A methodology for the design and development of gamified mobile apps for monitoring cancer survivors

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Abstract

An increasing number of cancer patients is treated and recover each year, and consequently there are survivors that require specialized and coordinated follow-up. The physical, social, working, psychological and emotional aspects of these survivors have to be characterized, investigated and treated by multidisciplinary and interdisciplinary teams. Nowadays, oncology community is focused on tracking records of interest in Patient-Reported Outcome (PROs) for patients of different cancer types. In the last years, several articles have proven that PROs are an effective method to improve the management of patient symptoms and, subsequently, clinical care. In this scenario, patient engagement is one of the most relevant aspects for PROs success. In this sense, one of the most promising strategies for increasing engagement is gamification, that is, the introduction of game elements in systems that are not games. Therefore, in this work we introduce a methodology for developing gamification apps for cancer survivors that aims at increasing engagement when collecting PROs data.

Keywords: Cancer survivors; Cancer patient monitoring; Methodology for eHealth gamified systems; Patient-reported Outcomes

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1. Introduction

Taking care of cancer survivors is a stage of continuous tracking, and its implementation is a challenge. This stage involves the follow-up of cancer survivors to detect relapses, the assessment of genetic cancer susceptibility of their family members, detection of new malignancies in cancer survivors, monitoring potential complications in treatments, prevention and early treatment of alterations of secondary psychological cancer state, and providing psychosocial support. The identification of associated pathologies such as bone problems, cognitive, memory, comprehension, gonadal toxicity and sexual dysfunction, is essential to organize the assistance of long-term survivors [1]. Psychological distress can have a severe negative impact on cancer patients. 32% of people diagnosed with cancer develop psychological problems. Among the vulnerability factors for depression in these patients, it is worth mentioning the poor skills to address the situation, poor social support and anxious concern [2].

Health problems related to disease sequelae and its treatment are a major health problem. This will require the development of new therapeutic strategies and assistance plans for these patients. Patient-reported outcomes (PROs) are the metrics that patients self-report about their own functional status, health outcomes, and quality of life. Common PROs questions include questions such us how well the patient carries out his/her social and/or physical activities, whether he/she is bothered by emotional problems or questions about physical health or specific illnesses. These registers also will contribute to analyses patients' unmet needs. Therefore, data collection helps to enhance the following of patient [3].

The use of a customized application to register PROs along with routine oncology follow-up consultations may help to find differences in the prevalence and severity of symptoms after completing chemotherapy, radiation therapy and/or other treatments. Likewise, it allows evaluating predictive factors that may indicate which subgroup of patients has more unsatisfied needs or symptoms. Another important point would be to evaluate patients' satisfaction using this application [4].

In this scenario, patient engagement to the application will be one of the focal points of PROs registration. A recent study [5] found that patients said that it would be helpful that healthcare providers encouraged them to ask about the specific steps for improving their healthcare processes and outcomes. In this scenario, healthcare gamification could generate positive effects on patients' health by promoting a better engagement and a better adherence to the treatment, increasing motivation and fostering resilience.

Gamification is the use of game mechanics in non-play environments and applications in order to enhance motivation, concentration, effort and loyalty [6]. Gamification offers advantages when motivating changes in the behavior and incrementing the use of applications [7]. Gamification is potentially relevant for achieving healthy

behaviors and facilitating the follow-up, since gamification intrinsically involves motivation and can be widely applied to different domains.

These techniques foster the growth of the participation of patients in the monitoring process and instigate then to complete tasks and achieve goals. However, the success in the use of game elements depends on the in-depth analysis of the typology of the patients and their context, the establishment of clear goals and the use of the right gamification elements for each user. Users will be affected in different ways depending on their personality or other individual characteristics, and also in the dimensions of the illness [8, 9].

As an example, lung cancer is not the same as breast cancer, not only in terms of disease but also in terms of the motivations and perceptions of patients suffering it. In patients with lung cancer, it is expected to find some sense of guilty and denial of the disease, since there is a social prejudice against smokers. Patients with breast cancer, on the other hand, suffer from body-image changes produced by surgical treatment.

Taking these factors into account was essential for this work. In order to design a gamification system, it is necessary the study and a deep understanding of discipline, disease, possible behaviors and population. Some of the most relevant issues are the ignorance of the specific condition, the desired behaviors or the target population [10].

Different types of gamification can be used throughout the illness pathway of patients. In the case of the registration of PROs, it is also necessary to achieve an engagement experience for users, transforming inconvenient tasks into fun activities. The more they participate, the more they are contributing to the knowledge and management of their disease. The final goal of the system should be positive effects on patient health, patient empowerment and optimistic emotions. Therefore, the adoption of gamified paradigms needs to be focused on the patient and to target not only the diagnostic stages but also the prevention phase.

A better understanding of patients will help to incorporate the right gamification features and active elements for driving meaningful innovation and a better understanding of behavioral physiology elements. In the gamification design process, all the stakeholders implied on the following should be consulted for a better understanding of the implied factors. In the case of cancer survivors, some factors such as social connection or healthier competencies must be studied in order to increase the user's desire to contribute to their health. Patients' empowerment also is recommended in the gamification process in order to engage them in the process. Therefore, applications are advisable to be developed using patient-centered practices. Also, the use of gamified models will be needed in order to keep the participants engaged and to motivate the participation of patients in the process.

Taking all the aforementioned issues into account, in this paper we deal with the need of including a patient-center design in the development of gamified applications for cancer survivors. A deep analysis of the target audience will be needed previously to system design. In this specific case of cancer survivors, we have detected a

strong need for empowering the user in order to motivate them to use the application designed to collect PROs. Some active gamification elements such as social connectivity or the use of personalized rewards and the possibility of contributing to the resources offered to the patients also help to engage them in the system. Therefore, our proposal is a methodology for the design and development of gamified mHealth apps oriented towards the monitoring of cancer survivors. This methodology has been developed starting from the state of the art on the development of mHealth apps, the management of PROs and the use of gamification. We have followed an approach centred on user needs, where users get involved in the development of the app. We have paid special attention to the election of gamification strategies and tactics, as we have focused on this aspect in order to increase users' engagement. Therefore, our methodology can serve as a basis for anyone who aims to develop a similar mHealth app.

This paper is structured as follows: Section 2 is about the state of the art in mHealth, the use of PROs and gamification in mHealth. Section 3 introduces the problems of cancer survivors. Section 4 explains in detail our methodology and its stages. Section 5 includes a case study, applying the methodology to the design and development of a specific app. Section 6 discusses the results of the work. Lastly, Section 7 mentions conclusions of the work, and depicts some future lines of research.

2. State of the art

There is a strong attention among the oncology community for tracking records of interest in PROs. In recent years, several articles on PROs have appeared, proving to be an effective method to improve the management of the patient's symptoms and, subsequently, clinical care [11]. Such information can be used both for patient care and for the continuous improvement of life quality. Memorial Sloan Kettering Cancer Center [12] collects PROs from patients in various situations, including prostate recovery and breast surgery. Once the information has been collected, it is sent to patients and health professionals, including graphic comparisons with similar patients. The analysis of a randomized controlled trial of 766 patients who received chemotherapy and regularly reported common symptoms over the Internet reduced the number of visits to the service emergency and improved overall survival. It also improved the patients' quality of life. Nurses responded to patients' reports with actions such as telephone counseling and new prescriptions.

