Integrating top-down and bottom-up requirements in eHealth development: The case of a mobile self-compassion intervention for people with newly diagnosed cancer

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Integrating top-down and bottom-up requirements in eHealth development: The case of a mobile self-compassion intervention for people with newly diagnosed cancer

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Abstract

Background: Psychosocial eHealth interventions for people with cancer are promising in reducing distress, however their results in terms of effects and rates of adherence are quite mixed. To overcome this, developing interventions with a solid evidence base is recommended, while still ensuring adaptation to user wishes and needs. Since most models of eHealth development are based on examining user experiences only (bottom-up requirements), it is not clear how theory and evidence (top-down requirements) may best be integrated into this process.

Objective: To investigate the integration of top-down and bottom-up requirements in the co-design of eHealth applications, by building on a case study of the development of a mobile self-compassion intervention for newly diagnosed cancer patients.

Methods: Four co-design tasks were formulated at the start of the project and adjusted and evaluated throughout: 1) explore bottom-up experiences, 2) reassess top-down content, 3) incorporate bottom-up and top-down into concrete features and design, 4) synergize bottom-up and top-down into intervention context. These tasks were executed iteratively during a series of co-design sessions over the course of 2 years, in which 15 patients and 7 nurses (recruited via 2 hospitals) participated. Based on these sessions, a list of requirements, a final intervention design and an evaluation of the co-design tasks was yielded.

Results: The final list of requirements included intervention content (e.g. main topics of Compassionate Mind Training such as psycho-education about three emotion systems, main issues that patients encounter post-diagnosis such as regulating information consumption), navigation, visual design, implementation strategies and persuasive elements. The final intervention ‘Compas-Y’ is a mobile self-compassion training that consists of six training modules and several supportive functionalities such as a mood tracker and persuasive elements such as push notifications. The four co-design tasks helped to overcome challenges in the development process such as dealing with conflicting top-down and bottom-up requirements, and enabled the integration of all main requirements into the design.

Conclusions: Our study addresses the necessary integration of top-down and bottom-up requirements into eHealth development, by examining a preliminary model of four co-design tasks. Broader considerations regarding designing a mobile intervention based on traditional intervention formats and merging the scientific disciplines of psychology and design research are discussed.

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Background: Psychosocial eHealth interventions for people with cancer are promising in reducing distress, however their results in terms of effects and rates of adherence are quite mixed. To overcome this, developing interventions with a solid evidence base is recommended, while still ensuring adaptation to user wishes and needs. Since most models of eHealth development are based primarily on examining user experiences (so-called ‘bottom-up’ requirements), it is not clear how theory and evidence (so-called ‘top-down’ requirements) may best be integrated into the development process.

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Methods: Four co-design tasks were formulated at the start of the project and adjusted and evaluated throughout: 1) explore bottom-up experiences, 2) reassess top-down content, 3) incorporate bottom-up and top-down into concrete features and design, 4) synergize bottom-up and top-down into intervention context. These tasks were executed iteratively during a series of co-design sessions over the course of 2 years, in which 15 people with cancer and 7 nurses (recruited via 2 hospitals) participated. Based on the sessions, A) a list of requirements, B) a final intervention design and C) an evaluation of the co-design process and tasks was yielded.

Results: A) The final list of requirements included intervention content (e.g. main topics of Compassionate Mind Training such as psycho-education about three emotion systems, main issues that people with cancer encounter post-diagnosis such as regulating information consumption), navigation, visual design, implementation strategies and persuasive elements. B) The final intervention ‘Compas-Y’ is a mobile self-compassion training that consists of six training modules and several supportive functionalities such as a mood tracker and persuasive elements such as push notifications. C) The four co-design tasks helped to overcome challenges in the development process such as dealing with conflicting top-down and bottom-up requirements, and enabled the integration of all main requirements into the design.

Conclusions: Our study addresses the necessary integration of top-down and bottom-up requirements into eHealth development, by examining a preliminary model of four co-design tasks. Broader considerations regarding designing a mobile intervention based on traditional intervention formats and merging the scientific disciplines of psychology and design research are discussed.

Keywords: eHealth; cancer; self-compassion; co-design; requirements; evidence-based
Introduction

Receiving a cancer diagnosis and going through treatments can disrupt many aspects of a person’s life, often affecting not only one’s physical, but also one’s mental and social well-being [1-6]. Psychological interventions for people with cancer are effective in reducing symptoms of distress and improving well-being, and are mostly delivered face-to-face, in individual or group format [7-10].

While face-to-face interventions may offer important benefits such as live social support, they are often not adopted by people with cancer. People with cancer already face many demands including medical appointments, and reasons for not participating in available interventions include the burden of travel, too many competing demands, and not feeling well enough to join sessions [11]. Interventions delivered through technologies such as eHealth may offer unique benefits such as increased accessibility and scalability [12], thereby reaching people who may not have otherwise participated. In addition, offering interventions in a mobile format may help with integration of newly learned skills into daily life, since most people nowadays carry their mobile device(s) throughout daily activities [13].

While eHealth interventions appear to be similarly effective in reducing mental distress compared to traditional intervention formats [14, 15], results regarding the effects of psychological eHealth interventions in the context of cancer are still mixed [16, 17], with varying rates of adherence [18]. Particularly when it comes to mobile interventions, many lack a solid foundation of theory and evidence [19]. To improve effectiveness and adherence, more theory and evidence-driven interventions are recommended [17, 19-22]. Simultaneously, it is important to take into account people with cancers’ wishes, needs and daily life, to increase the chance that the intervention is successfully adopted by the target group [23, 24]. Thus, what is needed to facilitate intervention success is an integration of both theory and evidence-based requirements (which we will call ‘top-down’, i.e. from the ‘abstract’ sphere of theory and evidence down to ‘concrete’ experiences of daily life) and people with cancers’ experience-based requirements (which we will call ‘bottom-up’, i.e. going from ‘concrete’ experiences of daily life up to ‘abstract’ theory and evidence).

