A Reusable Catalog of Requirements for Gamified Mobile Health Applications

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Abstract: The new era of mobile technologies has revolutionized all fundamental human pursuits in that many sectors have been reshaped and tangibly improved, such as education, finance, and healthcare. Referred to as mHealth, the use of mobile technologies to track and improve health outcomes is a rapidly expanding trend. A plethora of mobile health applications (mHealth apps) are being constantly developed thanks to the rapid adoption of mobile devices. From basic exercise trackers to powerful self-management tools, mHealth apps play several roles towards the provision of better healthcare. To induce playful experiences and boost engagement, gamification has proven to be extremely effective with mHealth apps. This paper presents a catalog of reusable requirements for gamified mHealth apps in terms of gamification, functional suitability, usability, and security, Further improvements are intended to be made continuously to the catalog by adding additional requirements scattered from other standards and information sources.

1 INTRODUCTION

As the world becomes gradually digitized, there is a growing potential for digital technologies to improve many aspects of health and social care provision (Bhavnani, Narula, and Sengupta 2016). Referred to as mHealth, the use of mobile technologies to track and improve health outcomes is a rapidly expanding trend. Efforts to adopt digital health apps into medical and clinical practice have progressed significantly, leading to a steadily proliferation of the mHealth industry. There are now over 318,000 mobile health applications (mHealth apps) available at the top app stores worldwide, namely, Google Play Store and Apple App Store, accounting for more than 200 apps being added each day (INSTITUTE. 2017). This staggering number is fuelled by a combination of factors including the increased penetration and ownership of smartphones, tablets, and other mobile platforms, the high burden of chronic disease prevalence, and the shift towards a patient-centric healthcare delivery (Pankomera and Greunen 2018). Besides, the rising need for tracking daily activities,

changing lifestyles and behaviours substantially results in the widespread use of mHealth apps (Baldwin et al. 2017). In this respect, mHealth apps promise to empower patients and healthcare providers at different levels and through a myriad of ways including ubiquitous access to accurate health information (Pankomera and Greunen 2018), consistent remote monitoring and vital signs self-management along with startling treatment adherence support (Baldwin et al. 2017; Byambasuren 2018). Another prevalent benefit of mHealth apps is shifted towards motivating positive health behaviour change, which is considered as the most frequently targeted lever for reducing the burden of preventable disease and enhancing wellbeing (Carroll et al. 2017; Johnson et al. 2016). Accordingly, gamification has persuasively proven to positively impact ingrained health behaviours. Typically defined as the use of game design elements in non-game contexts and settings, gamification is a vastly growing technique that can be used to motivate participation, engagement and loyalty (Sardi, Idri, and Fernández-alemán 2017a). Indeed, gamification can play a

central role in boosting user engagement with apps, particularly with mHealth apps (Lister et al. 2014). The use of gamification has already been recognized in fields such as business, training, and marketing, and it is increasingly tapping into the healthcare domain (Johnson et al. 2016). Conforming with a previous systematic literature review conducted on papers dealing with gamification in digital healthcare settings (Sardi et al. 2017a), gamification is largely leveraged to inspire users to exercise more effectively and more regularly and to help them manage their chronic conditions. The underlying idea of gamification is to harness people's innate motivation alongside the natural desire to learn, socialize, master tasks, compete, record achievements, build status, participate in self-expression and have fun. Appealing to these intrinsic motivators, the gamified technology employs rewards and competitive game features to induce user immersion in the app environment (Johnson et al. 2016). These incentives typically include earning points, achievement badges, and virtual currency or new levels, challenges and progress bars. The use of leader boards and making rewards visible to other users are ways of fostering user competition Through integrating these motivating elements, gamified apps are a natural pairing between psychology and technology, which adds more complexity to the process of their conception and development. To fulfil their ultimate goal, these apps should be developed in a way that complies with a set of requirements. Nevertheless, mobile technologies are growing at an ever-faster rate where user requirements and expectations are frequently changing. Therefore, software engineers should perform a series of requirements engineering steps to build efficient and reliable software products.

