

## Towards the Design of a Gamified Application to Increase Tuberculosis Treatment Adherence in Vietnam

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### Abstract

*Despite being treatable, tuberculosis (TB) remains among the most common causes of death worldwide. One of the countries with the highest-burden from TB is Vietnam. A major factor responsible for the high mortality rate is nonadherence to medication and the subsequent outbreak of multidrug-resistant forms of TB, which are harder to treat and show a lower chance of survival. Existing measures to increase medication adherence focus on monitoring medication intake without considering the reasons for nonadherence – the stigmatization of TB patients. Addressing this problem, we design a concept for a patient-centered, gamified application aiming to reduce stigmatization and empower TB patients. Based on a literature review and interviews with experts from science and practice, including former TB patients, we elaborate on the functionalities and gamified elements of the application. Eventually, we present the design concept for the application based on Lui et al.'s framework for designing a gamified information system.*

**Keywords:** Gamification, mHealth, Tuberculosis

### 1. Introduction

Tuberculosis (TB) is the 13th deadliest disease and the second leading cause of death worldwide from a single infectious agent; one of the countries with the highest-burden from TB is Vietnam [1]. To fight TB, Vietnam developed a national TB prevention strategy, which aims to reduce TB cases by implying information systems (IS) to improve early detection mechanisms, medication adherence, and treatment procedures. A major factor responsible for the spread and the high number of deaths from TB is the irregular adherence to medication, leading to the development of multidrug-resistant TB (MDR-TB). MDR-TB is expensive and difficult to treat. Thus, ensuring

continued adherence among those affected remains one of the major challenges in the fight against TB [2].

Existing approaches to promote adherence mainly focus on increasing compliance by monitoring the medication intake (e.g., telemonitoring) or providing external incentives (e.g., rewards) [3]. Unfortunately, these approaches did so far not have the desired effect. One reason is that these approaches focus on addressing the outcome, i.e., treatment irregularity, rather than the reasons for treatment nonadherence. These include lack of information regarding the importance of continued medication intake, medication-related side effects, and other economic and social factors [4], [5]. Especially, social factors, such as stigmatization (stigma), play a continuous role in causing people's non-adherence to TB treatments, as patients fear social exclusion, job loss and discrimination [4], [5]. Approaches aiming to inform TB patients about treatment possibilities and empowering them has been shown to effectively combat stigma, e.g., in the form of physical TB clubs, where patients can share experiences, motivate themselves or seek support in a non-prejudicial environment. However, these solutions are not scalable and increase the risk of re-infection due to spatial proximity [6]. Given the role of stigma in the fight against TB and the limitations of physical TB clubs in educating patients, this study aims to explore to foundations for creating a digital and scalable solution that helps patients deal with stigma and thus increase the likelihood of treatment adherence. For this, we propose a mobile application (app) that uses gamification elements. Gamification, comprising game design elements in non-game contexts, has become a valuable approach to engaging users in various domains [7]. Especially in the healthcare sector, gamification is increasingly recognized as a tool to motivate patients to adopt desired behaviors [8]. However, designing a gamified IS system is not trivial. If not properly tested and applied, gamification design and mechanisms might lead to unintended and

detrimental effects on patients. Therefore, it is important to understand the logic and interdependencies of gamified elements in context. Depending on, among others, cultural factors, the situation of patients, and the design of national healthcare systems, gamified elements can work differently [9]. Consequently, to design a gamified app that actually supports TB patients to combat stigma, domain experts, users, and other relevant stakeholders [9] need to be engaged in the process of building a gamified system. Hence, we ask the following research question: *Which features and gamified elements can be used to increase adherence of TB patients in Vietnam using a smartphone application?*

