The Results of an Iterative Evaluation Process of an Mhealth Application for Rewarding Healthy Behaviour Among Older Adults

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Abstract. It is a challenge to find effective ways for supporting older adults to increase their levels of physical activity and develop habitual physical activity behaviours. Within the GOAL project, an mHealth intervention to motivate older adults to be active was developed, by blending the iterative design and the evaluation activities. The aim of this paper is to present the results of the iterative evaluation process of this mHealth intervention. Evaluation end-points were usability, user experience and potential effect. In total, four cycles of evaluation and redesign of GOAL were conducted in order to create value-adding technology, and demonstrate its impact. Each cycle contained test-weeks, weeks for data analysis, and time for technical modification. In total, 28 participants (students and older adults) interacted with GOAL for a total of 476 days and provided their feedback. During the process, various usability issues were solved to improve GOAL. The users rated the usability of GOAL as acceptable. Older adults were positive about the idea to encourage a healthy lifestyle by using GOAL. During the final evaluation cycle, GOAL encouraged older adults to be more active and motivated them to reach their daily goal.

Keywords: Older adults · eHealth · mHealth · Games · Rewards · Iterative design · Usability testing · Evaluation

1 Introduction

Despite the benefits of being physically active, the overwhelming majority of European older adults do not meet the minimum physical activity levels necessary to remain healthy

[1]. Unfortunately, a sedentary lifestyle is currently predominant in European older adults. Among older adults, inactivity and a sedentary lifestyle are linked to numerous negative health outcomes, comparable to the negative health outcomes of smoking, excessive alcohol intake and obesity [2, 3]. Being physically active has many benefits: it prevents the development of chronic health-related problems, it improves psychological well-being and social outcomes [4], and can slow down muscle loss and prevent a decrease in strength [5–7].

It is a challenge to find effective ways to support older adults to increase their level of physical activity and develop habitual physical activity behaviours. It is known that older adults are less interested in improving their health, but more interested in retaining the state of health they already possess [8]. Next to this, they are more interested in intrinsically enjoyable activities, such as group activities [9], as they emphasise fun and enjoyment of social interaction as a motivation to be physically active. The engaging nature of games can also provide motivating and enjoyable means to comply with exercises and to increase physical activity [10, 11]. Games can be provided to older adults in the old-fashioned way, such as board games, but also as mobile applications for their smartphone or tablet. The latter is facilitated by the rapidly increasing use of such technologies for health-related purposes [12] and gamification (the application of game elements to non-game field) can engage older adults to use, and keep using technology [13, 14].

Within the GOAL project, a new mHealth intervention to motivate older adults to be active was developed. This mobile application rewards healthy behaviour, such as being physically active, training the memory and participating in social activities, with GOAL coins [15]. These coins can be used in mobile games. In doing so, GOAL addresses the adoption of mHealth application that remains limited in the older population [16, 17]. To facilitate improvement of GOAL and its uptake by older adults, an iterative approach was followed [18]. In the GOAL development process, this iterative design (where technology is developed, tested, and then redesigned and improved, using multiple iterations) and evaluation activities blended into each other. The aim of this paper is to present the results of the iterative evaluation of an mHealth application for rewarding healthy behaviour among older adults on usability, user experience and potential effect.

2 Methods

In order for a technology to be pleasurable and meaningful, and thus, to be a success, it must be first and foremost be functional and reliable. In other words, the tool must work from a technological point of view. Then, when it is deemed functional and reliable, one can focus on usability. Only when functionality, reliability, and usability are evaluated to a satisfactory degree, the focus can shift to the user experience (including acceptance). For the evaluation of GOAL, we took a similar approach. When we test the technology with the target group (i.e., older adults), we want to make sure that the technology is of such a quality that it works properly and has a minimum level of usability. In order to achieve the latter, two evaluations were conducted in which participants with a high level of digital literacy interacted with GOAL. Based on these experiences, the usability and user experience of GOAL were improved. We applied this approach, so as not to

burden a vulnerable population with low digital literacy (older adults) with a technology that had potential usability flaws, which could easily be identified by conducting tests with an easy to find, non-vulnerable group of participants. Only when we were sure that GOAL functioned properly on a technological level, and had an acceptable level of usability, did we embark on tests with older adults.

