VazaZika: A Software Platform for Surveillance and Control of Mosquito-Borne Diseases

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***Abstract*—Mosquito-borne diseases negatively affect economically emerging countries. Nevertheless, the current public healthcare solutions are insufficient to support disease surveillance and control. The citizen engagement in reporting mosquito breeding sites is hard to achieve but essential in preventing disease outbreaks. This paper introduces the VazaZika platform aimed to support the surveillance and control of mosquito-borne diseases. This platform evolves the VazaDengue legacy platform with gamification. Through game elements and rules, we aim to make enjoyable and challenging to report mosquito breeding sites via VazaZika. Citizens are continuously rewarded as they perform tasks in the platform. They progress in levels that enable new tasks and jump in rankings according to the citizens' location. Citizens can also join teams for engaging with challenges, which helps to develop a sense of belonging and connection against the spread of diseases. This paper reports the process of gamifying VazaDengue, the platform user interface and its conceptual model, aimed to support reuse.**

***Index Terms*—Gamification; Information System; Web System; Mobile System; Public Healthcare**

I. Contextualization

The *Aedes aegypti* mosquito transmits various diseases such as Zika [1]. Mosquito-breeding sites have rapidly spread worldwide due to poor basic sanitation plus warm and humid weather [1]. Thus, various countries have started to promote public healthcare solutions aimed to support the surveillance and control of mosquito-related diseases. Unfortunately, these solutions may fall short in engaging citizens with essential tasks, especially the report of mosquito breeding sites.

In 2015, we have introduced the VazaDengue [2] platform with the purpose of collecting and managing reports of mosquito breeding sites in Brazil. We aimed to provide the public health agents with reports that help them track disease outbreaks. The platform consisted of a mobile and a web system integrated via web services. The platform offered different features: (1) citizens report the location of mosquito breeding sites through the mobile system; (2) citizens and health agents monitor the reported locations through a dynamic map provided by the mobile and the web systems; and (3) the web system monitors social media like Twitter [3] for automatically identifying reports of mosquito breeding sites.

After deploying VazaDengue, we observed decay in the number of new platform users and views from April 2015 (VazaDengue release) to April 2018. Such decay suggested a lack of continuous user engagement with the platform. Thus, the health agents had an insufficient number of reports to cope with disease outbreaks. We then decided to incorporate gamification [4] into VazaDengue. Gamification means applying game elements and rules to non-game contexts for engaging people [4]. We aimed to make fun the constant report of mosquito breeding sites through game elements and rules.

Gamifying the legacy platform was far from trivial. It has basically required (1) to draw inspiration from successful gamified platforms and (2) to adapt an existing gamification method [5] to support specific activities of gamifying existing platforms

(e.g., revisiting requirements and architecture). This paper presents the VazaZika gamification process and conceptual model. The process has involved Brazilian public health agents and other professionals, such as epidemiologists. We aim to support software engineers in reusing knowledge from our experience with gamifying our platform.

II. Gamification Goals and Requirements

A. Defining and Prioritizing Goals

Once we evolved the VazaDengue legacy platform, we had to reason about which *gamification goals* we would like to achieve. The elicitation of these goals was based on our experience with implementing and monitoring the user engagement with those systems. The definition and prioritization of goals have enabled the VazaZika development team to choose the game elements and rules that best fit these goals in the future. We have defined the gamification goals via three steps as follows.

Step 1: we have met with the public health agents aiming at understanding the VazaZika system domain, thereby answering questions such as "How do mosquito-borne diseases spread?" and "What tasks can citizens perform to support both disease surveillance and control?" Our result was an initial list of gamification goals. **Step 2:** we have ranked and refined the previously obtained list with the purpose of (1) discarding redundant goals, (2) defining more specific goals, and (3) identifying what goals should be addressed first. **Step 3:** we have discussed to what extent gamification could address each goal.

We list the VazaZika systems goals sorted by descending priorities as follows. **Goal 1:** promote a constant report of mosquito breeding sites such that tracking disease outbreaks and eliminating sites become easier for the health agents. **Goal 2:** promote such reports in all Brazilian locations. **Goal 3:** promote varied tasks in terms of purposes, difficulty, and user engagement. **Goal 4:** provide tasks to be performed individually and in teams by citizens, in order to spread the systems' user base.