PROs can also play a relevant role in shared decision making. Several institutions have managed to integrate PRO collection into routine clinical care. Since 2011, the Dartmouth-Hitchcock Medical Center [13] has worked with PRO data. They collected data on pain, physical functioning and emotional health. These data were reviewed with the patients during the visits. Cincinnati Children's Hospital began collecting PROs from outpatients with the information automatically uploaded to the EHR flow sheets to be reviewed at visits.

However, some barriers with PROs records still exit. Technological problems, reimbursement and lack of standardized methods are some factors to be dealt with. In addition, in this type of following-up, when working with online tracking, motivation and engagement of users need to be taken into account for success in collecting this information. Moreover, feedback from medical professionals to patients will help to increase the sense of usefulness that patients have about registering their records.

User-centered approaches when developing mHealth apps is a field with several examples of success. In [14], authors describe the development and usability testing of "MedRec" app. They do three iterations of user-centered usability evaluation with several methods (observations, questionnaires and follow-up discussions with participants) in order to improve the prototypes. Another example can be seen in [15], a platform to promote active and direct data collection from patients is presented. Also, authors present a study defining the usability of the system. In addition, in [16], a dashboard for rheumatoid arthritis is developed using human-centered design. The final goal was to develop a tool to support a conversation between the provider and patient, centered on PROs established previously as high priority by both parties.

The study described in [17] proposes the implementation of a gamification system to promote engagement in the user's treatment with the use of health-related systems. Seven stages compose the method: analysis of system requirements, target audience, interaction flows, analysis of other gamifications systems, gamification elements analysis, development and evaluation.

There are more examples of the importance of gamification in this field. In [18], authors propose a set of theoretical frameworks that depicts gamification from the point of view of user's perspective. Moreover, Landers [19] discussed gamification processes, pointing out the need of taking into account the psychological characteristics of users. He also mentioned that game elements should be chosen to influence these characteristics.

One example where the methodology is de main contribution for the study is [20], where Pirovano et al. presented a methodology to create safe exergames for real therapy pathways. They illustrated the methodology with exergames designed for (1) balance and posture and (2) neglect rehabilitation, implemented and tested with post-stroke patients training autonomously at home.

In [21], authors established three main classes of motivational design to increase engagement: gamification, quantified-self and social networking, establishing that more user-centered variables need to be introduced in the gamification models in order to influencing continued use and systems adoption. Social networking applications and social benefit/feedback (e.g. social interaction) elements attend to invoke responses such as the sense of community [22, 23, 24, 25]. Social networking features included cheering, commenting, viewing of friends' activity logs on a timeline and a list of the friends a user interacts the most with.

Authors in [26] presented the need of studying also the counterproductive effects of gamification, having into account not only gamification goals but also real-world goals in order to apply gamification elements in a sensible dose. The importance of validating gamification elements is also introduced on [27]

In order to analyze the importance of gamification in healthcare systems, we have carried out a study of a selection of applications in which gamification, together with health, has helped patients, and in turn this gamification has allowed advances and discoveries in medicine.

In [28] there is a review of some popular taxonomies to identify the common strategies listed by some authors. After the study, Cugelman identified six core ingredients of gamification. These six mechanics of gamification are: Goals, Challenges, Reinforcement, Progress and Social. Hence, to know better the users of gamification, Marczewski proposed six user types that differ in the degree to which they can be motivated by either intrinsic or extrinsic motivational factors [28]: Philanthropists, Socializers, Free Spirits, Achievers, Players and Disruptors.

The Pain Squad app [30] collected information about pain suffered and the effects that cancer treatments have on children. The game followed a theme in which a police patrol must solve a crime. Children fill out a series of questions through the app, whereby when they finish, they receive a reward or a prize that they must collect. There is also the promotion within the patrol and the user can go up in rank. Each completed report helps the team solve the case in this way. In addition, it has some videos in which real agents congratulate the user for his achievement.

The Mango Health app [31] is aimed at helping all types of patients in their day-to-day treatment. This is done by counting the times the patient takes his/her medication and financially rewarding the patient. This way, the application sends an alert about each action in the treatment that has to be performed, rewarding each action with points. These points can later be changed into gift cards or donations that can be made to charities. In addition, this app shows the progress made in the treatment, the benefits it brings, a history and what is left for getting the next reward.

The objective of VERA [32] is to, as its motto says, "reinvent the experience of physical therapy". Authors developed a virtual platform in which watching through the television or any type of image player an animated instructor shows the exercise to be performed. The application asks the patient to follow the indications by copying the avatar that appears on the screen. In order to verify that the therapy is actually being performed, the program has a Kinect motion capture technology [33] which compares the performance of the patient as required by the pre-configured virtual therapist. A system similar to this one is KineActiv [34], which also uses Kinect-based technology. It is oriented towards the rehabilitation of the upper limbs. This system encourages patients to perform rehabilitation exercises by gamifying them. Thus, the correct performing of the exercises implies that an alien spaceship gets destroyed or that a chicken gets roasted.

In table 1, we can see the six mechanics of gamification of the study of Cugelman [28] compared with the applications aforementioned. One can observe that none of the applications meets all the gamification mechanics.

Table 1

The six mechanics of gamification compared with the applications studied.

	Pain Squad	Mango Health	VERA	KineActiv
Goals	Yes	Yes	Yes	Yes
Challenges	No	Yes	Yes	Yes
Feedback	No	No	Yes	Yes
Reinforcement	Yes	Yes	No	Yes
Progress	Yes	Yes	Yes	Yes
Social	Yes [a]	No	No	No

a Only share the classification with all users.

In conclusion, gamified health applications have contributed to improve patients' health and motivate them in following treatments, according the reported results in the existing literature. Gamification has been useful in the medicine field, especially in hard diseases. This has motivated our current work focused on gamification for supporting cancer survivors.

3. Cancer survivors' characteristics

The cancer survivor population is growing. Quality care for survivors includes surveillance of recurrence and second tumors, intervention in the control of symptoms and psychosocial needs and coordination of care. According to the United States Cancer Institute: "When it comes to cancer, survival covers the physical, psychosocial and economic problems of cancer, from diagnosis to the end of life. It focuses on the health and life of a person with cancer beyond the stages of diagnosis and treatment" [35]. Survival experience includes issues related to the ability to obtain medical assistance, follow-up, attention to the late effects of treatment, second primary cancers and quality of life. Family, friends and caregivers are also part of the survival experience.

Wendy Landier [36] recommends that survivor care plans must contain some factors such as rehabilitation, the optimization of the health potential of the survivor, recurrence monitoring, early detection of recurrence, early intervention on complications related to cancer and its treatment, health promotion, reduction of the risk of development of comorbidities or second malignancies, evaluation and intervention for the socioeconomic consequences of cancer and its treatment, standardization of access to work, school and insurance and coordination with Primary Care, sharing of information, and bypass circuits and protocols.