2.1   The GOAL Technology

From the point of view of the end-user, GOAL consists of the two core components: the GOAL website and the GOAL mobile application. The Website is the "entry-point" to the platform. This website leads the end-user to a signup page for new users. Within the website the end-user is able to set up an account or log in using already existing credentials. Upon registration or login, the user is exposed to the main dashboard of the web application from which they are able to navigate to the main sections of the application including the wallet (providing an overview of GOAL coin transactions), the physical activity dashboard, games and access to a social marketplace.

The GOAL mobile application is the information centre that the user can use to get all GOAL-related info and access the different GOAL services. It offers users' profile management, an overview of the gained GOAL coins, an overview and access to the games and an overview of the social marketplace tasks. Uniquely for the mobile version, it also offers physical activity tracking. The information is summarized in an overview screen, from where the user can navigate to screens with additional details (see Fig. 1). In an earlier paper the GOAL technology is described in more detail [15].

Fig. 1.   Overview screen of the GOAL Mobile Application.

2.2 Overview of the Evaluation Cycles

In total, four cycles of evaluation and redesign of GOAL were conducted in order to 1) create value-adding technology, and 2) to demonstrate its impact. Every cycle contained test-weeks and weeks for analysis of test data and technical modification. Table 1 displays the different cycles, their aim, the methods that were applied and the participants that were recruited in each cycle.

Table 1. Overview of the aim, methods and participants of each evaluation cycles.

Cycle	Aim	Method (s)	Participants
1	Usability	Pretest: demographics and think aloud protocol Post-test: exit interview and questionnaires	Students
2	Usability	Pretest: demographics and think aloud protocol Post-test: exit interview and questionnaires	Students
3	Usability and user experience	Pretest: demographics and think aloud protocol Post-test: exit interview and questionnaires	Older adults
4	Usability, user and game experience and potential effect	Pretest: demographics Post-test: exit interview and questionnaires	Older adults

3 Cycle 1

Participants were asked to complete a pre-test assessment. First, they were asked to complete a short demographics questionnaire. Then, a concurrent think-aloud protocol was administered in which they had to complete four predefined tasks within GOAL while verbalizing their thoughts. The data acquired in this way was supplemented by the observations of a researcher. The tasks included:

– Task 1: Downloading the GOAL mobile application.
– Task 2: Setting up an account.
– Task 3: Visiting the GOAL website.
– Task 4: Pairing the GOAL mobile application with the external Activity Coach application.

These tasks reflected some of the central functionalities of GOAL. Participants had five minutes to complete each task. If they could not complete the task within that time or did not want to proceed, they proceeded to the next task. After carrying out all tasks, they filled out the System Usability Scale (SUS) [19].

During this first cycle of the evaluation, participants were asked to use GOAL for 7 days. After these 7 days, participants were invited for a post-test assessment. This post-test assessment started with a short semi-structured interview, in which participants were asked to share their ideas about GOAL. We discussed the advantages, the points of improvement and the experienced problems. After the semi-structured interview, participants were asked to complete the SUS again.

Both the pre- and post-test assessment had an average length of 30 min. The tests were conducted in a usability lab. Each test was performed in a closed room to minimize distraction. Audio recordings were made during the tests. All participant gave informed consent prior to pre- or post-test assessment.

3.1 Technology

During the first cycle, a basic version of GOAL was used. This version included the GOAL mobile application and the Activity Coach application. The GOAL mobile application consisted of a dashboard presenting four functionalities: activity tracking, coin collecting, playing games, and challenging other users. The Activity Coach is a mobile application that can be paired with a commercial activity tracker and digital weighing scale to count steps and track weight. Next to the mobile application, the end-user had access to the GOAL website. This website leads the end-user to a signup page for new users. Within the website, the end-user is able to set up an account or log in using already existing credentials.

3.2 Participants

In total, ten participants were recruited for the first cycle of the GOAL evaluation. In the Netherlands five participants were recruited for pre- and post-test, although one did not participate in the post-test. In Greece, five participants were recruited who only participated in the post-test evaluation. During the evaluation of GOAL, we did not want to unnecessarily burden the target population (community dwelling older adults). As the maturity level was uncertain and multiple usability issues were expected, students and colleagues were asked to participate. Of the all participants, four were male and six were female. Their age was, on average, 29 years (range between 23 and 41 years old).