This integration of top-down and bottom-up requirements may be facilitated by co-design. Co-design is a collaborative creative process through which members of the target group and stakeholders become active participants in intervention design rather than the mere reactive subjects of user-centered design. In co-design, the user is not a passive object of study through observations or interviews only, but an expert of their experience, with the researcher as a facilitator [25, 26]. Top-
down requirements could be introduced into the co-design process by the researcher or by other experts. While in medical and behavioral research top-down requirements for interventions are common [27, 28], existing frameworks of eHealth development are predominantly based on bottom-up requirements and user-centered design (see [29] for a review). It is thus not clear how top-down requirements can be optimally integrated into the co-design process. Without proper integration, one problematic outcome could be an intervention with content and design that people like to use but which has no ground in scientific evidence. Another problematic outcome could be an application in which the scientific evidence dominates the final solution, while experience-based requirements (gathered early on in a project) are neglected or overruled by the project team. Therefore, our overall objective is to use the process of co-design to have top-down and bottom-up requirements and stakeholders explicitly meet and engage in a design conversation, leading to a coherent, integrated intervention which acknowledges the value of both types of requirements.

To meet this objective, we build on the case of the co-design of a mobile self-compassion intervention for people with newly diagnosed cancer. While most of the discussed psychological interventions for people with cancer are based on cognitive behavioral techniques or mindfulness, compassion-based interventions for people with cancer are rapidly emerging [30]. These interventions focus on developing compassionate acceptance of suffering and the motivation for alleviating distress. Participants of various compassion-based interventions have reported increased acceptance of the illness and limitations, improved emotion regulation skills and reduced feelings of isolation [30], making this type of intervention particularly relevant in the context of cancer. Indeed, our initial pilot study showed that people with cancer evaluated self-compassion as important and that they would prefer to receive an intervention shortly after diagnosis and in the form of a smartphone app [31].

Thus, the aim of our co-design study is to create an eHealth intervention that is grounded in both: 1) theory and evidence-based requirements, e.g. founded by established compassion-based interventions such as Compassionate Mind Training [32] (i.e., top-down requirements) and 2) experience-based needs, wishes and requirements of people with cancer and oncology nurses (i.e., bottom-up requirements). To achieve this integration, a set of co-design tasks are devised and evaluated throughout the development process. The co-design study will yield A) a list of integrated top-down and bottom-up requirements, B) a final design of a mobile self-compassion intervention for people with newly diagnosed cancer and C) an evaluation of the co-design process and tasks. Based on these outcomes, we will discuss the potential relevance of our co-design approach as a preliminary model of integrating top-down and bottom-up requirements in eHealth development.
Methods

Study design

As recommended by the CeHRes Roadmap approach to eHealth development, the design and development process constituted a participatory approach using continuous cycles of evaluation [29]. Throughout this process, co-design methods were employed in which people with cancer and oncology nurses served as the experts of their experience [25]. The study was led by a project team consisting of researchers with a background in either psychology (including health psychology and compassion science) or design, as well as patient advisors, oncologists, clinical psychologists, and software developers.

A-priori outline of co-design tasks and top-down requirements

Informed by existing eHealth development frameworks (see [29] for a review), we adapted our approach to focus explicitly on the integration of top-down and bottom-up requirements. Accordingly, an outline of co-design tasks was formulated by the project team at the start of the project and adapted throughout the development process, resulting in the following four iterative co-design tasks: 1) explore bottom-up experiences, 2) reassess top-down content, 3) incorporate bottom-up and top-down into concrete features and design, 4) synergize bottom-up and top-down into intervention context (see Table 1 for an overview). These tasks were executed during a series of co-design sessions, as described below. Additionally, to explore in-depth personal accounts of experiences with self-compassion post-diagnosis, the development of intervention content was conjointly informed by semi-structured individual interviews with people with cancer [33].
Table 1. Four iterative co-design tasks to enable the integration of top-down and bottom-up requirements.

| No. | Co-design task | Description |
|-----|----------------|-------------|
| 1   | Explore bottom-up experiences | Acquire input on experienced challenges and facilitators (in general and in relation to top-down scope) and the most important targets and topics for the intervention according to participants. |
| 2   | Reassess top-down content | Assess top-down content in the context of user recognition, appreciation and suggestions for alterations. Make adaptations to top-down content according to the needs and vocabulary of users, and reframe user wishes based on top-down content. |
| 3   | Incorporate bottom-up and top-down into concrete features and design | Specify and integrate bottom-up and top-down requirements, by translating them into concrete features and design and tangibly explore similarities and differences. Assess which bottom-up features are put forward by participants, and how participants experience features derived from top-down requirements. Discuss and prioritize requirements (by means of co-design exercises and trade-off decision making strategies). |
| 4   | Synergize bottom-up and top-down into intervention context | Focus on synergizing requirements into all levels of the intervention context. Matching the overall structure of the intervention (e.g. ordering, logic, main interface), communication channels (e.g. level of external support) and interaction flow to both the top-down requirements (e.g. regarding intervention rationale, implementation factors) as well as bottom-up requirements (e.g. regarding routines and life patterns of the user and stakeholders). |

