

Quality Evaluation of Gamified Blood Donation Apps using ISO/IEC 25010 Standard

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Abstract: In the light of the tremendous interest that gamified blood donation (BD) mobile applications (apps) started to gain, it is necessary to consider the quality assessment of the requirements implemented in this apps. In this paper, we provide a general overview of requirements for gamified BD apps, which have been retrieved from literature and extracted from the existing apps on the market. Using the ISO/IEC 25010 quality model, a checklist was established to analyse the influence of the identified requirements on 30 software product quality characteristics. The results obtained show a significant variability in the degree of impact of the various requirements. In particular, users' actions and App's features are the blocks of requirements that reached a very high degree of influence on quality characteristics. The only sub-characteristic affected by the whole range of requirements is Appropriateness of Functional Suitability. 92% of requirements influenced Operability characteristic whereas the lowest degrees of impact were noted for Compatibility (16%) and Transferability (11%). Blood donation apps' developers and stakeholders may consider the degree of impact analysis reported in this study to identify software quality requirements which could be included in the quality assessment of these apps.

1 INTRODUCTION

Blood donation (BD) is portrayed as a prosocial activity and maintaining a motivated pool of voluntary blood donors is the key perspective of any blood donation service. It is therefore important to understand factors that encourage individuals to donate blood and develop interventions to increase and manage their motivations (Goette et al., 2010). With the rapid prevalence of smart mobile devices and the proliferation of the new technologies in healthcare domain, BD mobile applications (apps) embody a promising approach for recruitment and retention of potential and regular blood donors (Yuan et al., 2016). Blood donation apps have the potential to reduce the resources required for donor recruitment. Find donations centres and eligible donors, keep records of BD activities and learn useful information about BD process are some of the main functionalities integrated in BD apps (Ouhbi et al., 2015). A further step towards enhancing the retention rates of blood donors involves applying gamification techniques. Vivid gamification interventions can be found in various domains such

as education, marketing, training and digital healthcare (Sardi et al., 2017). In general, gamification is the process of applying game-design thinking and game mechanics to serious purposes. Besides making activities more appealing and fun, gamification is a powerful tool to boost engagement and increase motivations. A potent gamification design draws upon a collection of game aspects including points, badges, leaderboards, avatars, among others. These elements induce feelings of mastery, progress and self-esteem. The use of gamification in blood donation has significantly increased during the last decade, therefore, diverse gamified mobile solutions intended to blood donors have emerged in research and practice. Several studies have been published investigating fundamental functionalities, characteristics and requirements of gamified BD apps (Domingos et al., 2016; Sabani et al., 2016; Sardi et al 2017b). Typical inherent requirements should be taken into consideration prior the development of any software product. As health-related mobile applications become more popular and widely claimed, it will be essential to apply software engineering (SE)

processes to assure the development of secure, high-quality apps. Besides the specification of functional requirements, eliciting Software Quality Requirements (SQR) represents a crucial part of the SE process as it determines the overall quality of the software product. As SQR started to gain increasing attention, the international research standardisation project SQuaRE (Software Quality Requirements and Evaluation) has developed a consistent standard series ISO/IEC 250xx for the software product quality, evaluated from the users and stakeholders point of view.

This paper aims to propose a comprehensive set of gamified BD apps requirements drawn out from literature and existing apps on the market and to identify which requirements should be implemented in the software product quality evaluation of a gamified blood donation app. The paper also analyses the influence of these requirements on software product quality characteristics by using the ISO/IEC 25010 standard.

The remainder of this paper is structured as follows: Section 2 presents an overview of the quality standards used and outlines the related work on the use of the software quality model for the evaluation of mobile applications. Section 3 describes how the requirements of gamified BD apps were extracted from literature and existing apps. Section 4 provide an analysis of the impact of the gamified blood donation apps requirements on software product quality. Major findings of the analysis are presented in Section 5 and thoroughly discussed in Section 6. Finally, Section 7 provides some final conclusions and directions for future work.