Cancer survivors represent a challenge and an opportunity for oncology to recover the leadership in the integral care of the cancer patient. There are not enough programs or institutional guidelines or proposals for Survivor Plans in Spain [1]. The impact that cancer causes in survivors produces a readjustment of roles that can sometimes

generate emotional exhaustion, disorientation, anxiety and depression, among others. In general, cancer survivors have a series of psychological and emotional needs and problems. The main problems or needs are: consequences of medical treatments (physical or functional changes) that can cause social or other retreat behaviors, fears and concerns related to the disease, proving a sense of lack of control that will lead to a multitude of concerns and feeling distressed and afraid, difficulties for reinstatement, changes in family and couple dynamics, with symptoms of males or worry and frustration, dependence, alterations of sexuality, difficulties in social relationships, changes in lifestyle, physical or functional limitations or the inability to assume the changes and their consequences sometimes lead the cancer survivor to social isolation. On other occasions, it is the silence of others that leads to develop feelings of abandonment for not having received the support they expected. In these cases, they may believe that others do not recognize their emotional discomfort. On the contrary, sometimes the others do not know how to express themselves, they do not want to bother them, or they do not know how to face their own fear. Other needs are based on the reinforcement of their self-esteem and self-concept. The person who has overcome a cancer may feel devalued, helpless or unable to restore normalcy in their life or to accept the changes that occurred after the disease, which can lead to disappointment of himself and poor self-concept and low self-esteem. It is also important to analyze the changes in lifestyle and recovery of everyday life. And finally, they also have problems related with changes in lifestyle and recovery of everyday life.

After this review of the problem of cancer survivors, we introduce some relevant symptoms associated with these problems such as panic reactions, confusion, denial, irritability, anger, sadness, insecurity, guilt, rejection, feeling lost, pressure, threat, dependence and hypervigilance of symptoms. All of them can be normal reactions understood within each circumstance but depending on the intensity with which they occur and the temporary duration of them, they could be considered within of psychopathology. Recent studies report that 25% of survivors have clinical levels of depression [37].

In the psychological approaches for cancer survivors, strategies and tools are usually aimed at improving the quality of life, enhancing their autonomy and increasing the perception of control over the threat of the disease, influencing the promotion of continuity and their vital project. The intervention will be aimed at addressing the main needs, the most relevant objectives being pursued as follows: Promote the identification, expression and management of fears, concerns and negative emotions (emotional expression and ventilation), train emotional regulation skills, teach appropriate coping techniques to manage the problems associated with the disease, facilitate posttraumatic growth (assimilation of experience with the disease, accommodation and personal evolution), management and adaptation to changes (e.g. body image, time distribution, and couple and family relationships), promote healthy lifestyles, facilitate communication, plan the future and prepare for socio-labor reintegration and report on guidelines to follow to return to a “normal” life. These factors will be of utmost importance in the design of the gamification strategy to be designed for the registration of PROs.

4. Materials and methods

In order to systematize the design and development of mobile apps intended to help monitoring cancer survivors, we have developed a methodology that makes the development of such apps easier and takes gamification aspects into account. The methodology is based on the classical user-centered methodologies for software development, and also on the works that we have reviewed in the state of the art. In particular, we have been inspired by the work by Pino Cechetti et al. (2019) [17], who demonstrated that gamification was effective in the context of health-related applications, as it did not add complexity to the application and promoted the desired-participation results. However, there are some relevant differences between that work and ours. Firstly, whereas Pinto Cechetti's proposal is for ill patients, our proposal is for survivors. Thus, where the former proposal addresses the patient's engagement to the treatment, we try to improve the engagement to monitoring. The latter is essential in order to improve and personalize how survivors get treated. A second difference is the implication of medical personnel in our methodology. We follow a user-centered approach where users are both patients and medical personnel, so the design and development of the app take both collectives into account from the very beginning, together with the development team. This development team will be made up of software engineers with experience in user-centered development and designers with experience in mobile user interfaces. And lastly, we have incorporated the strategies and tactics defined by Cugelman (2013) [28] as the relevant ones to consider when using gamification in the field of digital health.

Specifically, our proposal includes the following stages:

Stage 1: Study of the goals of the application.

Stage 2: Study of the level of prevention and the dimensions of monitoring.

Stage 3: Selection of gamification tactics.

Stage 4: Selection of personalization parameters.

Stage 5: Logical and structural design.

Stage 6: Visual design.

Stage 7: Design evaluation.

Stage 8: Implementation.

Stage 9: Implementation evaluation.

Next subsections describe each stage in detail.

4.1. Study of the goals of the application

As first step in the methodology, a stage about collection the goals of the application has to be carried out. The development team, together with medical personnel and cancer survivors that will be potential future users of the

app, will decide which will be the main goals that the application will fulfil. This will be a quite previous stage of requirements analysis, as it will be not necessary to go into detail.

Specifically, in order to carry out this stage, a multidisciplinary focus group will be stablished. This focus group will be made up by representatives of the development team, the medical personnel and potential users, that is, cancer survivors. Potential users will be chosen in a way that diversity is considered. Thus, there would be some ones that have just recovered and some others that recovered long time ago. Also, survivors from different types of cancer and that have undergone different treatments may be chosen, in the case that the application is developed as a generic one. It would be also possible to develop apps for specific types of cancers, and in that case, this would have an effect on the selection of potential users. An appropriate number would be between 6 and 9 potential users. The idea is that, within the group, one or two main goals of the application get defined, together with some secondary ones. Those goals would be later developed in the following steps. The session would be moderated by the representatives of the development team who, together with the medical personnel, would carry out the prioritizing of the goals.

4.2. Study of the level of prevention and the dimensions of monitoring

The next stages in the methodology are about collecting specific requirements of the application. These steps will also involve the patients and the medical personnel, as we will carry out a user-centered approach. Specifically, in this first step, some decisions have to be made about which level the app will reach in terms of prevention and monitoring. Some relevant questions to be answered in this stage are: (a) which type of monitoring the app will carry out (by means of sensors, questionnaires or both)? (b) Which information will be collected? (c) What will be the frequency of the data collection?

The means used for this collection of data will be some of the typical means for collecting requirements in used-centered approach. In particular, we recommend to perform questionnaires and/or interviews with both patients and medical personnel, and direct observation. The resulting product of this stage will be a document that answers the aforementioned questions.

4.3. Selection of gamification tactics

The use of gamification is one of the strongest points of the applications that will be generated using this methodology. Thus, the selection of the mechanisms of gamification is a quite important point that deserves a stage for its own. In this sense, our methodology works with the strategies and techniques for gamification defined by Cugelman (2013). In this way, it will be needed to define which strategy or strategies will be used in the application among the following: goal setting, capacity to overcome challenges, providing feedback on performance, reinforcement, compare progress, social connectivity, and fun and playfulness.

Moreover, when the strategy or strategies have been chosen, the specific tactics to implement them have to be defined. The list of tactics to choose among are again the listed by Cugelman: providing clear goals, offering a challenge, using levels, allocating points, showing progress, providing feedback, giving rewards, providing badges for achievements, showing the game leaders, and giving a story or theme. All these selections (of strategies and tactics of gamification) will again be decided by the development together with medical personnel and potential users. All the decisions made in this stage must be in line with the result of the two previous stages. Therefore, each selection of a strategy or tactic must be accompanied by a justification relating it to the goals of the application, the level of prevention and the dimensions of monitoring.