Prior to the start of the co-design sessions, top-down requirements were formulated for the self-compassion intervention based on existing compassion theory and evidence on compassion-based interventions (for an overview of intervention elements and evidence of effectiveness, see [30]), as well as on characteristics of effective eHealth interventions. Compassionate Mind Training served as a main framework for the intervention, which uses an evolutionary-based model of three emotion systems, and focuses on understanding our minds and emotions; developing feelings of compassion (including for experienced self-criticism) and compassionate acceptance; developing skills such as mindful awareness and compassionate imagery [32, 34, 35]. There is increasing evidence that Compassionate Mind Training, offered as part of Compassion Focused Therapy or in non-clinical form, is effective in improving well-being and reducing distress in general and chronically ill populations [30, 36-38]. In addition, exercises from positive psychology and Mindful Self-
Compassion training [39] were included in the development process. Furthermore, characteristics that are known to promote the effectiveness of and adherence to eHealth interventions were considered as top-down requirements, in particular persuasive design principles such as self-monitoring, receiving rewards and social support [40]. In addition to compassion-based intervention content, compassion as a design value was considered a top-down design requirement. In face-to-face compassion training or therapy, the trainer/therapist models compassion throughout the training process (i.e., with compassionate responding to difficulties, de-shaming of experiences) [41]. An aim for the development process was to model compassion throughout different features and content of the intervention (e.g., providing compassionate feedback when a user indicates high suffering; see also [42] for a discussion of how compassion may be enabled by technology). Taken together, this input formed the theoretical starting point for the co-design sessions (i.e., it provided the general frame and scope of the challenge to be explored with participants) and was introduced during various co-design exercises, particularly in the task ‘Reassess top-down content’ (see Table 2 for an overview of these co-design exercises).

**Participants and procedures**

Participants for the co-design sessions were recruited via two participating hospitals (one community and one university hospital). Eligible participants were adults with any form of cancer diagnosed between 6 and 24 months ago, who were willing to participate in one or more sessions and had sufficient command of the Dutch language. In addition, oncology nurses who work with these people with cancer were selectively recruited by the projects’ consulting oncologists. People with cancer received a study information leaflet from oncology nurses during regular consultations, which contained an overview of study procedures and referred them to the study website for information about the study, privacy-regulations, contact opportunities and sign-up. Included were 15 people with cancer (8 female, 7 male, aged 29-64 years), diagnosed between 6 and 24 months ago with a form of cancer (breast cancer *n*=6, all other forms *n*=1 each); and 7 oncology nurses (4 female, 3 male, aged 31-54 years) with 9 to 28 years of experience in working with people with cancer.

**Ethical considerations**

Written informed consent was obtained from all participants at the start of their first co-design session. Consent for visual recordings (photo or video) was reconfirmed at each occasion (verbal or written). The study was ethically approved by the authors’ institutional review board (no. BCE18853).
Co-design sessions

Seven rounds of co-design sessions were conducted during a period of two years (November 2018 – November 2020). At each session, 2-3 oncology nurses, 3-6 people with cancer and 2-3 facilitating researchers were present. The seven sessions were conducted twice, with participants from two distinct geographical areas (i.e., the two hospitals), once at a university medical center and once at a university. Each session lasted between 2 and 3.5 hours (session duration was adapted based on energy levels of participants). The last round of sessions was delayed and partially conducted online due to the COVID-19 pandemic. Sessions generally consisted of an introduction with a recap of the previous session, followed by an icebreaker creative exercise, two-to-three co-design exercises, a general discussion, and a concluding evaluation questionnaire. A mix of group and individual co-design exercises was employed to foster creative idea generation [43, 44]. A variety of co-design exercises was used, which could be categorized as “making tangible things” (e.g. creating 2-D maps, prototyping), “talking, telling and explaining” (e.g. card sorting, group discussions) and “acting, enacting and playing” (e.g. group games, roleplay) [44]. In contrast to user-centered design approaches in which user input is analyzed by researchers behind the scenes, input from the exercises was discussed, prioritized and summarized during the co-design sessions as much as possible, ensuring participants’ active role in the interpretation of the results. Small group exercises were conducted with people with cancer and nurses separately, after which outcomes were integrated in collective discussion and exercises. This approach was chosen to benefit from multidisciplinary perspectives while also creating a safe environment to share experiences among peers. In addition, participants occasionally engaged in exercises in between sessions in their home environment, e.g. usability testing of high-fidelity prototypes. Data were collected by means of physical materials from the co-design tasks (e.g., paper maps, post-its), as well as audio recordings, written notes and occasional video recordings.

The four co-design tasks were employed iteratively across sessions rather than only sequentially, thus encompassing components of different sessions. Study-specific session evaluation questionnaires addressed satisfaction, burden, inspiration, collaboration, learning new things, alignment with personal expertise, sense of involvement with the project and sense of influence over the design on a 5-point Likert scale with room for open-text input (e.g., “To what extent do you feel involved with developing a self-compassion app for people with cancer?”; see Multimedia Appendix 1). During the last session the full co-design process as well as the final design were evaluated with participants. See Table 2 for an overview of sessions, co-design exercises and tasks and Figure 1 for visual examples of paper materials utilized in the co-design exercises.
Table 2. Overview of sessions, co-design exercises and co-design tasks.