B. Defining Requirements

After defining and prioritizing goals, we have performed three steps to define requirements as follows. **Step 1:** we have elicited the gamification contexts of VazaZika from the existing platform. We aimed to answer questions such as "What factors do constraint the user engagement in VazaDengue?" and "Which existing functionalities should we gamify to boost the users' engagement?". As a result, we have discarded the gamification of certain functionalities provided by VazaDengue. For instance, the report of disease cases was discarded by a health agent demand. We provide additional details in our research companion website [6].

Step 2: we have discussed possible users of our gamified platform. We aimed to address questions such as "What are the potential users of the gamified systems?" and "How should citizens interact with our systems?" We addressed these questions by using personas [7] that help describing user profiles based on their possible needs and expectations with a system. Profiles usually contain the user name, age, and interaction contexts [7]. We have elicited five personas for VazaZika as exemplified in the following. **Persona 1:** *Laura* is *18 years old*, she *loves playing games*, and she *lives in a community affected by several many disease cases.* Our website [6] presents the full persona list.

Step 3: based on the elicited personas, as well as the existing VazaDengue systems, we have elicited the non-functional requirements for VazaZika. In total, we have defined: (1) five functional requirements, such as *The citizen can report mosquito breeding sites through text, pictures, and geolocation data*; (2) four gamification-specific requirements, such as *The citizen can perform tasks either alone or as part of a team*; and (3) six non-functional requirements, such as *The system must inter-operate through a shared communication protocol*. We present the complete requirements lists in the research companion website [6].

III. Conceptual Model

A. Defining Game Elements and Rules

We performed the following steps to define game elements for VazaZika. **Step 1:** by compiling a set of ten platforms that we are familiar with (e.g., Doulingo and Waze), we aimed to know: "What game elements used by familiar systems we could implement in VazaZika for engaging users?" Our goal was identifying game elements that could be perceived as successful in engaging users. We have identified 13 game elements in the platforms, which

we describe in our website [6]. Points and badges are the most frequent game elements, implemented by 70% and 60% of the studied platforms. **Step 2:** as a complement to the compilation of game elements, we relied on gamification for answering this question: "What game elements VazaZika should implement to properly engage users?"

We have decided to implement 11 out of the 13 game elements elicited in Step 1 (see [6]). In a first moment, we decided not to implement both *chats* and *notifications* in the platform. However, as users start using and engaging with VazaZika, we plan to monitor users' interactions to observe whether (1) users are likely to engage through chats based on their interactions via *comments*, and if (2) adding notifications could promote a more frequent interaction with certain features that eventually become less frequently used in the long term.

B. Defining Rules and Conceptual Model

Step 1: we defined two rule categories for gamifying our platform. *Relations between the set of systems and their users (SU)* determine how the user interacts with the platform through the game elements. As an example, the VazaZika citizens earn points after reporting a mosquito breeding site. It aims at acknowledging the citizen so that he/she feels encouraged to report sites again. *Relations between a pair of game elements (EE)* determine how one element affects another. E.g., points assigned to a VazaZika user count on the user ranking. Our website [6] lists the implemented rules.

Step 2: we built the gamification conceptual model [4] for visually representing how the gamified platform should operate internally. Figure 1 introduces the VazaZika gamification model. The figure represents the system user, game elements, and rules. Arrows represent the gamification rules as follows. Continuous arrows represent SU rules and dotted arrows represent EE rules. Aimed to address the stakeholders' needs, we did not gamify the interactions of health agents with the platform. Thus, our model does not comprise these actions.

IV. Prototyping and Implementation

A. System Prototyping

We performed five steps to define VazaZika interface. **Step 1:** we conducted brainstorming rounds

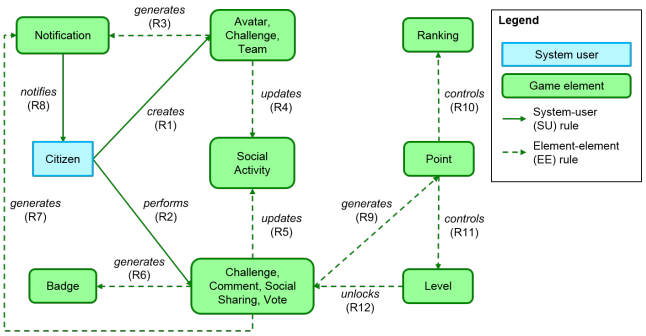


Fig. 1. The VazaZika gamification conceptual model

aimed to discuss the visual items of both mobile and web systems' interfaces. Our goal was answering questions like "How should we represent each game element as a visual item in the VazaZika's user interface?" and "How to organize the visual items in such a way that makes easy to access and manage them?" **Step 2:** a few developers have drawn low-fidelity prototypes that estimate how the visual elements should look like and be organized.