2 BACKGROUND AND RELATED WORK

This section provides a brief description of the standards used and draws an overview of studies that approaches the assessment of the quality characteristics of health apps.

2.1 Standards Used: ISO/IEC 25010, ISO/IEC 25023 and ISO/IEC 25030

The ISO/IEC 25010 is part of the SQuaRE (Software product Quality Requirements and Evaluation) series of International Standards which was launched in 2011 to supersede the ISO/IEC 9126 that was technically revised and republished in 2001. In ISO/IEC 25010 standard, software quality

is divided into two broad dimensions: product quality and quality in use. The software product quality model is composed of eight characteristics which are further subdivided into sub-characteristics that can be measured internally or externally. The internal quality measures are static attributes used to measure inherent properties of a software work product that are typically available during development. The external quality measures, for their part, are dynamic attributes that are used to address properties related to the execution of the software product in the system environment in which it is intended to operate. The other sub-model of the IEC/ISO 25010 'quality in use' relates to the outcome of human interaction with the software and has five characteristics, which are further divided into a set of sub-characteristics (ISO/IEC-25010, 2011). This sub-model is not tackled in this study.

The ISO/IEC 25023:2016 is part of the SQuaRE series of standards that cancels and replaces the ISO 9126-2 and ISO 9126-3. Although it is primarily intended to be used together with ISO/IEC 25010, it can also be used in conjunction with ISO/IEC 2503n and the ISO/IEC 2504n standards to address general needs with regard to system quality and software product. ISO/IEC 25023 describes a set of measures and provides guidance for quantitatively evaluating system and software product quality in terms of characteristics and sub-characteristics defined in ISO/IEC 25010 (ISO/IEC-25023, 2016).

To ensure the quality of the software, it is paramount to specify the right software quality requirements that will be the bedrock of the desired quality of the final product. The standard ISO/IEC 25030 uses the standard ISO/IEC 25020 to define which measures should be adopted for each characteristic and sub-characteristic identified in the standard ISO/IEC 25010 in order to specify the software quality requirements. It is the only standard of SQuaRE Series that is dedicated to identifying and specifying system/software quality requirements. The application of this international standard can help ensure that software quality requirements are clearly stated, correct and correspond to stakeholders' needs.

2.2 Overview of Related Work

Investigators and experts used a myriad of methods to evaluate the quality of health-related software products. Several studies prioritized usability as a referential concept for quality evaluation. Reynoldson et al. evaluated apps for pain self-management using quality assessment criteria and

testing usability with potential users (Reynoldson et al., 2014). A study by (Ouhbi et al., 2015) reported a quality assessment of a total of 133 free BD apps using a questionnaire concerning the compliance of these apps with mobile OS usability guidelines. In the same vein, (Zapata et al., 2014) assessed the accordance of 24 mobile Personal Health Records with iOS and Android usability guidelines. Another study aimed at the examination of multiple parameters around the quality of the most popular dietary weight-loss mobile apps available to the public using comprehensive quality assessment criteria (Chen et al., 2015). Moreover, a study was about proposing a rating tool to provide a multidimensional measure of the quality indicators of health apps (Stoyanov et al., 2015). Furthermore, papers within the evaluation of the quality of apps used software quality models proposed by the series of ISO/IEC standards.

3 REQUIREMENTS OF A GAMIFIED BD APP

This section summarises the main requirements of a gamified BD app considering system features and gamification aspects. The requirements elicitation phase was processed through reviewing related literature and evaluating the existing solutions in app repositories. The extraction was, particularly, based on studies targeting BD apps such as: 1) the study by (Foth et al., 2013) that proposes a design implications of a BD system based on their research findings on the necessary features for a BD app, and 2) the study by (Yuan et al., 2016) in which the authors determined the most relevant functions of BD apps to potential users besides investigating the degree of receptiveness of donors toward apps. Several studies focusing on gamification in blood donation solutions were also reviewed. For instance, the paper by (Domingos et al., 2016) presents the design of a gamified BD app that facilitates the interaction between users and blood centres. Another study by (Sabani et al., 2016) which focuses on integrating gamification elements into iOS BD apps to encourage donors and help end blood shortage. Furthermore, the findings of a previous review on gamified BD apps were used to extend the list of system requirements and gamification techniques (Sardi et al., 2017b). Given that the results of the aforementioned were obtained in 2016, a similar search was performed between August and September 2017 following the same search procedure in