| Session | Co-design exercises                                                                 | Co-design task |
|---------|-------------------------------------------------------------------------------------|----------------|
| 1       | a) Mapping of individual obstacles and facilitators in dealing with the cancer       | Explore        |
|         |   diagnosis, visualized as rocks and ladders                                         |                |
|         | b) Mapping of support that was or was not present from oneself/own network/          | Explore        |
|         |   professionals after the diagnosis, using a card sorting method                      |                |
|         | c) Identifying individual moments of self-compassion and self-criticism on           | Explore        |
|         |   post-its in relation to the diagnosis, then categorizing them in groups            |                |
| 2       | a) Trying out self-compassion exercises in the two weeks prior to the session.      | Reassess       |
|         |   Building a desired app and an undesired app represented on paper smartphone models,| Explore        |
|         |   by categorizing and altering the self-compassion exercises                        |                |
|         | b) Identifying additional topics and exercises to be addressed in the app, by       | Explore        |
|         |   adding to and altering topics identified in the first session                     |                |
| 3       | a) Trying out other psychosocial apps in the week prior to the session. Presenting  | Integrate      |
|         |   the apps in small groups, highlighting positive and negative user experiences.     |                |
|         |   Creating a map of the similarities and differences in the experiences of          | Integrate      |
|         |   functionalities in these apps, focused on: filling out and sharing information,   | Synergize       |
|         |   motivational elements, feedback, personalization and mode of information           |                |
|         | b) Exploring language use in the app by playing a card game in which the story of  | Integrate      |
|         |   the app was presented in five different ways (based on metaphors) on five cards,  | Synergize       |
|         |   where participants “played out” their preferences                                 |                |
|         | c) Creating a diagram of the way the app could be offered and supported by nurses  | Integrate      |
|         |   (when/to whom/how/how often)                                                     |                |
| 4       | a) Shaping the flow of and processes within the app, using cardboard boxes          | Synergize       |
|         |   representing different app modules to write on and move around                    | Integrate      |
|         | b) Creating paper prototypes of parts of the app using both defined (e.g.           |                |
|         |   printed buttons) and undefined (e.g. random or blank stickers) materials         | Integrate      |
| 5       | a) Interacting with a low-fidelity prototype of a homepage and engaging with        | Integrate      |
|         |   different homepage designs represented on posters                                  | Synergize       |
|         | b) Roleplays around app implementation and app recommendation by nurses and people | Reassess       |
|         |   with cancer                                                                       |                |
|         | c) Interacting with a low-fidelity prototype of the content of an app module        |                |
|         |   in the form of a smartphone app as well as on paper                               | Integrate      |
| 6       | a) Refining wireframes and high-fidelity prototypes provided by the app developer   | Integrate      |
|         |   (also in participants’ home setting)                                              | Synergize       |
|         | b) Mapping implementation processes and challenges based on diagrams from           | Explore        |
|         |   session 3 (nurses only)                                                           |                |
|         | c) Generating ideas for peer tips and experiences to be included in the app         |                |
a) Evaluating the 'final' version of the intervention in terms of bottom-up requirements (with minor changes still implemented) using whiteboards

b) Evaluating the co-design process using interview methods amongst participants

Figure 1. Examples of paper materials utilized in the co-design exercises. Co-design exercises are described in Table 2; A: obstacle card (session 1, exercise a). B: desired and undesired app (session 2, exercise a). C: map of motivational elements (session 3, exercise a). D: cardboard boxes representing app modules (session 4, exercise a). E: poster of a homepage design (session 5, exercise a). F: card game about tips (session 6, exercise c).

Integrating top-down and bottom-up requirements

The final requirements were yielded from the four co-design tasks, during which initial ideas for requirements were processed and prioritized (based on the MosCow categorization of “must haves” and “nice to haves” [45]). Trade-off decision making was used to balance various (conflicting) requirements. For example, a top-down requirement was to include caregiver support within the app to increase intervention effectiveness [37, 46], while bottom-up requirements were to minimize workload of nurses and to have a private intervention experience for people with cancer (see [47] for more details and examples of the strategies we used to merge conflicting requirements). Following
completion of a provisional list of requirements (session 4), collaboration with a commercial app developer agency was initiated. Financial and technical opportunities and constraints were then taken into account into the further prioritizing and refinement of requirements. While some of the processing of requirements was done by the project team in between sessions (e.g. gaining an overview of the financial impact of different requirements), most of the prioritizing was done during co-design sessions in collaboration with participants (i.e., with the aforementioned co-design exercises). The final requirements include functional (i.e., what the intervention should do) and non-functional (i.e., properties of the intervention such as usability) requirements [48]. Detailed software requirements (e.g., “when user clicks X, Y should appear”) are derived from the final requirements and are beyond the scope of this paper, as are specific formatting and visual design issues.

Results

Below we describe the outcomes of the seven co-design sessions, including A) the final list of requirements for the intervention and how they were implemented B) the content and functionalities of the intervention and C) an evaluation of the co-design process and particularly the four co-design tasks. Evaluation and implementation of the intervention are not part of this study.