4.4. Selection of personalization parameters

Personalization is a key important factor when developing software in health and wellbeing fields. It will be difficult to achieve a high level of engagement in the use of a mobile application for health monitoring if the user does not feel that the application takes their specific needs into account. Therefore, it is quite important to add personalization features in applications like the ones that will be developed following this methodology. In this way, in this stage of the methodology the development team will have to select which personalization parameters will be included in the application. However, even when the final implementation will be carried out by the development team, information from the medical personnel will be very helpful in this stage and will guide the final decisions. The idea will be to get the working of the app adapted to the typology of the patient.

In order to achieve this, in this stage some elements of the design of the app defined in the previous stage will be selected to be personalized. In addition, the factors that will determine such personalization will be defined. For example, if the app gives a reward to the user when they fulfil a task, it may be decided that the kind of reward depends of some factors such as how the user evaluated previous rewards. This information will be decided after collecting information from medical personnel and potential users of the application.

Therefore, from the study carried out we see that it is important to work on resources that can help in the improvement of gamification. It is important to adapt the resources to the evolution point of the cancer survivor. If any resource is not properly based on a previous assessment of deficiencies, stress, emotional blockage and cognitive capacity, it is possible that it is ineffective. It may not respond their demands because it either lacks clear messages or because these are too broad or scarce. The goal of the customization of these resources is to create an interactive and dynamic process aimed at growth and change in the way of thinking, feeling or acting in each survivor. To undertake this, new forms of therapeutic action will contribute to reduce suffering and to improve control over the disease.

Below, we detail the problems and needs, strategies and tools, resources and resource types that may be needed in the proposed kind of gamified applications, so that all these can be used when applying the methodology.

- Problems and needs:
  1. Consequences of medical treatments (physical or functional changes) that can cause social withdrawal or other behaviors.
  2. Fears and concerns related to the disease, proving a sense of lack of control that will lead to a multitude of concerns and to feel distressed and afraid.
     - Concern about managing physical sequelae, rehabilitation, fear of relapse, reviews and results, fear of dilation between appointments.
  3. Difficulties for reinstatement.
     - Physical or functional sequelae.
     - Labor instability concerns.
  4. Changes in family and couple dynamics, with symptoms of discomfort or worry and frustration:
     - Feeling of lack of family support or overprotective attitude
     - Increased communication between family, couple and friends.
  5. Dependency:
     - Need to continue receiving help, discomfort
  6. Alterations of sexuality.
  7. Difficulties in social relationships:
     - Difficulty in assuming changes, social isolation, feelings of abandonment.
  8. Self-esteem and self-concept:
     - Devaluation, impotence or inability to restore normalcy in your life.
  9. Changes in lifestyle and recovery of everyday life
     - New care, food, exercise.
- Strategies and tools (SAT):
  1. Promote the identification, expression and management of fears, concerns and negative emotions (emotional expression and ventilation).
  2. Train emotional regulation skills.
  3. Teach appropriate coping techniques to manage the problems associated with the disease.
  4. Facilitate posttraumatic growth (assimilation of experience with the disease, accommodation and personal evolution).

5. Management and adaptation to changes (e.g. body image, time distribution, and couple and family relationships).
6. Promote healthy lifestyles.
7. Facilitate communication.
8. Plan the future and prepare for socio-labor reintegration.
9. Report on guidelines to follow to return to a “normal” life.

The strategies and tools used for the psychological approach for survivors are aimed at improving the quality of life, enhancing their autonomy and increasing the perception of control over the threat of disease. For this purpose, the intervention will be aimed at addressing the main problems and needs.

4.5. Logical and structural design

This stage is about the design of the functionality of the application and of how its elements will be arranged. This stage will include: (i) the development of a hierarchical list of the tasks to be performed by the application; (ii) the definition of the structure of the application, and (iii) the development of mockups of the screens of the application. The development team of the project will carry out this stage. A full document of logical structural design, including the set of mockups, will be the product obtained after this stage has been fulfilled.

4.6. Visual design

This stage is about designing a visual style to the elements defined in the logical and structural design, which may have been modified by the personalization elements in the previous stage. Specifically, the style guide of the application will be defined, and it will be applied to every screen and menu in the application, so the full design gets finished. The development team will carry out this stage. Thus, it is essential that in the team there is at least one member with expertise on user experience (UX) and design of mobile apps, as this background is key when designing the visual aspects of the application. Standards and recommendations about visual designs will be taken into account. That is, the visual design will be in line with what is recommended for apps for the specific technology being used (Android, Apple). Also, accessibility guidelines will be taken into account. Thus, the final product will have to meet standards like EN 301549:2018 (Europe) or Section 508 and its regulation (US).

4.7. Design evaluation

As we are following a user-centered approach, the evaluation is not limited to the final steps of the process. Thus, we have included here a stage for the evaluation of the design previous to its implementation. In this stage, a prototype will be developed and techniques for the early evaluation of prototypes will be used. Specifically, it is recommended to perform the following evaluations:

- *Heuristic evaluation*. Some usability experts will analyze the prototype following usability guidelines and will identify common problems that can be solved at this point of the design process.
- *Cognitive walkthrough*. Medical personnel and potential users will act as users in this evaluation method, so that UX experts in the usability team can identify problems in the interaction and tasks to perform that are not clear. As happens in other stages of the process, the selection of potential users should take the real diversity of users into account.

4.8. Implementation

Once the design of the application has been completely defined, the app is implemented. In order to carry out this stage, the suitable framework or technology will be chosen depending on the devices and context in which the application will be developed. The use of multi-platform frameworks will be considered, in order to reach a wider range of audience.

4.9. Implementation evaluation

Once the application has been developed, the implementation is evaluated. A full usability test will be the ideal way to test the usefulness of the application and the satisfaction of end users. Questionnaires and interviews will be used when needed in a pre-test and/or post-test basis. As it is usual in this kind of methodologies, depending on the result of the evaluation, some of the previous stage may be carried out again to make the necessary changes to improve or correct the identified items.

5. Case study

In order to test the usefulness of our methodology, we have applied it to the design and development of a specific application for monitoring cancer survivors. This section details how we have applied the steps in the methodology to develop the app.

Stage 1: Study of the goals of the application.

The main objective has been to develop an application that adapts to the comprehensive monitoring of cancer survivors, carrying out a comprehensive monitoring of physical and emotional factors, so that doctors/psychologists can improve their follow-up. Some secondary goals of the app are: (a) to improve social relationships, (b) to improve the engagement to the monitoring process and (c) to improve motivation and satisfaction.

Stage 2: Study of the level of prevention and the dimensions of monitoring.

At this stage, in several meetings with doctors/psychologists and patients, we identified which information should be collected in the app, and the different sections in which to collect it.

Patients were mostly interested in having a place in the application where they could consult the medication that had to be taken and the appointments with the doctors/psychologists.

The doctors agreed that it would be interesting that patients keep track of medication and appointments. They also mentioned that sometimes they had to conduct patient surveys, but they were not always completed because it was a very long or tedious task. Therefore, we decided to carry out some surveys in the app, to check whether they replied them through the app and patients could be properly monitored.

It was decided that the surveys would be conducted on a daily basis. In order to collect a high amount of data, patients filled two surveys every day, differentiating one that measured the level of sleep and another with the activities that the survivor had performed throughout the day.

For the different tasks the following information would be collected: for appointments (a) name, (b) consultation, (c) date, (d) time, (e) location and (f) observations; for the medication (1) name of the medication, (2) dose, (3) time of the taking, (4) days a week of the taking and (5) observations. Five questions will be asked for the surveys, first we will explain the four that are general for the two surveys (a) amino, (b) pain, (c) symptoms and (d) energy throughout the day.