3.3 Pre-test Assessment

Usability Issues: During the pre-test, the participants had problems with executing the four basic tasks. Participants had problems with finding the GOAL mobile application in the Google Play Store. Additionally, participants preferred receiving feedback when having successfully registered. Participants also indicated that they were unaware of the term "stride length". However, participants thought the ability to update their profile through the settings menu was intuitive. When going to the website, participants noticed that it was not optimized for use on the mobile phone, although they indicated they would like to use the website on their phone. They would find it convenient to have a link to the website in the mobile application.

Usability: Pre-test, the GOAL mobile application SUS scored was between 28 and 75 points. The average score on the SUS was 55 (SD 20.2) indicating that the usability is "ok".

3.4 Post-test Assessment

Praise for the GOAL Platform: The participants liked the potential to get a reward for being active. They indicated that it would be fun to track activities and set goals. The participants also liked the user interface of the mobile application, which, they stated, was easy to use and intuitive. One participant indicated that this mobile application could be possible interesting for children, especially when they are physically inactive.

Usability Issues: The participants indicated that none of the options were functional. The step counter did not work for them, it was unclear if they needed an external activity monitor to count steps, the participants could not collect any coins or set goals/tasks, and the games were not available yet.

Usability: Post-test, the SUS score changed, the four participants recruited in the Netherlands rated the GOAL mobile application between 43 and 68 and an average score of 56 (SD 10.5, n = 4). Together with the five participants from Greece, the usability of the GOAL mobile application was rated "ok" (SUS score 70 (SD 17.6)).

4 Cycle 2

For the second cycle of the GOAL evaluation, we followed the same methods as described for the first cycle. However, one of the tasks to be performed during the pre-test to assess the usability of GOAL was changed (task 4). The participants had to complete the following four tasks:

– Task 1: Downloading the GOAL mobile application.
– Task 2: Setting up an account.
– Task 3: Visiting the GOAL website.
– Task 4: Pairing the GOAL mobile application with one of the available games ("Let's Quiz!" or "Pair me!").

4.1 Technology

During the second cycle, a GOAL mobile application with several updates (mainly bug fixing) was used. This version of the GOAL mobile application could be paired with the Activity Coach and could be paired with two games that could be downloaded from the Google Play store: "Let's Quiz!" and "Pair Me!"

4.2   Participants

Considering the outcome of the first cycle of the GOAL evaluation and the number of requests for improvement, we decided to invite students to participate again. To evaluate the improvements of the GOAL platform, the participants of the first cycle were asked to also participate in this second cycle. Additionally, new participants were recruited in both the Netherlands and Greece. In total, 13 participants completed the second cycle. Of the participants, 5 were male. Their average age was 29.1 years old (range of 16–47 years).

4.3   Pre-test Assessment

Usability Issues: The participants still had several problems with the execution of the four basic tasks. Participants again had problems with finding the GOAL mobile application in the Google Play store, and indicated that it was unclear whether and how they could save the entered profile details. The participants viewed the website on a laptop and found the design nice and clean, with clear headings. Participants liked that they could find the games in the GOAL mobile application, although they would like to receive a confirmation that they successfully connected the game to the GOAL mobile application. It was suggested to integrate the games into one app package with the GOAL mobile application, so no separate downloads would be necessary.

Usability: The GOAL mobile application SUS score was between 40 and 85 points. The average score on the SUS was 61.5 (SD 21.8) indicating that the usability is "ok".

4.4   Post-test Assessment

Praise for the GOAL Platform: The participants who also participated in the first cycle of the GOAL evaluation claimed that the updated mobile application was clearly improved. Setting-up the account was very intuitive, and participants found the explaining texts about stride length and other entries useful. Two games were now available to play and participants enjoyed to play the quiz. Moreover, participants were happy that their scores from the games also appeared in the GOAL mobile application. Participants also liked the way their activity level was represented; the graphs were informative and it was nice to have different representations of activity levels.

Usability Issues: Participants did not collect any coins, nor understood how they could collect coins. Moreover, despite being able to set tasks, it was hard to understand what could be done with them. Some participants mentioned that the step counter did not work at all, others thought it only worked after opening the mobile application, and a few stated that the step counter was not accurate. "Let's Quiz!" appeared to have some bugs; questions were repeated, too hard, or contained errors. Four participants who had already participated in the first cycle, mentioned that they forgot their password and would like a 'password reset' button.