A) Final Requirements

Table 3 shows a summary of the main list of requirements. These requirements regard aspects such as the content of the app (e.g. psycho-education about the three emotion systems tailored to the context of cancer), navigation (e.g. having the option to skip or save exercises), visual design (e.g. minimal and soothing), implementation (e.g. a standalone app embedded in regular care) and persuasive elements (e.g. receiving push notifications). The final requirements are the direct outcomes of the co-design sessions. To illustrate: a co-design exercise addressing obstacles and facilitators post-diagnosis (session 1, exercise a – see Table 2) yielded experienced obstacles of a lack of energy and mental clarity. Furthermore, it became clear across sessions that participants would value help to remember to engage with the app and to stay motivated, without feeling pressured. Specifically, evaluating other apps (session 3, exercise a) yielded that subtle motivational elements in the form of viewing progress within the app or getting inspirational messages (e.g., a progress bar that changes color, a tip of the day) would be fitting, in contrast to earning badges or points: “You already feel miserable, you shouldn’t have to earn anything. But there has to be something that pulls you to the app.”. Motivational elements were then further examined with prototyping (e.g., session 4, exercise b; session 6, exercise a). Based on these outcomes of various co-design exercises, requirement no. 8 regarding subtle persuasive elements was formed. While these requirements are specific to this intervention, generalizable intervention characteristics may be inferred from each. For instance, the above example illustrates that non-invasive and inspirational persuasive design elements are implemented to make the intervention engaging without being perceived as inappropriate or coercive (e.g. notifications containing a quote or brief exercise rather than an explicit reminder to complete an exercise). Similarly, in balancing tunneled vs. freely available content, requirement no. 15 illustrates that we implemented both types of content, which are then cross-referenced (e.g. pointing out relevant module content in the automated feedback of the mood tracker; a freely accessible exercise ‘light of the day’ is expanded upon in two modules).

Following prioritizing and trade-off decision making, all main requirements were met in the intervention design. However, some functionalities were implemented in a simplified form and some requirements were only partially met. For example, we included a mix of audio, video, text and images to convey information, but we were not able to include audio recordings for all written text to listen instead of read. Participants had indicated that this would substantially help with concentration.
difficulties, however financial constraints prevented us from implementing this. Table 4 shows an overview of the ways in which the final requirements (as listed in Table 3) were implemented in the intervention.

Table 3. Final list of matched top-down and bottom-up requirements.

| No. | Top-down requirements                                                                 | Bottom-up requirements                                                                 |
|-----|----------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------|
| 1   | Linking existing content of Compassionate Mind Training to bottom-up challenges to create a tailored intervention | Topics to include in intervention: accepting the illness and limitations, taking care of your body, asking for and accepting help, guarding social and physical boundaries, motivating yourself in a positive way, coping with anxiety, regulating information consumption |
| 2   | Main focus on self-compassion training that can be applied to various practical contexts | Receiving ample, practical and localized information about treatment of and living with cancer |
| 3   | Psycho-education about three emotion systems, self-compassion and self-criticism       | To-the-point and practical psycho-education that is tailored to the context of cancer   |
| 4   | Reflective exercises about three emotion systems, self-compassion and self-criticism   | Exercises that generate insight into and awareness of emotions and self-talk in the context of cancer |
| 5   | Mindfulness exercises, soothing-rhythm breathing and visualization exercises           | Brief meditative exercises with down-to-earth, non-spiritual language that facilitate rest |
| 6   | Having compassion for suffering (offering compassionate feedback) and training own capacity to notice and reduce suffering | Tips and tricks to “get rid of” suffering (e.g. in automated feedback)                 |
| 7   | Address all key elements of Compassionate Mind Training, adapted from traditional intervention formats | Mix between “bite-sized” text/video/images/audio to convey information (to help with concentration difficulties) |
| 8   | Persuasive design elements such as rewards and praise                                   | Subtle motivational elements without too much gamification                             |
| 9   | Mood tracking to enhance awareness of emotions and facilitate compassionate responding | Mood tracking on multiple scales, having an overview of mood changes over time & optional feedback |
| 10  | Employ social support persuasive design elements such as social facilitation           | Having a private app without direct peer-contact, while including experiences of peers |
| 11  | Pseudonymous rather than Onboarding/log-in process as simple and                        | Onboarding/log-in process as simple and                                              |
Table 4. Overview of implementation of final list of requirements into intervention.

| No. | Implementation in intervention |
|-----|--------------------------------|
| 1   | Each main module addresses a main element from Compassionate Mind Training. All such elements are explained in the context of bottom-up topics. Submodules address different bottom-up topics. |
| 2   | Intervention has a main focus on self-compassion training adapted to the context of cancer. An information page contains selected weblinks with practical cancer-related information. |
| 3   | Psycho-education about three emotion systems, self-compassion and self-criticism is tailored to the context of cancer and contains practical examples. |
| 4   | Reflective exercises about three emotion systems, self-compassion and self-criticism tailored to the context of cancer. |
| 5   | Brief mindfulness/soothing-rhythm breathing/visualization exercises with down-to-earth, practical guidance. |
| 6   | Automated feedback using compassionate language (e.g. recognizing suffering, acknowledging that suffering is part of life) that stimulates self-regulation while also offering suggestions for exercises. |
| 7   | Mix between images, videos and audio to convey psycho-education and exercises. Use of audio is limited to meditative exercises. |
| 8   | Subtle use of rewards and praise such as receiving a visual reward upon completing a module (e.g. a new part of an incomplete image appears). |
| 9   | Mood tracker on three scales based on the three emotion systems, with an option to receive automated feedback and a graph showing mood progression over time. |
| 10  | A private app without direct peer-contact, with quotes from peers about their experiences related to the module theme. |
| 11  | Simple on-boarding that requires creating an account on registration, while staying logged-in for subsequent sessions. |
| 12  | Minimal app design using a monochromatic color scheme |
| 13  | Nurses explain the app to people with cancer in their own words, emphasizing parts of the intervention that they expect to align with
| 14 | Standalone private app for user without in-app communication or information sharing with nurses, integrated in regular care. |
| 15 | App contains six modules that can be accessed after one week without having completed previous content; functionalities that are freely accessible at any time from the menu bar; option to mark pages as favorite. |
B) The intervention: ‘Compas-Y’