order to update the pre-obtained list of gamified BD apps. Two more apps were found relevant on the market. Nine apps, of which five on Android and four on iOS were therefore included in the current study. A list of these apps is available upon request by email to the authors.

The main requirements of gamified BD apps were selected and regrouped in five clusters: App's accessibility, donor's personal information, user's actions and app's components.

3.1 App's Accessibility

App's accessibility is one of the important factors to consider when developing a mobile application. It gathers a bunch of requirements related to the availability of the app for users either before or after installation. The accessibility requirements are as follow: **AA1**. The operating system (OS) type. This requirement regards the app's availability in the well-known app repositories (iOS, Android, Blackberry, Windows Phone). **AA2**. The OS version. Given that new features are consistently added to the OS, new versions are being launched accordingly. Although it is not necessary to upgrade the OS, the user might be obliged to perform the upgrade to be able to install a specific app. Hence, the AA2 concerns the compatibility of the app with OS version. **AA3**. Cost. In app repositories, there are free and paid apps. Although paid apps have high value content and features, free apps are the most popular because users are less willing to purchase apps. In-App Purchases (IAPs) remain a prominent alternative for users seeking low price but advanced features. **AA4**. Language. Several apps provide the possibility to change the language from an in-app setting or by adjusting the phone's selected language. **AA5**. Geographical limitation. It is important to define whether the app should have a restricted availability for users in certain countries, or should be accessible from all over the world. **AA6**. Internet access. This requirement indicates whether the app requires internet connection to function. Building an app that works in both online and offline modes is considered as an effective feature.

3.2 Donor's Personal Information

Author(s) Mobile applications usually require users to offer up a certain amount of information to get the full experience with the app. Unregistered donors are therefore requested to create a user profile that contain their following personal details (PD): **PD1**.

Full name, **PD2**. Gender, **PD3**. Date of birth, **PD4**. Email, **PD5**. Address, **PD6**. Phone number.

3.3 User's Actions

User's actions (UA) constitute a set of inherent actions that should be specified in the requirements document. It should be indicated whether the user can or cannot perform these actions: **UA1**. Be authenticated using login credentials, **UA2**. Add information, **UA3**. Modify information, **UA4**. Delete information. **UA5**. Share information, **UA6**. Upload images.

3.4 App's Components

This block of requirements includes both the service-oriented features and the common gamification elements of BD apps.

3.4.1 App's Features

App's features (AF) define the requirements related to the characteristics of the app. It contains: **AF1**. Search and geolocation of local blood drives and nearby donation centres. **AF2**. Search for blood donors. **AF3**. Blood calculation. This feature provides users with their estimated blood type considering their relatives' blood types. **AF4**. Connection with blood centres. **AF5**. Scheduling and management of donation appointments. **AF6**. Push notifications for blood donation events. The donor may receive alert messages for blood campaigns and for special blood shortage. **AF7**. Reminders. These help users remember their scheduled appointments or their next date of eligibility to donate blood. **AF8**. Information on blood, its types and the blood donation process. These can help donors make their blood donation experience as safe and pleasant as possible. **AF9**. Social media. Users can share blood donation experience on social media sites, to raise awareness and encourage others to donate. **AF10**. Donation history. Users can keep track of the history of their blood donations. **AF11**. Blood donors' teams. Users can create/join a team of donors to **AF12**. In-App FAQ (Frequently Asked Questions section that improve user's experience.