Generally, the success of a software product is often defined as one that is delivered on time, on budget, and with all the features as originally specified. In this context, requirements reuse has been proposed as an advanced requirements elicitation technique that has a great deal of potential in terms of achieving maximum productivity, quality, and consistency throughout the product development lifecycle (Palomares, Quer, and Franch 2017). Pacheco et al. have proposed a structuring approach using software requirements catalogs (SRC) to support software reuse (Ivan et al. 2016). This approach structures requirements belonging to the same domain in sorted lists (i.e., catalogs), in which each one of the software requirements has to be described in terms of its functionality and classified conforming to its importance. Moreover, these requirements must be identified in a unique way to

facilitate the search within the catalog. A requirements catalog is versatile as it can be adapted into different projects. The SRC approach is oriented to small-sized software enterprises that develop custom-built software products. Health apps are a good instance of this specific type of software products.

To the best of our knowledge, there is no requirements catalog dealing specifically with the relevant characteristics of gamified software products for healthcare. Subsequently, the major contribution of the present paper is the definition of a conventional reusable requirements catalog for gamified mHealth apps, which covers gamification aspects and a few important quality characteristics. This catalog, denominated as 'GHA-CAT' is chiefly concerned with the specification of a well-founded set of gamification aspects that are likely to meet the desired needs of stakeholders and developers of any category of mHealth apps. Despite the hype surrounding gamification, neither an agreed standard nor a requirements catalog is currently available for gamification, specifically in health settings. The quality characteristics addressed in the proposed catalog are drawn from the ISO/IEC 25010 product quality model and are limited in Functional Suitability, usability and security. In fact, the satisfaction and pleasure induced by gamification, its effectiveness, and usefulness are closely associated with the degree of ease of use and of understandability engendered by gamification while using the fully fledged health-related gamified software (Vargas Enríquez 2016). Besides, given the sensitive nature of the data collected, stored, and shared among most of the gamified mHealth apps, security has to be considered throughout the development cycle of these apps to preserve the integrity, confidentiality and privacy of users' data which will likely enhance user trust and engagement with the software (Martínez-pérez, Torre-díez, and López-coronado 2015; Mavroeidi et al. 2019).

2 GHA-CAT: A REUSABLE REQUIREMENTS CATALOG FOR GAMIFIED mHealth APPS

The elaboration of the requirements catalog for gamified mHealth apps 'GHA-CAT' builds on a requirements engineering approach called SIREN (SImple REuse of software requiremeNts). Proposed and developed by a research group from the University of Murcia (Toval et al. 2002), this

practical approach aims at reducing the total effort and cost of software development along with increasing the overall software productivity and quality (Ivan et al. 2016), through the creation, selection and elicitation of reusable requirements. Several studies in the health area have used SIREN methodology for the development of reusable requirements catalogs (Ouhbi, Fernández-alemán, et al. 2017; Zapata et al. 2018). The GHA-CAT was developed following the process depicted in Figure 1. First, the main information sources were identified. Literature and formal documents such as standards and guidelines were considered. Next, relevant requirements for the development of gamified mHealth apps were extracted from the sources previously selected. Then, the catalog GHA-CAT was generated from these requirements following the IEEE standards' structure. Finally, the generated catalog is maintained and updated regularly upon changes and/or modifications in standards, policies, and legislations. This last phase is paramount as it facilitates the requirements' adaptation into new projects. Furthermore, it addresses catalogs' incompleteness and performs a change control strategy for establishing a baseline for each developed catalog before potential modifications (Ivan et al. 2016)
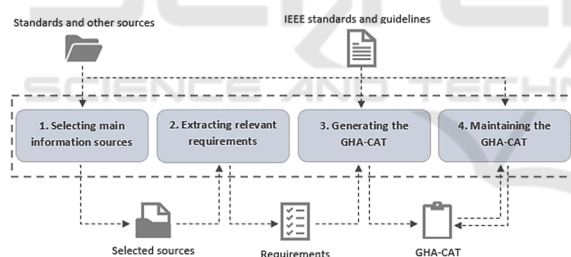

Figure 1: Catalog generation process.

2.1 Information Sources

Requirements for the GHA-CAT have been derived from the literature on gamified solutions (e.g. (Darejeh, Darejeh, and Salim 2016; Johnson et al. 2016; Morschheuser et al. 2017; Sardi et al. 2017a) and from a number of studies dealing with software quality particularly with regard Usability, Operability and Security, including requirements catalogs (Jensen et al. 2009; Toval et al. 2002; Zapata et al. 2018), evaluation studies (Moumane, Idri, and Abran 2016; Ouhbi et al. 2015; Rodríguez, Oviedo, and Piattini 2016) and reviews (Martínez-pérez et al. 2015; Salinesi and Comyn-wattiau 2015). In addition, the following international standards and technical reports have been used to specify these requirements.