A question will vary to know a fact that has happened at night and another of what has happened throughout the day. One survey (data of the night) will ask users about the level of sleep and the other (data of daily activity) will ask about the activities they have performed throughout the day.

In addition, if users positively answer to the pain question, then they will be asked two extra questions about (b.1) pain level and (b.2) body parts with pain.

Stage 3: Selection of gamification tactics.

In this stage, after analyzing all the strategies defined in the methodology, we will select the following: (a) reinforcement, (b) progress and (c) social connectivity. Also, the tactics chosen were (1) using levels, (2) allocating points, (3) showing progress, (4) providing feedback and (5) giving rewards. The part that we are going to focus on most is that of social connectivity, joining all strategies and tactics in a kind of personalized social network.

Stage 4: Selection of personalization parameters.

In our case, the main problems and needs are presented, together with the strategies and tools used to solve these problems, to be able to customize the types of resources that would be useful for the survivors:

- Resources:
  - Information:
    - Healthy lifestyle

    - Disease (doubts)
    - Guidelines for returning to work
    - Measures to prevent side effects
    - Expected symptoms
    - What do I have to inform my doctor?
  - Motivational. Share by survivors and medical professionals. We check how each resource affect each patient (they valued them) in order to personalize the type of resources they receive to:
    - Feel fine
    - Be relax
    - Get excited
    - Give strength
    - Encourage them.
  - Exercises:
    - Mindfulness
    - Physical
    - Yoga
    - Pilates
    - Sleep therapy
- Resource Types:
  - Music
  - Video
  - Image
  - Sentence
  - Exercises
  - Others

We now analyze which parts of our gamification system cover the interventions necessary for the previously defined strategies and tools. Our intervention regarding SAT 1 will be to conduct a survey that addresses the patient's main fears, for which they receive points for carrying it out. For SAT 2, one way to regulate emotions will be to provide the patient with motivational resources, which will be previously validated by the medical

staff. In this way, the use of a resource that make another patient feel fine can help others. With the validations we can also see if the patient has been helpful.

For SAT 4, we will use the forum of doubts in which patients and doctors will communicate. Doctors can give direct information to patients about what they need, giving points for each question asked and increasing the points if they help other patients, validated the answers by the doctors. This same forum can be used for SAT 7. In SAT 7 the system can also give points to the patient for each resource that the patient uploads and each resource that the doctor validates. In this way, the patient and the doctor will communicate indirectly, through the validation of resources. The patients will also be able to communicate with other patients through evaluations of resources, also indirectly.

Information resources will be used for SAT 3, 6 and 8. They will differ for each type of SAT. For example, for SAT 3, the patient will be given an information resource about the disease. For SAT 9, two types of resources can be used both for relaxation or exercise exercises, and for information on how to return to work or healthy lifestyle.

Finally, all the support that we can give the patient in making decisions, through rewards, is very important. We must respect their right to either receive information or not, and only provide the information requested by the patient.

Stage 5: Logical and structural design.

The system architecture of the app uses a Model-View-Controller (MVC) pattern for both applications, the mobile application and the web application. Hence, when the modules and functionality are expanded or changed, only the modified parts will be affected, and the others will be able to work as before without making any substantial changes. The web front-end is built as a templated CodeIgniter website that communicates with the application programming interface (API), and the mobile front-end is built in Java and XML. XML is used only for the view of the user interfaces, but not for data, which is always managed in JSON.

The back-end API is an MVC structured RESTful JSON API built with PHP, aided by the framework CodeIgniter. The database driver is MySQL and it makes https requests to connect the API with the database.

The gamification system allows patients to share resources with the other patients, not as a social network itself, but as a network with which patients interact with each other but in an anonymous way.

The rewards for patients are their own shared motivations, being validated by the psychologists before being introduced them into the reward system. We wanted that the content that a patient can share is not harmful for other patients or is able to demotivate them.

To get rewards, patients should complete the daily survey. They always get a motivating phrase and can choose another reward. They can choose between a motivating resource, an exercise or not getting anything. The

patients shall be able to rate the phrases and motivational resources on a scale of 1 to 5. The patient shall also be able to perform an exercise.

An important part of the gamification system is the scoring system. In any gamification system, the number of points must be well defined for each task. The patient has to have the sensation of reaching the maximum points very soon, otherwise the patient may have the sensation of not progressing. The way in which the patient receives the points will be distributed as follows:

- Rate the resources:
    - Motivation: 150 points.
    - Information: 150 points.
    - Exercise: 150 points.
- Rate the motivation phrase: 100 points.
- Sharing a resource: 200 points.
    - The resource is validated by medical staff / psychologists: 150 points.
    - That resource is valued: (a) 1 star: 100 points, (b) 2 starts: 125 points, (c) 3 starts: 150 points, (d) 4 stars: 175 points and 5 stars: 200 points.
    - The resource is added to favorites by another patient: 250 points.
- The patient adds a medication: 100 points.
- The patient modifies a medication: 50 points.
- The patient adds an appointment: 100 points.
- The patient modifies an appointment: 50 points.
- The patient adds a question in the forum: 100 points.
    - Someone (doctor / psychologist or other patient) responds to the patient's doubt: 50 points.
    - The patient answers a question: 100 points.
    - The doctor validates the patient's response: 100 points.

The points have been assigned so that, in consultation with the psychologists, the most important tasks have more points. These tasks can be important because psychologists want to see their evolution with the PROs or because we consider important tasks for the constant use of the application. We assigned fewer points to tasks that are performed more frequently or are less important. For example, each time the patient receives a reward, the app shows a phrase and the patient can rate it (more often), but from there they can choose between (1) motivation, (2) exercise, (3) information or (4) nothing, making it less possible that they could evaluate them, so the system will give more points for that action. What gives the patient the most points is to share resources, in consultation with psychologists. This task is useful for the gamification system to scale well and not always have the same rewards, increasing users' motivation.

Figure 1 presents an activity diagram of how patients receive points after completing a survey. First, we need to know if patients have assessed the phrase that is always shown at the reward selection screen. Then, if patients choose a reward no matter what they choose, we assign them 150 points if they have assessed the reward.

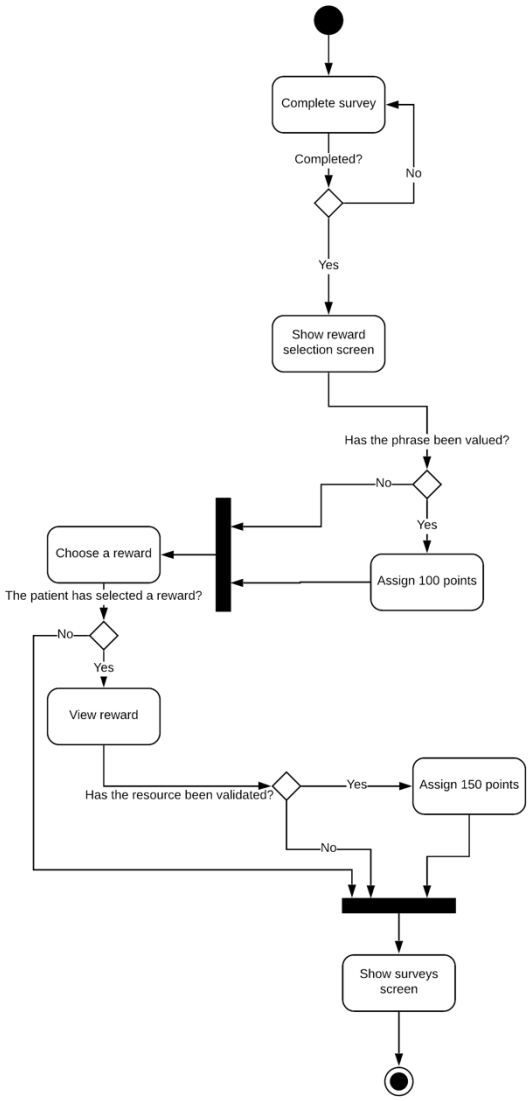


Figure 1. Activity diagram of the assignment of points after a survey.