Usability: During the post-test, the SUS scores changed. The nine Dutch participants rate the GOAL mobile application between 32 and 80, with an average score of 58.2 (SD 12.8, n = 9). The four participants from Greece rated the GOAL mobile application between 72.5 and 80, with an average score of 76.3 (SD 3.2, n = 4). Taken together, the post-test SUS score averaged at 65.7 (SD 17.0, n = 13).

5   Cycle 3

For the third cycle of the GOAL evaluation, we followed the same methods as described for the first and second cycle. The tasks to be performed during the pre-test to assess the usability of the GOAL platform were the same. However, to assess the end-user experience we asked the participants to complete post-test after the short semi-structured interview a questionnaire focusing on end-user experience. This questionnaire with summated rating scales was based on the Technology Acceptance Model (TAM) [20]. We expanded TAM with factors that have been found to shape the user experience of mHealth technology: enjoyment [21], aesthetics [22], control [23], and trust in the technology [24].

5.1   Technology

During the third cycle, a GOAL mobile application with several updates was used. The features of the GOAL mobile application were expanded. In this version the activity tracking was optimized by the option to switch for activity tracking to the Activity Coach app (which incorporates steps data from a Fitbit tracker). Next to this, improvements were made to various charts to present GOAL activities and the level of daily activity to the user. Last, in this version of the GOAL mobile application it was feasible to manually create and reward tasks within the social marketplace.

5.2   Participants

After cycle 1 and 2 of the GOAL evaluation, the maturity level of the technology was sufficient to ask community dwelling older adults to use the technology for a longer period of time (1 week). In total, eight participants completed the third cycle. Initially, fifteen community dwelling older adults agreed to participate, but three owned an incompatible smartphone, two did not have or did not use a smartphone, one decided to withdraw, and one had health problems during the evaluation sessions. Two participants were female. The average age was 72 (range 69–76) and five participants completed higher education. The participants were members of a panel that is aimed to involve older adults in eHealth design.

5.3   Pre-test Assessment

Usability Issues: During the pre-test, seven participants managed to download and install the mobile application. One participant did not manage to do so. Some participants mentioned they had never used the Google play store to download and install a

mobile application. When creating an account, the participants struggled with finding the registration screen and typing the password twice, and two participants asked whether the password needed to fulfil requirements. The GOAL mobile application crashed several times when attempting to fill in the user's weight in the profile section, and many participants struggled with filling in the profile details (they had trouble with finding the next profile section, saving the profile details, and scrolling to the right date of birth). When going to the GOAL website on a computer, four participants managed to find the login page without help. Logging on to the website appeared to be troublesome, because many participants could not read where to enter the details, due to a low contrast between letters and background. Two participants wanted to have bigger letters, but three older adults indicated they liked the simple design. Two older adults did not understand how to return to the main dashboard. All participants could install the game and login, although the login screen was unintuitive.

Usability: The GOAL mobile application SUS score was between 55 and 80 points. The average score on the SUS was 70 (SD 8.5) indicating that the usability is "ok".

5.4   Post-test Assessment

Praise for the GOAL Platform: Half of the participants enjoyed the games, and three older adults indicated they would like to use the mobile application if it would actually count steps accurately. The dashboard was perceived as simple and basic, with a nice overview of everything. Older adults also enjoyed looking at how many steps they took, with one person considering the idea of collecting coins for fun.

Usability Issues: Five participants indicated that the step counter did not work and did not count steps at all. Two participants indicated that they do not carry their phone all the time, and one would prefer to have a watch. Some participants did not understand MET minutes, the red line in the activity graph, and two participants preferred more explanations about the menu and functions of the GOAL mobile application. Three participants indicated they would like to record cycling as well, and a Dutch mobile application version was also preferred. The participants did not specifically like collecting coins, and many did not collect coins as their step counter did not work. None of them used coins in the games. Two older adults forgot their password and could not use the memory game.

Usability: At the post-test, the SUS score changed. The eight participants rated the GOAL mobile application between 40 and 87.5, with an average score of 65.6 (SD 15.7, n = 8). This is slightly lower than pre-test score.