The final mobile self-compassion intervention ‘Compas-Y’ that resulted from the co-design sessions, consists of six sequential training modules as well as features that are accessible at any time from the home page. The intervention content is based on Compassionate Mind Training, with a few additional elements of positive psychology (e.g. functionality “light of the day”) and Mindful Self-Compassion (e.g. exercise “How would you treat a friend?”). Diversity, equity and inclusion design aspects (see [49]) were addressed to some extent, for example by offering content understandable to people with various degrees of exposure to formal education, alternatives to breath-focused exercises, closed captions for videos and diversity in visual representation. See Table 5 for a brief overview of intervention content, and Multimedia Appendices (2) for an extensive overview including aims and user outcomes and (3) persuasive design elements. Each module has a theme (e.g. recognizing and regulating emotions, taking care of your body), and includes psycho-education and exercises aimed at cultivating self-compassion in the time after a cancer diagnosis. Each module contains an optional component where users can read experiences (brief quotes) of peers and nurses related to the module theme. Each week, a new module becomes available regardless of user progress. Features that are directly accessible from the app homepage include a mood tracker, an exercise in which the user recalls a pleasant experience of the day, a page with favorite exercises and a practical information page. In both the module exercises and the mood tracker, automated feedback is given based on the users’ input (e.g. “Your drive system is active. Perhaps you are feeling restless and rushed. Sometimes that is just the way it is. To not blow up this feeling, you could activate the soothing system. For example by taking a moment of rest, or by taking three deep breaths.”). Users can track their progress on the home page, where a compass symbol indicates which (components of) modules are completed as well as which component was last opened. Push notifications are used to stimulate integration of the content into daily life. All content remains available after the intervention period of 6 weeks, and users can continue to use their favorite exercises, receive notifications and/or restart the modules. See Figure 2 for screenshots of the ‘Compas-Y’ intervention, and Multimedia Appendices (4) for a video demonstration and (5) for additional screenshots per requirement.
Figure 2. Screenshots of the ‘Compas-Y’ intervention. On the left: homepage of the ‘Compas-Y’ intervention, containing a central compass navigation element with 6 modules and a menu bar with supportive functionalities. On the top right: start of the exercise “light of the day”; on the bottom right: start of the mood tracker.
Table 5. Overview of app modules and supportive functionalities with their key components.

| Module                  | Key components                                                                 |
|-------------------------|-------------------------------------------------------------------------------|
| 1. Introduction to the app and self-compassion | - Psycho-education about self-compassion  
- Exercises in mindful awareness and soothing breathing rhythm  
- Exercise in finding (brief) positive experiences throughout the day |
| 2. Emotions in the context of cancer | - Psycho-education about three emotion systems (soothing, drive and threat)  
- Soothing breathing rhythm exercise with imagery (soothing)  
- Compassionate information seeking; finding resources based on own needs (drive)  
- Psycho-education about anxiety; practicing to recognize and allow anxiety (threat) |
| 3. Self-compassion and self-criticism | - Psycho-education about self-compassion and self-criticism  
- Imagery exercises about compassionate self and inner critic  
- Soothing breathing rhythm exercise with compassionate friend  
- Self-compassion expressive writing exercise |
| 4. Taking care of your body | - Soothing breathing rhythm-based compassionate body scan  
- Psycho-education and exercises about the difference between compassionate motivation and self-correction and self-critical motivation or attacking in the context of health and lifestyle behaviors  
- Psycho-education about compassion for own needs in the context of sexuality and intimacy |
| 5. The people around you | - Psycho-education about the three flows of compassion  
- Soothing breathing rhythm-based loving-kindness meditation  
- Setting boundaries and asking for help based on compassion for own needs |
| 6. Continuing with resilience | - Psycho-education and exercises about positive psychology: gratitude, savoring, strengths  
- Reflection on self-compassion practice and how to continue  
- Soothing breathing rhythm meditation with focus on tone of voice, posture |

Supportive functionalities

| Description                                                                 |
|-----------------------------------------------------------------------------|
| Overview of modules | Visual element central to the homepage (compass symbol) that depicts the (availability of) 6 modules and user progress |
| Mood tracker | Mood tracking (one question for each emotion system) with automated feedback based on three emotion systems |
| Favorite exercises | Marking exercises as favorite within the modules, which then appear in the users’ personal list of favorites |
| Light of the day | Exercise where user inputs a (brief) positive experience of their day, supported by examples |
### C) Evaluation of the four co-design tasks and the co-design process

#### Evaluation of the four co-design tasks

Given that we were able to meet most requirements, our co-design experiences indicate that the four co-design tasks were successful in enabling the integration of top-down and bottom-up requirements. Throughout the development process, the co-design tasks helped address two main challenges. The first is the need to continuously balance integrating top-down content into the co-design exercises, without being too leading. The “Explore bottom-up experiences” task was helpful to examine any challenge or beneficial experience post-diagnosis as experienced by people with cancer, not only in the context of self-compassion. In contrast, co-design exercises of the “Reassess top-down content” task had the explicit goal of introducing top-down content. Thus, having the four tasks each with their own function enabled to give space to both type of requirements without overly prioritizing one or the other.