- ISO/IEC 25010 standard for software product evaluation, which defines a quality in-use model and a product quality model that are relevant for all software products and computer systems (ISO/IEC-25010 2011).
- ISO/IEC 25023 standard provides quality measures for quantitatively evaluating system and software product quality in terms of characteristics and sub-characteristics defined in ISO/IEC 25010 (ISO/IEC-25023 2016).
- ISO/IEC 25040 standard provides a process description for evaluating software product quality and clarifies the general concepts (25040:2011 2011).
- ISO/IEC 27799 standard for information security management in health (ISO/IEC 27799 2016).
- CEN/TR 15640 standard provides measures with which to ensure the safety of patients using health software (CEN/TR 15640.).
- ISO 9241-210 standard for ergonomics of human-system interaction (9241-210 2019).
- The W3C standards for web and mobile devices (W3C n.d.).

2.2 Requirements' Specification

Following the identification of relevant standards and information sources, requirements related to the focal areas of the present study were analysed and specified. The requirements specification process was conducted based on the recommendations and guidelines provided by the IEEE 29148 standard (IEEE 29148) which not only describes in a comprehensive manner the processes related to requirements engineering activities but also defines a complete and normative guide for the proper preparation of Software Requirements Specification (SRS). A thoughtful and well-organized SRS document reduces significantly the development cost and is a prerequisite to high-quality software product. Drawing on this guidance, the general structure of the catalog was organized in a way that complies with the contents of an SRS recommended by IEEE 29148 as shown in Table 1. Accordingly, all requirements of the GHA-CAT are encompassed in Specific requirements sections and are organized under their corresponding subsection. With the recommendation of the IEEE 29148 standard with regards to additional requirements, gamification requirements are organized under a separate section labelled 'other requirements'. What follows is the presentation of each category of these requirements.

2.2.1 Gamification Requirements

Perhaps the core pillar delineating the success and effectiveness of gamified mHealth apps is the efficient use of appropriate game design elements. Gamification requirements therefore constitute an important section in GHA-CAT. Due to the absence of standardized guidance on building gamified mHealth apps, some developed gamified apps may negatively impact the overall user experience, resulting in unintended or unethical behaviour. An effective gamified health solution should include a combination of game design elements that promote most of the following persuasive strategies:

- Relatedness and social influence
- Purpose and goal setting
- Mastery
- Reinforcement and progress tracking
- Autonomy
- Fun and playfulness

2.2.2 Functional Suitability Requirements

Functional suitability is one of the most important quality characteristics, since it entails that a software product meets the needs and requirements of its users. Besides functional appropriateness, it covers functional correctness which alludes to the degree of the system to generate correct results with the needed level of precision, and functional completeness that stands for the system's capacity to provide all the functions specified by the user (ISO/IEC-25010 2011).

2.2.3 Usability Requirements

Usability has long been recognized as an influential factor affecting the productivity and success of interactive systems and products (9241-210 2019; Rajanen and Rajanen 2017). As a product quality characteristic, usability is defined in the ISO standard (ISO/IEC-25010 2011) as "the extent to which a product, system, or service can be used by specified users to attain specified goals with effectiveness, efficiency, freedom of risk and satisfaction in a specified context of use". Six attributes are encountered under the usability characteristic which are: appropriateness, recognizability, learnability, operability, user interface aesthetics, user error protection, and accessibility.

Table 1: Table of contents (IEEE 29148-2011).

2.2.4 Security Requirements

Security and data privacy issues are one of the major hurdles threatening the effectiveness of mobile health applications. Being one of the central quality characteristics, security is defined as the degree of information and data protection provided by a software product so that users have a level of data access appropriate to their types and levels of authorization (ISO/IEC 27799; ISO/IEC-25010 2011). It covers five sub-characteristics which are confidentiality, authenticity, integrity, non-repudiation, accountability.