User Experience: The scores on the user experience are presented in Table 2. Indicating the wide range, the opinions of the participants were very diverse. Overall, their opinion on the user experience determinants was neutral. However, five participants indicated that the mobile application was "easy to use".

Table 2. User experience score of evaluation cycle three.

	Range	Average	Attitude of participants (n) towards the GOAL platform		
			Positive	Neutral	Negative
Enjoyment	1.8–4.5	3.3 (SD ± 0.9)	1	7	0
Aesthetics	1.5–5.4	3.4 (SD ± 1.1)	1	6	1
Control	2.0–6.7	4.0 (SD ± 1.6)	2	4	2
Trust in technology	2.0–4.5	3.4 (SD ± 0.8)	1	7	0
Perceive usefulness	2.0–5.0	3.0 (SD ± 1.1)	3	5	0
Ease of use	1.0–6.0	3.0 (SD 2.0)	5	2	1
Intention to use	1.8–4.5	3.3 (SD ± 0.9)	1	7	0

5.5 Focus Groups

During cycle 3 of the GOAL evaluation, we also discussed GOAL with a group of older adults from a local elderly association. After an introduction of the GOAL technology, the older adults were asked to share the advantages and disadvantages they saw, and their ideas concerning the possibility to earn GOAL points.

In total, 21 older adults participated during the two focus groups. The majority of the participants were male (62%). The average age of participants was 72 years old (SD ± 3.7 years; range 64–79 years-old). As advantages, the majority of the participants (52%) mentioned the aim of the technology to encourage a healthy lifestyle. Next to this, seven participants mentioned that the fact that GOAL is free to use (no financial reimbursement). Another five participants mentioned that they liked the idea to learn something new and experienced using GOAL as fun or a nice challenge. As disadvantages, participant mentioned the fact that the GOAL mobile application is only available for Android smartphones (nine participants) and that the GOAL mobile application is mainly in English (five participants). As another disadvantage it was mentioned that the target population is partly reluctant towards playing mobile games (five participants).

Thirteen participants, claimed that maintaining health could be the biggest reward when using GOAL. Another reward that was mentioned is "making progression visible" (by seven participants). Next to this, four participants experienced being active as a reward in and of itself. With respect to earning GOAL coins, eight participants claimed that they wanted to earn GOAL coins by being physically active. Last, the participants were asked how they would like to spend the GOAL points they earned. Nine participants would like to receive a gift card for (digital) books/newspapers (n = 3), for things related to their hobby (n = 5), or to buy new technology (n = 1). Four participants would like to help others or a charity, one participant would like to spend coins on activities with his/her grandchildren, and one participant would like to receive a discount on his/her health insurance. Finally, eight participants had no interest in spending earned GOAL coins.

6 Cycle 4

Various improvements were made after the third cycle. As the primary focus of cycle 3 was on usability and user experience, limited data was gathered on the actual use of the technology. Therefore, cycle 4 focused on the use of GOAL by the target population (community dwelling older adults) with pre-installed technology on a Samsung S3 smartphone and a Fitbit Alta step counter. During pre-test, participants were instructed on how to use the smartphone with the pre-installed mobile application and the Fitbit. They put the Fitbit on their wrist and were told to synchronize the Fitbit with the smartphone every day. During pre-test, the participants completed several questionnaires:

– The revised Sports Motivation Scale (SMS-II) [25], a validated instrument for assessing sports motivation; a domain closely related to adopting a healthy lifestyle. [26]
– The Physical Activity Scale (PAS) [27], a scale in which respondents indicated the hours per day spent in nine different activity categories, ranging from sleeping and resting, to running and playing tennis.
– A health literacy questionnaire [28], with three questions three focused on respondents' confidence and need for help in understanding health information

The participants were asked to use the Fitbit and smartphone for at least two weeks in their normal life. They could use the GOAL mobile application at their own discretion. A post-test assessment was scheduled fourteen days later. During the post-test interview, participants expressed their general experience with the GOAL application, completed the System Usability Scale, and the TAM section of the User Experience Questionnaire from previous cycles, with the addition of several questions on likeability and motivation. Last, during a semi-structured interview, participants addressed the separate components of GOAL. The post-test assessment had an average length of 45 min. Audio recordings were made during the tests. All participants gave informed consent prior to pre-test assessment.