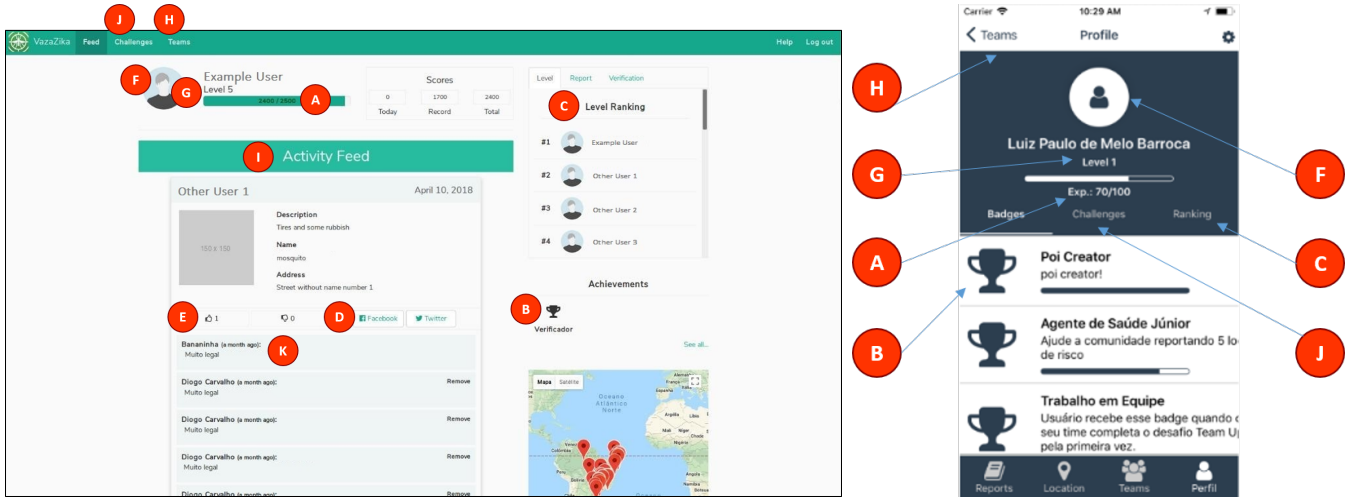
B. System Implementation

Step 3: Figure 2(a) shows the main screen of the mobile system, and Figure 2(b) shows the main screen of the web system. We highlight in the figure the visual representations of each game element implemented by VazaZika as follows: Point (A), Badge (B), Ranking (C), Social Sharing (D), Vote (E), Avatar (F), Level (G), Team (H), Social Activity (I), Challenge (J), Comment (K).

We relied on agile development principles [8], such as short development cycles (biweekly) and iterative design, implementation, and testing. Regarding the technologies that we employed to implement the VazaZika systems, we used the following. **Mobile system:** React Framework for multi-platform interface development; SQLite for data persistence. **Web system:** PostgreSQL for data persistence; IntelliJ for development. **Both systems:** Balsamiq mockup tool; Git for system version control; JSON as our standard format for data transmission; and REST as the object transfer pattern.

V. Potential Knowledge Reuse

An Adapted Gamification Method: We relied on a gamification method [5] to guide the process



(a) Mobile system (b) Web system

Fig. 2. Main screen per VazaZika system

of gamifying VazaZika. However, this method, similarly to others provided by the current literature [9] [10], focuses on the gamification of systems built from scratch. Thus, they do not consider the existing knowledge about a system (e.g., domain, requirements, and architecture). As a response to that limitation, this paper documents the gamification process, which includes activities such as reasoning about the existing system and past users (Steps 2 and 3 of Section II-B). We expect to support developers in gamifying existing systems.

A Conceptual Gamification Model for Healthcare Systems: We have defined our conceptual model based on 11 game elements recurrently implemented by successful systems, such as Duolingo and Waze. We also carefully designed 12 rules aimed at interrelation systems and users, as well as pairs of game elements, in order to achieve well-defined gamification goals. Thus, system designers in charge of eliciting either game elements or rules to a gamified system could reuse our conceptual model to define the game elements and rules that help them achieve a satisfactory users' engagement, especially in the case of healthcare systems with a similar purpose of VazaZika (e.g., [11]).

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