3.4.2 Gamification Elements

This sub-block identifies the gamification aspects implemented in the app. It includes: **GE1**. Points. Users can earn points after each donation, which can be redeemed for real-world items. **GE2**. Special

incentives when donating upon emergency blood shortage calls. **GE3**. Status. Users obtain a new status every time they reach a blood donation milestone. **GE4**. Rewards for referring others. **GE5**. Tracking of donations' progress. **GE6**. Users' ranking on leaderboard to encourage friendly competition. **GE8**. Visualization of achievements including collected badges, points earned and lives saved.

4 IMPACT ANALYSIS OF GAMIFIED BD APPS

This section describes the analysis process used to measure the impact of the requirements defined for gamified BD apps on software product quality. The analysis process was founded on that of previous studies (Idri et al., 2016; Idri et al., 2013; Ouhbi et al. 2015), but was readjusted to the field of gamified blood donation to answer the following research question:

RQ: What influence do requirements of gamified BD apps have on software product quality?

The analysis process consisted on carrying out three steps:

Step 1. Analysis of the Product Quality Characteristics and Sub-characteristics.

The ISO/IEC 25010 was analysed in order to understand the meaning of each external characteristic and sub-characteristic. In conjunction with this standard, the ISO/IEC 25023 standard was used to grasp the definitions of the quality measures used for quantitatively evaluating system and software product quality in terms of characteristics and sub-characteristics.

Step 2. Checklist of Gamified BD Apps' Requirements using ISO/IEC 25010 Software Product Quality Model.

The two first authors built a checklist to determine the potential impact of each pre-identified requirement on external sub-characteristics of the product quality model. The checklist is available upon request by email to the authors. There were no discrepancies between the authors during the process. The checklist was revised and verified by the third author in a way that respects the following instruction: A software product quality sub-characteristic is considered to be affected by a requirement if the variables used in the calculation of the external metric are affected by this requirement.

Step 3. Calculation of the Degree of Impact of Gamified BD Apps’ Requirements on Software Product Quality.

Three degrees of impact are calculated:

1. $DI(EC,B)$: degree of impact of a block of requirements B on an external characteristic EC. This degree is calculated according to the following equation: $DI(EC, B) = \sum DI(EC, R) / N(R)$ where $DI(EC, R)$ is the degree of impact of requirement R on an external characteristic EC and N(R) is the total number of requirements in the block B.

2. $DI(EC,R)$: degree of impact of a requirement R on an external characteristic EC. This degree is calculated according to the following equation: $DI(EC, R) = N(EsC, R) / N(EsC)$ where N(EsC, R) is the number of sub-characteristics of EC that are affected by R and N(EsC) is the number of sub-characteristics comprised in EC.

3. $DI(EsC, B)$: degree of impact of a block of requirements B on an external sub-characteristic EsC. This degree is calculated according to the following equation: $DI(EsC, B) = \sum DI(EsC, R) / N(R)$ where $DI(EsC, R)$ is the degree of impact of requirement R on an external sub-characteristic EsC.

N(EsC) and N(R) are obtained from the checklist established in step 2.

After that the calculation of these degrees was performed, the results were classified into five groups: Very high if the result is between 0.90 and 1.00; High if the result is between 0.7 and 0.89; Moderate if the result is between 0.4 and 0.69; Low if the result is between 0.2 and 0.39; and Very low if the result is between 0 and 0.19.

5 RESULTS

As an attempt to answer the research question defined for this study, this section presents the results of the impact analysis of gamified BD apps’ requirements on software product quality