6.1 Technology

During the fourth cycle, a GOAL mobile application with several updates was used. The social marketplace feature was improved extensively. For instance, task invitations could be ignored, task creators could delete pending tasks and past tasks were listed in a new screen. Next to this, there was a redesign of the UI of the GOAL mobile application and bugs were fixed. Last, a gamification layer (Island Exploration game) was available. This game rewarded end-users with mini games when the daily step goal was reached.

6.2 Participants

In total, fifteen participants were included in this evaluation. Seven of them also participated in the third evaluation cycle. Of these participants, eight were male and seven were female. Their average age was 69.6 ± 5.4 years (range 59–78). Nine participants completed higher education, and fourteen lived together with a partner. All participants

answered the eleven questions regarding their motivation to live healthy [26]. From this questionnaire, it appeared that eleven participants were intrinsically motivated to live healthy. The average health literacy score was 0.76 ± 0.1 on a 0–1 scale. The average estimated MET (metabolic equivalent) per 24-h day was 46.4 ± 8.2 (range 31.1–58.2), which falls right below the 49.66 as measured by Aadahl and Jørgensen [27] in 39 Danish men and women from the age range 20–60.

6.3 Post-test Assessment

Praise for the GOAL Platform: Most participants enjoyed seeing their step count and activity level and many of them were motivated to go for a walk if they saw that they had a low step count. Even older adults who indicated they were not motivated by the numbers, stated that they sometimes went for an extra walk to make some additional steps. Meeting the step goal was challenging for some, but older adults also enjoyed reaching their goal.

Some participants mentioned they enjoyed playing the games; especially Let's Quiz received positive feedback. Pair Me was also perceived as fun and a few older adults indicated they enjoyed the mini game in the Island Exploration game. One person would definitely buy the GOAL mobile application if it became available.

Usability Issues: The participants did not have to install the GOAL mobile application themselves, so no feedback could be provided on downloading and installing the app. Each participant used the GOAL mobile application in combination with a Fitbit that needed to be synchronized with the smartphone using the Fitbit app every day. This caused some problems, as the Bluetooth connection between the Fitbit and the smartphone did not always work.

Unfortunately, technical problems biased the opinion of some participants, while other participants experienced fewer problems. Using the Fitbit also influenced the feedback, since several participants only checked their step count on the Fitbit watch and app, as they said it was easier.

Some participants had technical problems with receiving GOAL coins in the GOAL mobile application. However, many of them expressed that they did not look at how many coins they collected, so they did not notice that they had not received any. Some other participants, who had not this technical problem, also indicated they did not look at the number of coins they received. Reasons for this were that they did not know what to do with these coins, they received too many coins for it to be interesting, or earning coins did not motivate them to be more active and/or use GOAL.

Usability: The GOAL mobile application scored between 27.5 and 97.5 points on the SUS (n = 15). The average score on the SUS was 68 ± 15 indicating that the usability is "ok".

User Experience: The score on the user experience are presented in Table 3. As can be seen from the wide range, the opinions of the participants (n = 15) were very diverse.

Willingness to Pay: Participants indicated their willingness to pay by choosing from the following options: One time 0, 5 or 10 euros, and 2, 5 or 10 euros per months. Very

Table 3. User experience score of the cycle 4.

	Range	Average	Attitude of participants (n) towards the GOAL platform		
			Positive	Neutral	Negative
Ease of use	1–6.5	3.8 ± 1.8	4	8	3
Intention to use	1–7	3.9 ± 1.7	4	8	3
Perceived usefulness	1.5–6	3.2 ± 1.1	3	11	1

few participants (n = 2) would be interested in paying a monthly fee. Six participants were interested to pay a onetime fee of 5 euro (n = 3) or 10 euro (n = 3) and also six participants were not willing to pay for the GOAL mobile application at all.

Gaming Experience: The opinions about games being included in GOAL were diverse. Some participants indicated that they enjoyed the memory game and almost half of the older adults had played the quiz and thought it was fun to do. The older adults who had played the quiz made the following comments: The questions do not fit the target group, the same questions appear repeatedly after a while, and the font size is too small for comfortable reading. The memory game caused problems, as participants claimed that they were logged out of the game and found it too much trouble to log in again. The Island Exploration game lacked an explanation; participants indicated that they did not know how to start a mini game, or how to play it.