In Figure 2, one can see an activity diagram of the assignment of points to an assessment resource. Depending on how many stars other patients indicate on the evaluation of that resource, more points are assigned to the author of the resource. At the same time, if that resource is added to someone's favorite list, 250 points are given to the author of the resource.

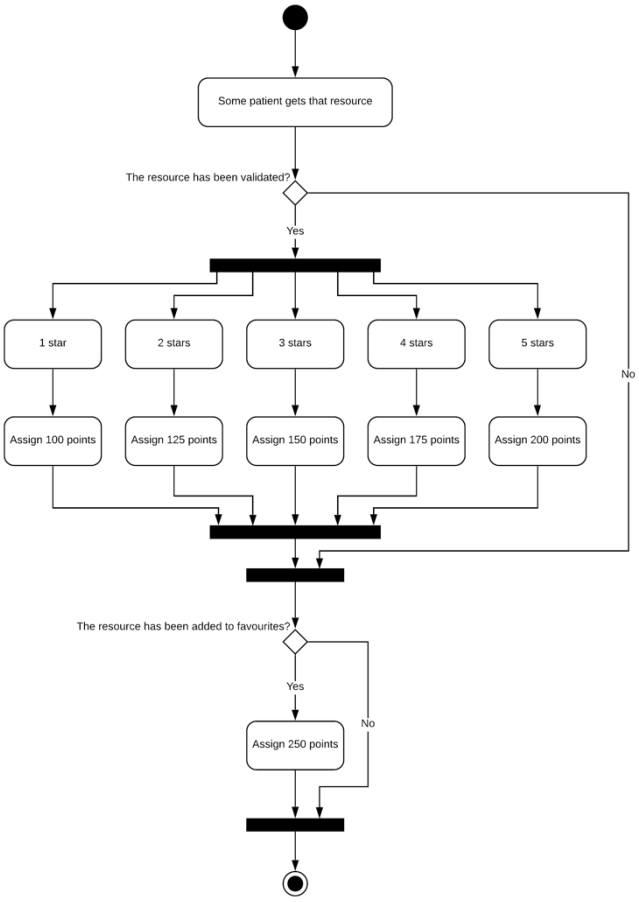


Figure 2. Activity diagram of the assignment of points to a resource.

Stage 6: Visual design.

The application style guide will also be carried out at this stage. The visual characteristics are the same as Google's Material Design graphic language. A clean, colorful design with dimensional effects has been carried out. The objective of this style guide is to achieve a user interface that allows any type of surviving patient to have direct communication with all the design elements of the application, after recognizing, at first glance, what is interactive and what is not.

We guarantee redemption in the design without loss of quality for different types of screens. Another objective is to create a visual language that synthesizes the principles of adequate designs, innovation and adaptability, focused on improving UX.

All shapes, iconography, typography, space and color are based on Material Design, since it is consciously arranged to create a hierarchy, communicate meaning and always from a specific approach.

Stage 7: Design evaluation. Several cognitive walkthrough tests were performed with doctors/psychologists and patients, and changes were made with respect to the design. In the first prototypes made in Adobe XD without any functionality, several flaws in functionality and interaction were detected.

Some functionality failures were the form of some parameters such as the level of sleep, which was finally decided to show numerically in order to be more comfortable and clearer in terms of usability. Other changes were about the interaction, as changes to add a button so that users always have the option of returning to the beginning without having to open the menu, since according to the opinion of several patients it was not easy for them to return.

Lastly, other modifications were made in the design, such as changing the place of large titles and properly handling screen layouts for making it easier to view and identify of all the relevant screen elements.

Stage 8: Implementation.

At this stage, the implementation of the application was carried out. Examples of screens that solve the problems discussed in stage four will be shown, as well as the modifications indicated in the previous stage.

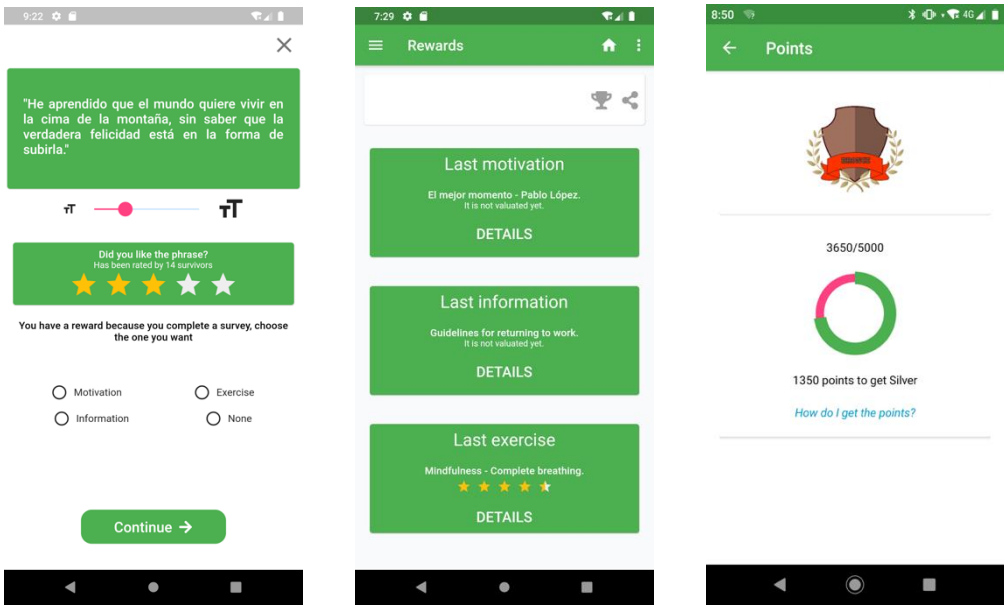
For these screens, it is worth making it clear that content is mixed in English and Spanish, because for this article we used the English version of the application for facilitating its reading, although the application supports both languages. However, the psychologists and patients were from Spain, and they used the Spanish interface of the app, and they consequently wrote everything in Spanish and mainly linked resources in Spanish. For example, some rewards are (a) resources that patients uploaded as motivations and phrases or (b) information that psychologists wrote for patients about the disease and exercises.

In Figure 3a, the patient can observe a motivational phrase that can be valued, and has the option of choosing a reward. The patient can choose between motivation, information, exercise and nothing, since as we said in stage four, we must support them when they want to receive the rewards or not, and only in the reward type they prefer to receive.