characteristics. The checklist comprises 30 external sub-characteristics and a total of 37 requirements specified for gamified BD apps. As shown in Figure 1, The block AA has the lowest degree of impact on software quality characteristics. Compatibility and Maintainability are the least influenced by the blocks of requirements among eight quality characteristics as their degrees can be described as low and very low. Functional Suitability is moderately influenced by AA and PD blocks. All the blocks have low to very low degree of impact of Security characteristic. Transferability is only influenced by AA block with a low degree. UA, PD, AF and GE blocks have a moderate degree of influence on Operability and a very high degree of impact on Performance Efficiency. Figure 2 presents the degree of impact of each requirement of gamified BD apps on the external characteristics. Functional Suitability is the only characteristic that is influenced by all the requirements. 91% of requirements affect the Operability characteristic. Performance Efficiency is influenced by 86% and Reliability by 84%. For Maintainability and Security, the impact is measured considering 54% and 35% of the requirements, respectively. The lowest degrees of impact are obtained for Compatibility (16%) and Transferability (11%). The requirements AF4 and AF5 have the most impact on software quality followed by UA1 and AF10. In contrast, AA3 is the requirement that have the least influence on the quality characteristics. Detailed insight into the impact of the blocks of requirements on each external sub-characteristic is illustrated in Figure 3.

Appropriateness is the only sub-characteristic that is affected by the whole range of requirements. Whereas, none of the requirements has an impact on three sub-characteristics of Maintainability, namely Analyzability, Changeability and Testability in addition to one Compatibility sub-characteristic (Replaceability). Confidentiality is the most affected Security sub-characteristic. PD, UA, AA and GE blocks have an equal degree of impact on

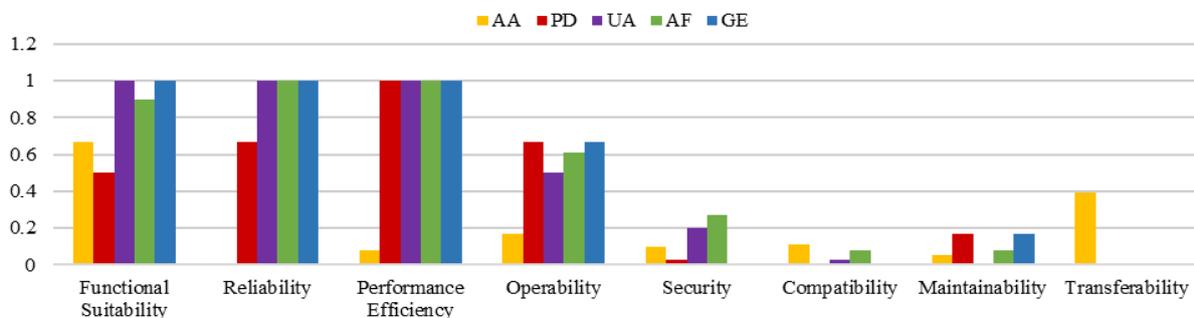


Figure 1: Impact of a block of requirements on an external characteristic.

Performance Efficiency sub-characteristics. Among Operability's sub-characteristics, Technical accessibility and Appropriateness recognizability are the most affected by all the blocks of requirements. Maintainability is roughly influenced through Modularity sub-characteristic. Learnability, Reusability and Modification stability are only influenced by one requirement: AA3, AA2 and AA6, respectively.

6 DISCUSSION

This section discusses the results and the main findings of this study and presents their implications for developers of gamified BD apps.

6.1 Main Findings

This study lists a set of requirements of gamified BD apps that were drawn out from literature and from the existing gamified BD solutions in app repositories. Among this compilation of requirements, (AF1) Search and geolocation of donations centres and (AF2) Search for blood donors were the features that are predominantly included in the gamified BD apps. One important aim of developing a mobile app in the area of blood donation is facilitating communication between blood donors, recipients, and donation centres (Mostafa et al., 2014). All the requirements underwent the analysis process described in section 4 in order to obtain their degrees of impact on the external quality characteristics. With the exception of the OS version (AA2) and cost (AA3), all the requirements can be considered as software quality requirements. After performing the impact analysis, the blocks UA, AF and GE were found to have an important impact on the quality characteristics. Considering the UA block, UA1: to be authenticated is the requirement that mostly affect software product quality, followed by UA6: Upload images. Security and privacy constitute an essential part of mobile applications systems development, particularly health applications that store several data regarding patients' health status (Martínez-pérez et al., 2015). Improper implementation of security information can have severe repercussions on users and stakeholders alike. Authentication (UA4) represents a crucial source of security shortcomings and has therefore a notable impact on software product quality. A secure authentication can be achieved through adding another layer of security over the user credentials, this can include one of the three authentication' classes, such as