We also asked the participants how they liked the separate components GOAL. They rated the GOAL mobile application, PairMe!, Let's Quiz, and the GOAL Island Exploration game on a scale of 1 to 7 (very fun to very dull). The scores are presented in Table 4.

Table 4. Likeability scores for the four components GOAL.

	Range	Average (1 = very fun, 7 = very dull)
GOAL mobile application	1–6	3.1 ± 1.8
PairMe	1–5	3.2 ± 1.1
Let's quiz	1–6	3.3 ± 1.7
Island exploration game	1–6	3.6 ± 1.4

Motivation: The participants indicated how they were motivated by the GOAL mobile application to be more active and rated three statements on a scale of 1 (completely agree) to 7 (completely disagree) (Table 5). It became apparent that participants feel motivated by GOAL in general, but not by collecting coins or by playing the Island Exploration game.

Table 5. Scores on three statements about motivation to be more active.

	Range	Average (1 = agree, 7 = disagree)
GOAL motivated me to be more active	1–5	2.5 ± 1.6
Receiving GOAL COINS motivated me to be more active	4–7	5.1 ± 1.3
The Island Exploration game motivated me to be more active	4–7	5.1 ± 1.2

7 Discussion

The aim of this paper is to present the outcomes of the iterative development and evaluation of an mHealth application for rewarding healthy behaviour among older adults. In total, 28 participants (students and older adults) interacted with GOAL for 476 days and provided their feedback for improving the technology. During the iterative cycles, various usability issues were solved to improve the usability of the GOAL platform. In the end, the usability of the GOAL platform was acceptable. The aim of GOAL is to motivate the target population (older adults) to live an active life. During the focus groups, the majority of the participants were positive about the idea to encourage a healthy lifestyle by using GOAL. And during the final evaluation cycle, most participants enjoyed seeing their step count and activity level and many were motivated to go for a walk if they saw that they had a low step count. Older adults enjoyed reaching their goal and felt motivated by GOAL in order to be more active.

For this study an iterative approach was followed. In four iterations, the technology was developed, evaluated with end-users, and redesigned. An advantage of this approach is the possibility to tailor GOAL to the specific environment and skills of the older adults. This will, following Broens et al. 2007 [29], maximize the probability of successful implementation. However, successful implementation of technology is not a purely technical topic and multiple aspects need to be taken into account. In general, the acceptance of technology by older adults is based on four aspects: individual aspects, technology aspects, social aspects and delivery aspects [30]. During our evaluations, we mainly focused on technology factors (design and functional features that affect how older adults interact with technology) and individual factors (characteristics of older adults as individual users that affect their interactions with technology). To get a broad overview of the acceptance of GOAL by the older adults it will be good to focus in further studies on the social (expectations and needs that arise from the social and cultural contexts that older adults are in) and delivery (ways in which technology is communicated and distributed to older adults for purchase and use) factors.

An iterative approach is an important component in the development and successful acceptance of eHealth [18]. However, it is not very common in the literature on usability testing to address multiple iterations in one study. A recent scoping review by Maramba et al. 2019 [31] found that in less than a third of the included studies at least two iterations were discussed. This could be due to the possibility that iterations had already

taken place prior to the study has being reported [31]. It would be valuable when this kind of information was reported and more information was provided on previous iterations.

As participating in this evaluation of GOAL was voluntary, the selection bias of the subjects is a weakness of this study. The majority of the older adults who were willing to participate, were technology-minded and had the basic skills to use a (smart) phone, tablet or laptop. To assess the usability of GOAL we used the SUS. It was recently found that this instrument is not optimal as a stand-alone usability benchmark for eHealth [32]. Therefore, we also assessed the usability of GOAL by a Think-Aloud protocol to determine the usability issues. For this protocol the participants had to complete several takes, unfortunately we did not report on the task completions or the time to complete the requested task, as this would be a more mature method to test the usability of GOAL.

8 Conclusion

In this paper we have reported on a series of evaluations of different prototypical versions of GOAL. Results show that usability and user experience are satisfactory, but that there is still room for improvement. Results on potential effectiveness suggest that the technology can fulfil its goal: making older adults more active and lead a healthier lifestyle. Combined with the fact that there is willingness to pay shows that the concept of GOAL is evaluated positively, and that, at the current moment, the technology has a satisfactory maturity level.

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