Figure 3b is the screen where the patient can see their last rewards, and can assess them if they had not been valued before.

The patient will be able to see the accumulated points and their classification on the screen in Figure 3c. In this way, users can see their progression and what it lacks to move up the ranking more visual, and thus increase their motivation to continue using the application.

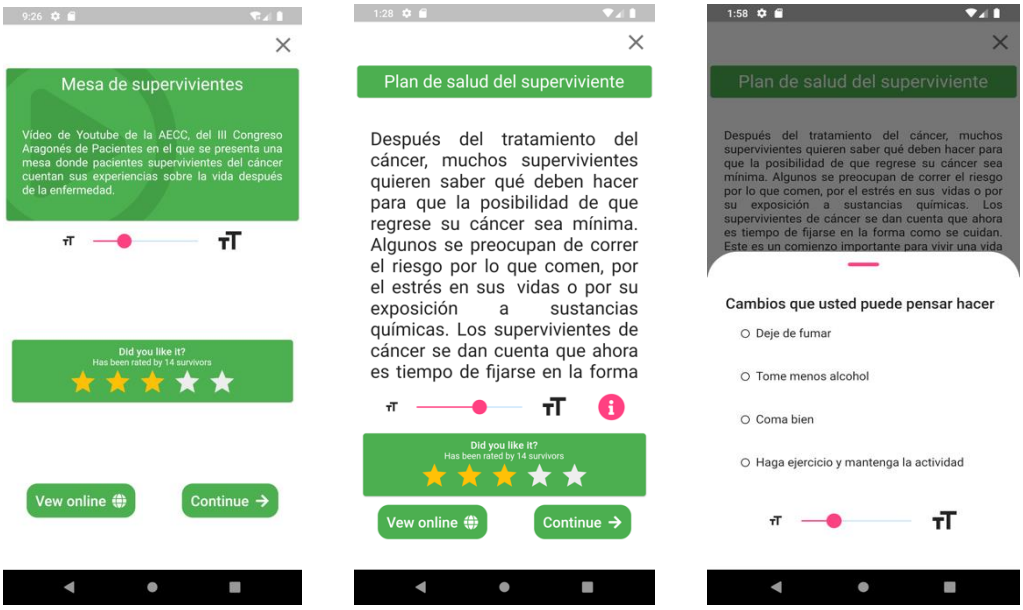
Figure 4a shows an example of informative reward in the form of video. This example presents a video made by the AECC where surviving patients tell their experiences after overcoming the disease. All rewards will have this format with a title, a description, the panel to be valued and a button to view them online.



(a) (b) (c)

Figure 3. Screens of the personalized rewards 1: (a) Reward selection screen, (b) Rewards screen and (c) Points screen

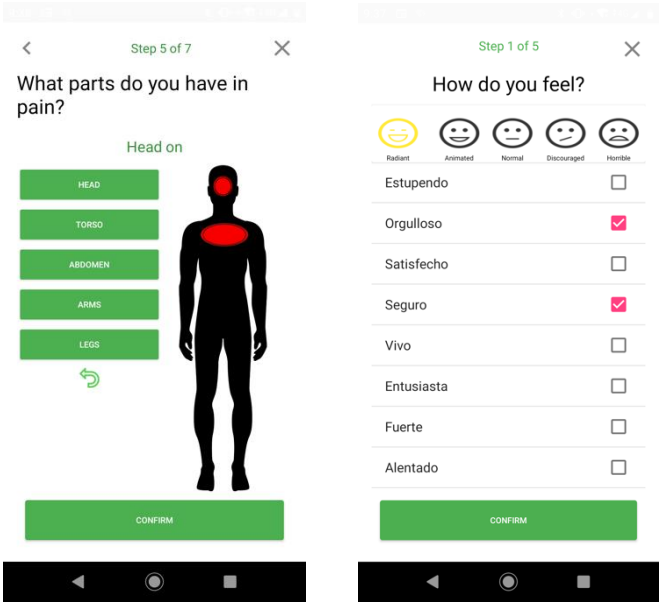
There is also the option to view the complete reward online and evaluate it. In the example of Figure 4b, the reward shows a survivor's health plan. Based on the study of the survivors and seeing how important it is to receive information, we have implemented another type of screen, Figure 4b has a title, a longer text for the content of that reward and an information button, where one can get additional information. If there is no additional information, the button is not shown. In this case, the patient can see a list of how to follow a healthier lifestyle, as shown in Figure 4c.



(a) (b) (c)

Figure 4. Screens of the personalized rewards 2: (a) Video information screen, (b) Information screen and (c) More information button content

Finally, there is an example of the surveys that will be carried out on the patient. In Figure 5a, the user can indicate where they feel pain. Figure 5b shows the question about the mood.



(a) (b)

Figure 5. Survey screens: (a) Mood screen and pain screen (b) Body parts with pain

In Figures 3a, 3b, 4a, 4b and 4c, one can see examples of accessibility, since a way of increasing the letter size has been incorporated for patients that cannot read it properly.

As one can observe, the application has been implemented with respect to the design guide of stage six with large buttons, clear and resizable letter, as well as a clean and easy-to-use interface.

Stage 9: Implementation evaluation.

We tested the usability of the generic gamification system in [38]. There were 15 users that voluntarily participated in this study, without any economical compensation, for 2 weeks. They were 40.53 years old in average with a standard deviation (SD) of 16.85. They were 7 males and 8 females. All of them were cancer patients or cancer survivors. We used the System Usability Scale (SUS) [39] to measure the usability, which is measured with a questionnaire with 10 items. We also used the Usefulness, Satisfaction and Ease of Use (USE) [40] to measure the ease of use, which measures four dimensions: (a) Usefulness (8 questions), (b) Ease of use (11 questions), (c) Ease of learning (4 questions) and (d) Satisfaction (7 questions). We urged participants to fundamentally value the motivation part in the use of the application, ranking the system, motivational resources, the exercises and the resource-sharing functionality. The average results of SUS were in the 1–5 range and the average results of USE were in the 1–7 range. We converted these results to the same range of 0–100 for the SUS and USE questionnaires, in order to be able to easily compare both results.

Regarding usability, the average result of SUS test was 69.2 in the standard range of 0-100, and the standard deviation (SD) was 20.0. Figure 3 shows the results of the individual items from the SUS scale. Hence, the average result of USE test was 80.64 in the standard range of 0-100, and the SD was 15.08. Figure 4 shows the results of the individual items of the different dimensions of the USE questionnaire, sorted by (a) usefulness, (b) ease of use, (c) ease of learning and (d) satisfaction, from the USE scale.