2.3 Generation of the Catalog

With the purpose of simplifying the search and reuse of the requirements identified in the GHA-CAT and

in conjunction with their integration with the existing requirements documents, each category of requirements investigated in the present study is incorporated in the corresponding subsection of the SRS. Due to space constraints, only a few requirements for each subsection are shown in Table 2. The identification of requirements has been performed in a way that adheres to 'loose coupling and high cohesion' guideline, in order to ensure a high degree of flexibility of the whole system. Each requirement has a unique identifier and a clear description. Additional attributes may be completed to capture further information about the requirement such as source, date, priority, status, rationale and risk

(Wheatcraft, Ryan, and Dick 2016). These attributes can subsequently be used to manage both the requirements and the project along with helping to track the status of the project and its underlying engineering activities throughout the system lifecycle. Requirement's traceability is an overarching requirements management practice that not only defines requirements dependencies but also allows for analysis of how potential changes in requirements impact other requirements and the project as a whole. Tracing requirements can take different forms such as dependency, derivation, inclusion, exclusion, satisfaction and validation.

Table 2: CAT-GHA Requirements specification.

Gamification requirements	
G1	The app shall be user-centered in that it reflects user perceptions.
G2	The app shall integrate a combination of game mechanics.
G3	Gamification elements shall be well and seamlessly integrated.
G4	The app shall stand upon a clear set of guiding rules to avoid reward-driven behavior and cheating.
G5	Gamification elements shall not crowd out the intrinsic motivation for performing interesting tasks.
G6	The app shall enable social discovery between users.
G7	Basic information in user profiles shall be public within the app community to promote social interaction.
G8	The app shall provide at least one social interaction mechanism (commenting, tagging, instant messaging, etc).
G9	The app shall enable users to build and/or join communities of users that truly match their areas of interest and goals.
G10	The app shall scale the difficulty and help users acquire new skills.
G11	The app shall scale the challenges according to the user's current capabilities.
Functionality Suitability requirements	
FS1	The functional content of the app shall be useful for users in a way that matches their needs and expectations.
FS2	The features and functionalities of the app shall be clear and simple to access and use.
FS3	The features and functionalities of the app shall be consistent and well-integrated.
FS4	Through its different sections, the app shall provide utile and adequate content to the users.
Usability requirements	
U1	The user shall be able to easily learn to use the app and its features.
U2	The design of the app shall be comprehensible by the user.
U3	The interaction design of the app shall be intuitive, easy to learn and equally easy to remember.
U4	The app user interface should be simple with succinct elements and clear features.
U5	The app shall include a help section.
	[U6-1] The help section shall be well complete, easy to scan and effortlessly searchable.
	[U6-2] The help section shall have all resources and contact information accessible at any given point.
	[U6-3] The help section shall be context sensitive and shall explain how to achieve common tasks.
Security requirements	
S1	The app shall provide a privacy policy.
	[S1-1] privacy policy shall be understandable and conspicuously posted.
	[S1-2] The privacy policy shall clearly inform users of the information accessed, collected, or transmitted by the app and how that information is used, secured, and disclosed.
S2	Functionality that may infringe the privacy and security of users shall not be activated before the user voluntarily and in the knowledge of the related risks gives his/her consent.
S3	The app data stored in the user device shall be encrypted to prevent leakage.
S4	The personal data shall be adequate, relevant, and limited to what is necessary to the purposes for which they are processed.
	[S4-1] Only personal data necessary for the purpose(s) shall be processed.

3 RESULTS

This section illustrates the applicability of the catalog GHA-CAT using a gamified mHealth app. The selected app for evaluation using this catalog is Blood Donor which is perhaps the most gamified app in blood donation field. Blood Donor is a free app developed by the American Red Cross to motivate people to donate blood through gamification principles. The app is available in both Google play and Apple app stores. In this evaluation, the iOS version of the Blood Donor app has been used. A checklist has therefore been generated from the adapted catalog GHA-CAT* which included major aspects in terms of gamification, functional suitability, usability and security. The checklist took the form of a questionnaire regrouping 29 items. The possible answer to these questions is either 'Yes', 'No, 'Partially' or 'N/A' which means not applicable.

Table 3 summarizes the results of the evaluation perform on the Blood Donor app. The answers to the questionnaire are as follows: Yes: 26, No: 3.