The second challenge that the co-design tasks helped address is prioritizing and dealing with conflicting top-down and bottom-up requirements (see [47] for our decision making strategies). The tasks “Incorporate bottom-up and top-down into concrete features and design” and “Synergize bottom-up and top-down into intervention context” enabled to prioritize requirements together with participants. This was done with explicit discussions, but also by materializing the various requirements e.g. with paper prototypes, which allowed us to make conflicts and priorities tangible. These co-design exercises often quickly made clear which requirements were non-optional (e.g. bottom-up: not adding to the workload of nurses by offering a guided app, top-down: having some extent of a sequential learning structure). Thus, the four co-design tasks served as a guiding framework while investigating and merging different top-down and bottom-up requirements.

#### Evaluation of the co-design process

The seven sessions were consistently positively received by participants, with a median score of 4 (scale of 1-5) for all workshops and all evaluation questions. Thus, the sessions were well aligned with the energy levels and personal expertise of participants and offered them inspiration and learning. Many participants particularly appreciated sharing experiences with each other and collaborating with both nurses and people with cancer, in order to learn from and incorporate different perspectives. One participant described “[The sessions] showed me how important such an app is, since so many people experience the same things. Yes each in their own way, but in the end quite similar.” Some participants particularly valued working together in a guided creative process to help future people with cancer, while others emphasized personal benefits such as increased acceptance of their illness. One participant described: “Every session was surprising (...) in the beginning I always thought, I have no idea what to put on paper, but at the end of the day we looked back and it was special to see what we came up with”. In retrospect, participants reported a sense of pride about the final design, and in it they recognized the implementation of most of their expressed wishes and needs.
Discussion

This study set out to explore ways in which top-down and bottom-up requirements can best be integrated into eHealth development, by building on the case of the development of a mobile self-compassion intervention for people with newly diagnosed cancer. We will discuss 1) the final requirements and the design outcome ‘Compas-Y’, both as a testament to the apparent successful integration of both bottom-up and top-down requirements, and as an example of adapting a traditional intervention to the context of mobile technology; and 2) the process of integrating top-down and bottom-up requirements using our four co-design tasks. Furthermore, the interdisciplinary aspects of this study and strengths and limitations are addressed.

Final requirements and design outcome: a mobile self-compassion intervention

Top-down requirements for the intervention included key components of Compassionate Mind Training (e.g. psycho-education about three emotion systems, soothing breathing rhythm exercises) [32] and making use of persuasive design principles such as self-tracking [40]. Bottom-up requirements included addressing common challenges post-diagnosis such as coping with anxiety and regulating information consumption, and tailoring top-down content to the context of cancer by means of providing applied examples (of peers). Bottom-up requirements related to design and functionality, such as content offered in brief sessions, subtle motivational elements like progress tracking, and simple navigation and visual design are in line with other co-design projects of various mobile applications for people with cancer [50-52], and may indicate a common need for a reduced cognitive load when interacting with such applications. Moreover, the final requirements illustrate how we resolved design dilemmas that other eHealth designers may also face, including tunneled vs. freely available content [53], offering push notifications without being too intrusive [54], and including automated vs. caregiver support [55]. The final design ‘Compas-Y’ can be seen as a version of Compassionate Mind Training (top-down input) that is fully adopted to people with cancer (bottom-up input) - and also, as bottom-up needs that are met with (elements of) Compassionate Mind Training. For example, a bottom-up topic such as ‘information consumption’ (i.e., coping with the diagnosis by (excessively) seeking cancer-related information) is integrated with top-down content (e.g. acquiring resources (information) as part of our innate drive system), and intervention-specific compassion exercises are offered (e.g. observing what emotions are activated when seeking information). Similarly, top-down and bottom-up requirements are implemented on all intervention levels (content, navigation, visual design, implementation structures etc.).

Since there was no existing technology-enabled version of Compassionate Mind Training available, our co-design process also involved adapting a traditional intervention format to a mobile intervention. Like the majority of evidence-based psychological interventions, Compassionate Mind Training was originally developed for face-to-face use, employing a session based, didactic style of training [56]. However, holding on to this format may not necessarily be fitting or necessary for technology-based interventions and may limit researchers in adopting different means of achieving intervention goals that are unique to mobile or technology-based interventions [57]. In our adaptation of Compassionate Mind Training, we aimed to make use of the particular characteristics and opportunities of mobile applications (e.g. self-tracking and push notifications to facilitate in-the-moment integration of skills, information presented in short texts, videos, audio-files and images, use of persuasive design strategies and design approaches). Mobile technology indeed not only offers the potential to offer content directed at enhancing the users’ own compassion, but also to assist with the recognition of suffering, in order to model a compassionate response (see also [42]). In ‘Compas-Y’ this was implemented with a mood tracker that offers feedback adapted to the users’ score (e.g., a supportive message when anxiety is high). Other examples include the use of artificial intelligence to recognize the emotional load of text-based diary input [58] and the use of sensor-based technologies.
to track biomarkers related to emotional arousal [59]. With the further development of novel technologies, such opportunities become more available/affordable and will likely shape further developments in compassion training.