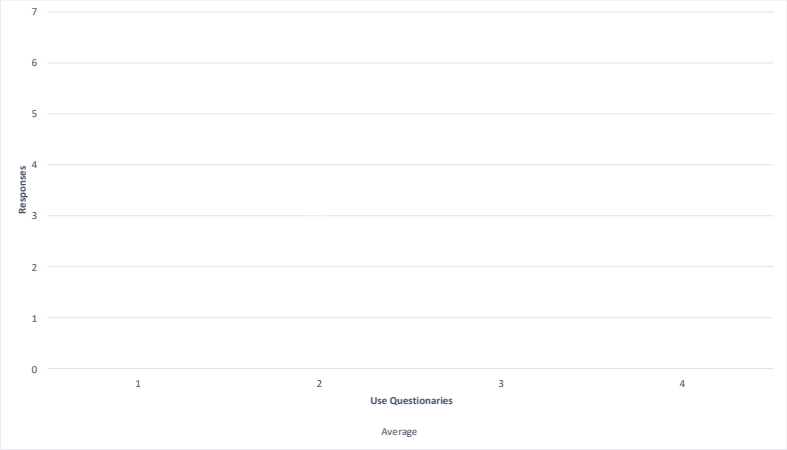


Figure 6. Results of SUS questionnaires

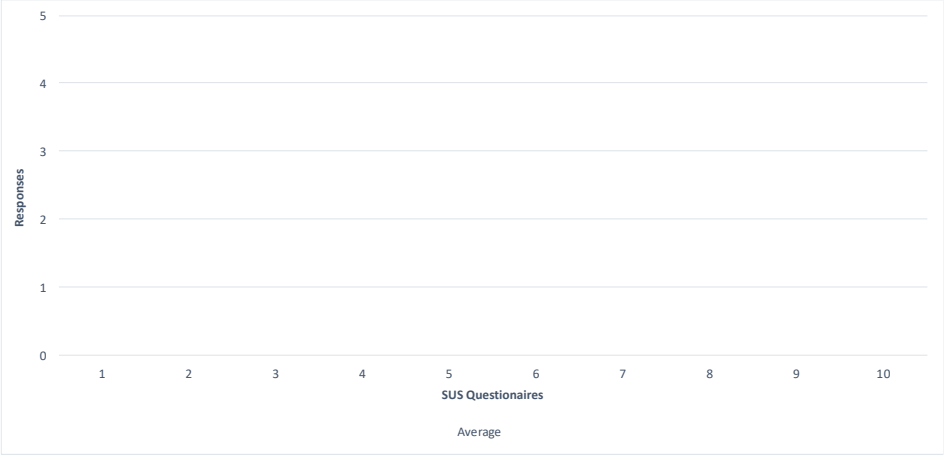


Figure 7. Results of USE questionnaires

To see if the resources we defined in stage 4 were well defined, we conducted a survey with the three medical professionals who worked with us, to validate the resources as well as the main features of our gamification system. Generic gamification system has been adapted in this paper to a specific type of users: cancer survivors.

The survey was divided into questions about information resources with the following questions: in table 2, (1) information resources (in general), (2) Information about healthy lifestyles, (3) Information about the disease / related aspects with overcoming the disease, (4) Information on guidelines for returning to work, (5) Information on changes in physical appearance, (6) information on measures to prevent side effects, (7) Information about "what do I have to inform my doctor / psychologist?", and (8) doubt forum; another phase of motivational resources with the following questions in table 3, (1) motivational resources (in general), (2) resources to make you feel happy, (3) resources to relax, (4) resources that excite you, (5) resources that give strength and (6) resources that give encouragement; another phase with the exercises that could be done with the following questions in table 4, (1) exercises (in general), (2) mindfulness exercises, (2) physical exercises, (4) yoga exercises, (5) exercise exercises Pilates and (6) sleep therapy exercises; and finally the aspects of the gamification that we had defined with the following questions in table 5, (1) ranking of points, (2) visualization of resources, (3) share resources and (4) save favorite resources. Tables 2, 3, 4 and 5 present the results of these surveys.

Table 2

Results of the information resources survey

	1	2	3	4	5	6	7	8
Average	5.00	5.00	5.00	4.67	4.67	5.00	4.67	4.33
SD	0	0	0	0.58	0.58	0	0.58	1.15

Table 3

Results of the motivational resources survey

	1	2	3	4	5	6
Average	5.00	4.67	5.00	4.00	3.67	4.00
SD	0	0.58	0	1	0.58	1

Table 4

Results of the exercises resources survey

	1	2	3	4	5	6
Average	5.00	4.67	5.00	4.67	4.67	4.67
SD	0	0.58	0	0.58	0.58	0.58

Table 5

Results of the gamification aspects survey

	1	2	3	4
Average	4.00	5.00	5.00	4.67
SD	1	0	0	0.58

6. Discussion.

The results of descriptive statistical analysis indicate that participants considered the application was easy to use and provided useful information. The highest rate was the ease-of-use dimension that we consider essential in order to all the patients know how to use the application and carry out the task of the app without needing help from an experienced person. Both in the SUS and USE questionnaires, values of standard deviation indicated that the participants' responses were highly consistent.

The answers have assessed the use of resources very positively. In particular, the information resources have been valued with a higher score and the motivational resources with less significant scores, in which although with high punctuation it would be necessary to work more on them or define them better in the future. The highest-scored motivational resources was relaxation, together with the fact that mindfulness exercises were also valued very high. One can observe that relaxation is a very relevant aspect for survivors. Finally, the best valued aspects of gamification were to share resources and visualize them, so we see that the intervention named as social support network in stage 4 can be very useful.

Interdisciplinary care must be the standard of care for all cancer patients. In the case of survivors, a study of the literature has been made where their specific characteristics and needs are presented (section 3). Regarding the gamification system, in the case of focusing on cancer patients, its adaptation should be assessed according to

the type of cancer and the type of patient. Furthermore, the resources must be adapted to patients and/or survivors, depending on their type, condition, or other influencing factors.

Professionals recommend adding other types of resources such as (a) psychosocial resources to which you can resort (e.g. entities and NGOs) and how to access them, (b) legal issues regarding the workplace (e.g. disability and leave), (c) leisure activities that can make your health better, (d) testimonies from other people who have also overcome it, and (d) activities to exercise attention and memory.

The app will be further assessed with survivors in later phases, although the preliminary results are promising.

7. Conclusions and future work

This article has focused on creating a methodology to engage patients, in our case cancer survivors, to use periodically health applications for their own well-being, by means of gamification methods.

It is essential, as we have also seen in the literature, to analyze users and that gamification gets focused on the user. In other articles that we have studied, the study of the profile is not so highly valued when performing gamification. Emphasizing the importance of incorporating the user profile into the methodology is essential for making an appropriate design of the application. In the case of survivors, it is very important to take both physical and psychological aspects into account, such as anxiety or depression.

The presented system could be adapted to different types of cancer patients or other types of patients even from other health areas. In this way, we would need to analyze patient's characteristics and needs. In order to adapt the system, a new study should be done (based on the presented methodology) to adapt the gamification system. The resources must be oriented to the users who will use the application. It is essential to make a filter of resources for these users by the medical professionals who will use the application.

Finally, we observe that it is important to collect the PROs and to do that gamification is quite relevant, since it encourages cancer survivors to use the app with an extra motivation.

In the future, one of the main objectives of the project is to perform non-invasive recording and measurement of patient evolutions, using devices or sensors, to improve both their treatment and their quality of life. In this way, we will have more options to give points to patients either by putting achievements by traveled distance, steps by day/week or simply by using the devices regularly along with the application.

When the proposal has been tested by more patients, a study will be carried out to check if the information/motivation has been useful to the patients, since to the best of our knowledge no other studies focused on cancer survivors using gamification to motivate them in the use of new technologies. Also, we want to assess whether psychologists have been helpful, in the same way that it has not been a burden for them to have to

verify that all the resources shared by the users were valid to enter them in the reward system. In this way, we can further evaluate whether the system is scalable in practice.

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