asking a secret question, using a smart card or implementing biometric authentication (Kjeldgaard et al., 2012). With regard to the requirements considered as apps' features, connection with donation centres (AF5) is one of the AF block requirements to have a great influence on software product quality. One of the most interesting aspects of the mobile health sphere is its ability to promote communication across the healthcare sector from caregivers and patients. Nonetheless, the lack of a standardized and efficient form of data exchange is one of the most critical issues encountered by health apps' developers (Al-habsi & Seldon, 2013). Scheduling appointments (AF4) is another aspect of connecting to donation centres. The possibility of tracking donations history (AF10) is another requirement that threaten the software product quality of mobile applications as it implies privacy issues. Lastly, a notable and equal impact on software product quality was identified for all the requirements of gamification elements block (GE). Although the application of gamification to BD apps has various benefits, it can be rendered ineffective if poorly implemented. Using gamification mechanisms that do not mesh the audience's need and burdening the app with a plethora of gamification elements are some of the problems that negatively impact the overall quality of the software product (Pereira et al., 2014). Moreover, the results show that along with Functional Suitability, Reliability and Performance Efficiency are the external characteristics which are highly affected by requirements of BD apps. Frequent disconnection and limited energy autonomy are some of the limitations of mobile environments that have significant influence on Reliability characteristic. Whereas Performance Efficiency is affected by limited storage capacity and lower bandwidth. On that account, it is critical to take into consideration these limitations at requirements elicitation phase. According to the checklist, Operability sub-characteristics were fairly affected by gamified BD apps' requirements. The limitation of user smartphone interface is one of the obstacles that may be encountered by Operability characteristics (Idri et al., 2013).

6.2 Implications for Research and Practice

This study has identified a range of requirements for gamified BD apps, which developers and evaluators can translate to SQR for the assessment of software product quality. Software product quality evaluation

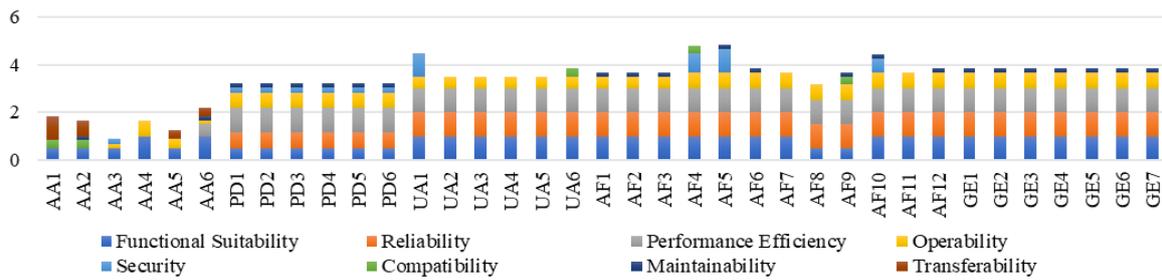


Figure 2: Impact of a requirement on an external quality characteristic.