4 DISCUSSION

Despite the growing popularity of gamification in mHealth apps, no specific standard has been found that clearly defines reusable requirements in terms of the integration of gamification elements. Thus, the GHA-CAT is very useful for developers and designers of gamified mHealth apps. Conjointly with gamification core pillars, the GHA-CAT also includes reusable relevant quality requirements of which developers can elicit and specify their needs with regards functional suitability, usability and security as being considered highly effective within gamified systems (Vargas Enríquez 2016).

Table 3: Checklist to assess the Blood Donor app.

ID	Question	Result
Q1	Does the app integrate a combination of game mechanics?	Yes
Q2	Are the gamification elements well and seamlessly integrated into the application?	Yes
Q3	Does the app provide at least one social interaction mechanism (commenting, tagging, instant messaging, etc.)?	Yes
Q4	Does the app enable the user to build and/or join communities of users that truly match their areas of interest and goals?	Yes
Q5	Does the app scale the challenges according to the user's current capabilities?	Yes
Q6	Does the app include small attainable goals to help users begin new behaviors and keep commitment?	Yes
Q7	Does the app provide the user with immediate feedback on their performance?	Yes
Q8	Does the app enable the user to constantly track their progress?	Yes
Q9	Does the app reward user progress through extrinsic incentives (e.g., points, badges)?	Yes
Q10	Does the app grant users with the possibility to redeem their virtual rewards?	Yes
Q11	Does the app include a sense of game-like playfulness while serving a serious purpose?	Yes
Q12	Are the features and functionalities of the app clear and simple to access and use?	Yes
Q13	Are the features and functionalities of the app consistent and well-integrated?	Yes
Q14	Is the design of the app easily comprehensible by the users?	Yes
Q15	Is the interaction design of the app intuitive, easy to learn and equally easy to remember?	Yes
Q16	Does the app include a help section?	Yes
Q17	Does the app handle errors in a right way?	Yes
Q18	Are the error messages polite, friendly, and jargon-free?	Yes
Q19	Is the informational content of the app categorized adequately?	Yes
Q20	Is the undo function available for most operations?	Yes
Q21	Does the app enable users to configure language settings to suit their preferences?	No
Q22	Does the app enable users to handle both screen orientations?	No
Q23	Is the content of the app well-presented and well-ordered?	Yes
Q24	Are the fonts used for text in the app appropriate?	Yes
Q25	Is the color scheme used on the user interface of the app adequate?	Yes
Q26	Does the app provide a privacy policy?	No
Q27	Does the app process only relevant personal data?	Yes
Q28	Does the app allow input validation to check the data supplied?	Yes
Q29	Does the app provide a strong authentication mechanism?	Yes

Considering the fulfilled items among those in the checklist, the Blood Donor app yielded a coverage score of 89.7%. In fact, the Blood Donor app has a few minor flaws with regards usability and security. Therein, this app lacks the ability of screen orientation which it is not only helpful for users with low vision but also provides opportunities to create better user experience as it offers an additional layout with a simple turn of the device. Further, the app does not implement a multi-language support, undoubtedly, because it is intended for American residents, however, the United States has always been a country noted for its linguistic diversity. It goes without saying that English language apps tend to fare well in many parts of the world but adopting the native language of users is paramount as it avoids miscommunication, widens reachability and builds loyalty and user trust. Furthermore, the absence of the privacy policy in this app may lead in violation of user privacy. Although being included in the website of the app, it is highly recommended to present an inapp privacy policy that accessible for the user at any moment (Martínez-pérez et al. 2015).

5 CONCLUSIONS

In spite of the unquestionable popularity of gamification in health care area, there is no formal standard that regulates its implementation. The present paper therefore proposed a catalog of requirements for gamified mHealth apps. Originated from recommended standards and multiple information sources, the GHA-CAT encompasses the most relevant requirements in relation to gamification, functional suitability, usability and security. This catalog is therefore intended to help stakeholders and developers in eliciting, specifying and validating requirements of gamified mHealth apps. It can be used for audit purposes as well.

For future work, it is intended to prioritize the catalog items using an appropriate requirements prioritization technique in order to guarantee the usefulness of the catalog even in critical circumstances (i.e., tight deadlines, budgetary constraints). It is also expected to continuously improve the content of the catalog using additional information sources such as new standards or other stakeholders' needs.

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