be a part of a routine.

Lastly, technical limitations concerning ReflectPal's application space also needs to be addressed, as several participants encountered problems with the installation of ReflectPal through Google Assistant, despite following a step-by-step installation guide. Encountering these problems during installation may have affected participants' overall user experience and attitude towards ReflectPal, as it led to participants being frustrated already before interacting with the application. Additionally, design limitations were also induced as a result of choosing Google Actions and Dialogflow to host the main logic. The five-second timeout limit of user inputs for each intent and the overall context having a fixed lifespan of 20 minutes, had the effects that we, to some extent, were restricted in

our design choices. We suggest that future work examine ways of preventing these technological implications, for example, by exploring other platforms to design DAs.

CONCLUSION

This study was formulated as a proof of concept to explore if DAs could be used to support reflection, and results merely provided indications on how reflection through self-assessment can affect individuals. Nevertheless, our results bear witness to demonstrate that DAs are more than sufficient to enable reflection. We introduced ReflectPal to provide initial insights on using DAs for individual reflection on collaborative activities. We presented a collection of collaborative challenges that provisionally demonstrated to be suitable for inducing reflection. Our two-week in-situ deployment showed that participants generally appreciated being introduced to a structured way of reflecting on their own behavior in collaborative activities and that structured reflection in some cases led to meta-reflection. Moreover, we found that purely voice-based interaction still faces some limitations in its current state, but that text-based input as a fallback option for how to interact seems like a way to accommodate this. An essential goal in sharing our findings has been to highlight trade-offs, encourage conversation about DA capabilities, and call attention to certain aspects of DAs and reflection, which are likely to benefit from more research. We highlight the following topics as subjects of interest for further investigation within this research area and within the field of HCI: meta-reflection; motivational factors of DA usage; the balance between generality and specificity; research beyond the Danish problem-based learning-oriented setting; as well as expanded work on the current technical limitations of DAs.

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