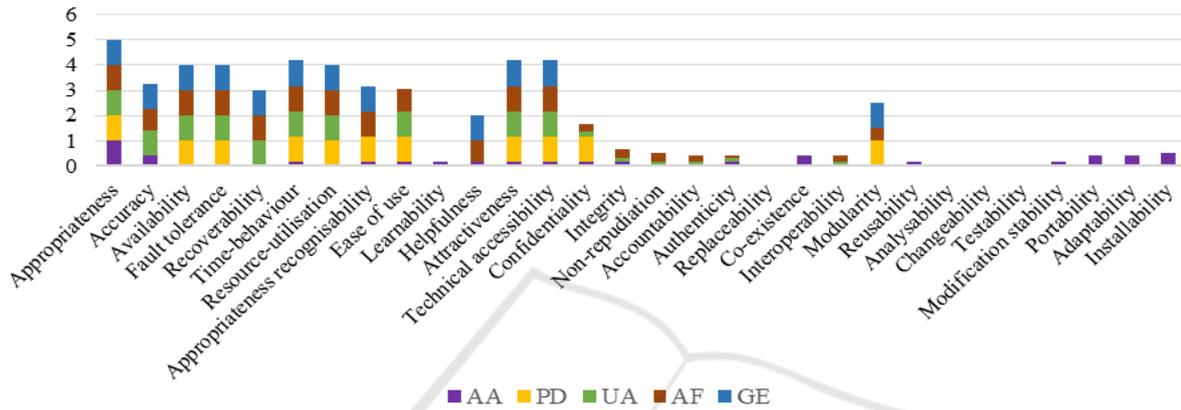


Figure 3: Impact of a block of requirements on an external sub-characteristic.

can be undertaken during or after the development or acquisition process. The requirements of gamified BD apps for external quality characteristics should be quantitatively described in the SQR. The checklist established in this study on the influence of BD requirements on quality characteristics may be of significant use to developers of gamified BD apps. Stakeholders could take advantage of the suggestions made in this study to draw up the requirements the essential requirements that help augment the overall quality of gamified BD apps.

7 CONCLUSION AND FUTURE WORK

In this paper, a compilation of 37 requirements for gamified BD apps were extracted from literature and from the few available apps in iOS and android repositories. A software quality assessment was performed using the ISO/IEC 25010 quality model in conjunction with ISO/IEC 25023 standard. A checklist was therefore established aiming at calculating the degree of influence of the gamified BD apps requirements on 30 quality characteristics. According to the outcomes of this study, some quality characteristics, through certain sub-

characteristics, were more impacted by BD apps requirements than others, namely, Functional Suitability, Operability, Reliability, Performance Efficiency and Security. One limitation of this study is that it may have disregarded relevant requirements for gamified BD apps. Nevertheless, a thorough review of literature and extensive search in app repositories were undertaken to alleviate this threat. Future work will involve several research lines. We intent to perform an empirical evaluation of existing gamified BD apps using the results of this study. We also consider assessing the quality-in use of gamified BD apps using the ISO/IEC 25010 quality model. Another interesting future perspective would be that of investigating the disparity in the degrees of the impact of requirements for BD apps.