The process of integrating top-down and bottom-up requirements

To achieve integration of the aforementioned top-down and bottom-up requirements, this study devised and evaluated four co-design tasks: 1) explore bottom-up experiences, 2) reassess top-down content, 3) incorporate bottom-up and top-down into concrete features and design, 4) synergize bottom-up and top-down into intervention context. Overall, participants evaluated the co-design sessions as valuable and engaging, and the co-design tasks enabled the implementation of all main requirements into the design. In our co-design study the four tasks enabled dealing with challenges such as integrating top-down content into the co-design exercises in a balanced way, and dealing with conflicting top-down and bottom-up requirements. Dealing with conflicting requirements (and goals, expectations, and power dynamics) is a known challenge in co-design even without introducing top-down requirements [60, 61], and working with the co-design tasks may offer a helpful way to make divergences explicit. The co-design tasks may be used in the context of established approaches to eHealth development, in which consideration of theory-based requirements is generally lacking. Indeed, in a recent scoping review of methods used in eHealth development, Kip and colleagues found that very few studies reported on theory-based methods and the main identified area for improvement for eHealth development models was to add explicit goals and activities aimed at integration of evidence-based approaches [62]. The current study could guide this development, for example by incorporating ‘theoretical framework’ as a development phase in existing models and using the four co-design tasks to synchronize this with development phases related to bottom-up requirements (e.g., the ‘contextual inquiry’ phase in the CeHres Roadmap). Of note, the co-design tasks likely will need to be adjusted and re-evaluated in light of particular characteristics of other co-design projects, for example when the modality of a design is undefined (e.g., offline book or smartphone application) or when external experts rather than researchers are representing top-down input during co-design sessions.

Interestingly, the focus on either top-down or bottom-up development of eHealth interventions largely represents differences in scientific disciplines from which these approaches originate. In behavioral science, developing interventions based on theory and evidence is important not only for developing effective interventions, but also to further develop and test their underlying theories and mechanisms [28]. In Intervention Mapping for example, theory-based intervention methods and strategies are selected to meet predefined intervention objectives [27]. In design research on the other hand, developing interventions based on creativity methods without too many pre-defined objectives is important to allow for innovation and charting unknown territories. Since both approaches have their merit, Schmidt (2020) proposed a hybrid interdisciplinary model in which behavioral science can supply evidence-based approaches and design research can offer speculative hypotheses and innovative solutions [63]. Indeed, in our interdisciplinary co-design study we attempted to bridge both fields by integrating both theory-driven (top-down) and contextual (bottom-up) knowledge, as well as by employing methodology from both fields. This resulted in iterative cycles of design and evaluation using (low-fidelity) prototypes, while also creating a “final” version of the intervention that could be evaluated in a pre-post hypothesis testing design. Thus, even though the underlying principles and quality requirements of these fields may clash at times, we concur that using both generative and analytical approaches offers complimentary value in the development of eHealth interventions.

Strengths and limitations

This study was strengthened by an extensive co-design development process of two years. This
allowed for an in-depth exploration of both bottom-up and top-down requirements, as well as a thorough field-testing and evaluation of co-design tasks. The final intervention is not only a testament to the apparent successful integration of both bottom-up and top-down requirements, but also of adapting a traditional intervention to a context of mobile technology. Yet this study is also limited in several ways. First, the four co-design tasks are only based on a single co-design study, and their utility in other contexts remains unclear. A series of co-design studies might have resulted in a different set of tasks, based on challenges that arise across co-design settings. In addition, this study was shaped by pre-defined objectives based on acquired funding, such as the objective to have a working smartphone application after two years. Although this limits shifting the agenda to other potential solutions that may arise [64], such objectives can also be seen as a kind of top-down requirement (similar to financial constraints) that simply become part of the development process. Finally, while this paper focuses on potentially divergent top-down and bottom-up requirements, this is not to suggest that there are no divergent requirements within top-down (e.g. conflicting evidence) or bottom-up (e.g. different needs amongst participants) input (for further discussion of this issue, see [47]).

**Conclusion**

In the design of eHealth interventions to support people with cancer, an emphasis on evidence-based research needs to be met with taking lived experiences into consideration, and co-design may be used to do so. Yet here the question is, where in the co-design process do the theory and evidence come in? We have devised and evaluated four co-design tasks to enable the integration of theory and evidence (top-down) requirements with needs, wishes and experiences of users and stakeholders (bottom-up) requirements. Executed within a series of group-based co-design sessions, participants evaluated the co-design process as valuable and rewarding. We conclude that the four tasks form a helpful preliminary model for top-down/bottom-up eHealth development, by making both types of requirements explicit and brought into a shared design conversation. However, the utility of this approach in other co-design contexts (e.g., with different financial constraints, design modalities or project teams) remains unclear. The four co-design tasks yielded a final list of requirements, encompassing e.g. the need for tailored, “bite-sized” and engaging psycho-educational content on coping with emotions after a cancer diagnosis. The resulting design ‘Compas-Y’ is a mobile self-compassion application that consists of six training modules and several supportive functionalities and persuasive elements. This intervention serves as an applied example of how top-down and bottom-up requirements may be integrated into a design, as well as of the adaptation of a traditional intervention format to mobile delivery. Overall, these design and process outcomes serve to further inform technology-enabled compassion training in general and top-down/bottom-up eHealth development in particular, in the context of people with cancer and beyond.
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Figures
Examples of paper materials utilized in the co-design exercises.
Screenshots of the ‘Compas-Y’ intervention.
Multimedia Appendixes
Evaluation questionnaire for the co-design sessions.
URL: http://asset.jmir.pub/assets/f9e333fc8d68f8afe2efb21c287a269e.docx

Comprehensive overview of app modules, aims, user outcomes, key components and exercises.
URL: http://asset.jmir.pub/assets/5c2dd922f69fa5b41b4ab843db31784.docx

Overview of persuasive design principles incorporated in the intervention.
URL: http://asset.jmir.pub/assets/6aab7661a2810ed2f2e853770a3002a.docx

Video demonstration of the intervention 'Compas-Y'.
URL: http://asset.jmir.pub/assets/d1b711694843ba8d9bcb5b5501a8c2a9.mp4

Screenshots of the intervention for each final requirement.
URL: http://asset.jmir.pub/assets/8129d9836a5c69bee9d548aedca133d.docx