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REFERENCES

- Al-habsi, A. A. A., & Seldon, H. L. (2013). A communication module for mobile Personal Health Record. In *IEEE 7th International Power Engineering and Optimization Conference* (pp. 727–731).
- Chen, J., Cade, J. E., & Allman-Farinelli, M. (2015). The Most Popular Smartphone Apps for Weight Loss: A Quality Assessment. *Uhealth, JMIR Mhealth*, 3(4).
- Domingos, D. C. L., Lima, L. F. S. G., Messias, T. F., Feijó, J. V. L., Anthony, A. R., & Soares, H. B. (2016). Blood Hero: an application for encouraging the blood donation by applying gamification. In *IEEE 38th Annual International Conference of Engineering in Medicine and Biology Society* (pp. 5624–5627).
- Foth, M., Satchell, C., Seeburger, J., & Russell-bennett, R. (2013). Social and Mobile Interaction Design to Increase the Loyalty Rates of Young Blood Donors. In *Proceedings of the 6th International Conference on Communities and Technologies* (pp. 64–73).
- Goette, L., Stutzer, A., & Frey, B. M. (2010). Prosocial Motivation and Blood Donations: A Survey of the Empirical Literature. *Transfusion Medicine and Hemotherapy*, 37(3), 149–154.
- Idri, A., Bachiri, M., & Fernández-alemán, J. L. (2016). A Framework for Evaluating the Software Product Quality of Pregnancy Monitoring Mobile Personal Health Records. *Journal of Medical Systems*, 40(50), 1–17.
- Idri, A., Moumane, K., & Abran, A. (2013). On the Use of Software Quality Standard ISO / IEC9126 in Mobile Environments. In *20th Asia-Pacific Software Engineering Conference* (pp. 1–8).
- ISO/IEC-25010. (2011). INTERNATIONAL STANDARD ISO / IEC / IEEE Systems and software engineering — engineering.
- ISO/IEC-25023. (2016). INTERNATIONAL STANDARD ISO / IEC FDIS 25023 (Vol. 2016).
- Kjeldgaard, C., Dyhr, A., Klonovs, J., Petersen, C. K., Olesen, H., & Hammershøj, A. (2012). Development of a Mobile EEG-based Biometric Authentication System. In *WWRF Meeting*.
- Martínez-pérez, B., Torre-díez, I. De, & López-coronado, M. (2015). Privacy and Security in Mobile Health Apps: A Review and Recommendations. *Journal of Medical Systems*, 39(181).
- Mostafa, A. M., Youssef, A. E., & Gamal, A. (2014). A Framework for Smart Social Blood Donation System Based on Cloud Computing. *Health Informatics Journal*, 3(4), 1–10.
- Ouhbi, S., Fernández-Alemán, J. L., Toval, A., & Idri, A. (2015). Compliance of Blood Donation Apps with Mobile OS Usability Guidelines. *Journal of Medical Systems*, 39(6), 1–21.
- Ouhbi, S., Fernández-Alemán, J. L., Toval, A., Idri, A., & Rivera Pozo, J. (2015). Free Blood Donation Mobile Applications. *Journal of Med. Systems*, 39(5), 1–20.
- Ouhbi, S., Idri, A., & Fernnandez-Aleman, J. L.. (2015). Applying ISO / IEC 25010 on Mobile Personal Health Records. In *8th International Conference on Health Informatics* (pp. 405–412).
- Pereira, P., Duarte, E., Rebelo, F., & Noriega, P. (2014). A review of gamification for healthcare contexts. Design, User Experience, and Usability: User Experience Design for Everyday Life Applications and Services: *3rd International Conference, DUXU 2014*, 742–753.
- Reynoldson, C., Stones, C., Allsop, M., Gardner, P., Bennett, M. I., Closs, S. J., ... Knapp, P. (2014). Assessing the Quality and Usability of Smartphone Apps for Pain Self-Management. *Pain Medicine*, 15, 898–909.
- Sabani, A. C., Kerthyayana Manuaba, I. B., & Adi, E. (2016). Gamification: Blood Donor Apps for iOS Devices. *Journal of Game, Game Art and Gamification*, 1(1), 14–26.
- Sardi, L., Idri, A., & Fernández-alemán, J. L. (2017). A systematic review of gamification in e-Health. *Journal of Biomedical Informatics*, 71, 31–48.
- Sardi, L., Idri, A., & Fernández-alemán, J. L. (2017). Gamified Mobile Blood Donation Applications. In *5th International Work-Conference on Bioinformatics and Biomedical Engineering (Vol. 1, pp. 165–176)*.
- Stoyanov, S. R., Hides, L., Kavanagh, D. J., Zelenko, O., Tjondronegoro, D., & Mani, M. (2015). Mobile App Rating Scale: A New Tool for Assessing the Quality of Health Mobile Apps. *JMIR Mhealth Uhealth*, 3(1).
- Yuan, S., Chang, S., Uyeno, K., Almquist, G., & Wang, S. (2016). Blood donation mobile applications: are donors ready? *Transfusion*, 56, 614–621.
- Zapata, B. C., Niñirola, A. H., Idri, A., Fernández-alemán, J. L., & Toval, A. (2014). Mobile PHRs Compliance with Android and iOS Usability Guidelines. *Journal of Medical Systems*, 38, 1–16.