In this paper, we work out the design for a gamified app that educates people infected with TB to be more resilient and help each other in dealing with stigma and social consequences. Besides providing information and direct channels to doctors and healthcare workers, additional functionalities are incorporated encouraging patients to openly discuss the disease and support each other, thus counteracting stigma. To work out the features and functionalities of the app, we first conduct a literature search to identify possible gamification mechanisms. Next, we validate whether the identified mechanisms are suitable to be applied in the context of TB in Vietnam by conducting semi-structured interviews with diverse stakeholders (i.e., doctors, healthcare workers, TB patients in Vietnam), encouraging them to openly discuss the disease and issues in TB treatment and stigma. Building upon the interviews, we work out the functionalities for the app and the gamification elements to be implemented. Based on the framework for designing a gamified system suggested by [10], we eventually present a first design concept for the app.

## 2. Related Work

### 2.1 Problem Statement - Tuberculosis

Considering the treatment options for TB, the good news is that TB is curable if the disease is detected and treated promptly. By taking a combination of several antibiotics, patients can be cured within six months [11]. However, this changes if resistant or multidrug-resistant bacterial forms of TB evolve due to medication misuse [2], such as not taking medications continuously or only for a short period. "Resistance" thereby signifies that the bacterium is resistant to at least one of the four antibiotics applied to treat TB.

The term multidrug-resistant (MDR-TB) is used if resistance to at least one of the two first-line antibiotics evolves [12]. In the case of MDR-TB, the treatment duration extends from initially six months to up to 18

months. In addition, various second-line antibiotics must be taken, which significantly increases the cost of treatment and may lead to increased side effects caused by the partly toxic second-line antibiotics. Moreover, treatment success rate drops significantly [1]. The main reasons for nonadherence to medication and consequently for the development of MDR-TB include the patient's economic situation, the type of treatment (inpatient or outpatient), and the burden of stigma [1]. Stigma is a social process marked by exclusion, rejection, blame, or devaluation that occurs because of the experience or reasonable expectation of an unpleasant social judgment about a person or group with a specific health problem [13]. Fighting TB means fighting the stigma of the disease [1]. A vital approach is empowering patients by educating them about the disease and its treatment possibilities so that they can handle and communicate openly about their disease and thus actively fight stigma [14].

Vietnam is considered one of the high burden countries for TB. Ranking 10th in the world, Vietnam is both a high TB and high MDR-TB incidence country with 172,000 persons with new TB each year, including 8,400 persons with drug-resistant TB. Despite the high rate of incident MDR-TB cases, only 38% are initiated treatment with a successful completion rate of only 72%. Thus, the latter is a significant contributor to the case fatality ratio of 6%, whereby 10,400 individuals die of TB each year in Vietnam. [1].

### 2.2 Gamification

There is no common definition of the term gamification. While [15] define gamification as "the use of game design elements in non-gaming contexts" [16, p. 2425], other researchers like [16] highlight the desired outcome and define gamification "as a process of enhancing services with (motivational) affordances to invoke gameful experiences and further behavioral outcomes" [16, p. 2]. In this paper, we use a combined definition of [15] and [16], interpreting gamification as the use of game design elements in services to achieve desired outcomes. The elements best known and most often associated with gamification are points, badges, and leaderboards, abbreviated as PBL [17]. These reward users, e.g., for advancements or for reaching specific milestones [18]. The successful use of gamification also requires considering the interplay of the individual elements used. Not doing so bears the risk of not achieving the expected improvements in behaviors, potentially even having a harmful effect on the user in the long run [19], [20]. Instead, to achieve a meaningful outcome, a wide range of factors must be considered, such as the characteristics of the user, the

relationship of individual elements towards each other, and the provision of feedback [10], [20]. Therefore, research refers to gamification as a process in which gamified elements and other components, such as design principles, are incorporated into a well-designed system considering the interplay of different factors [16], [20]. As of today, the use of gamification for health in Vietnam has been very limited. Recent fields in which gamification was applied for improved health outcomes include nutrition and dietary habits [21] as well as mental health and well-being [22]. To the best of our knowledge, there is no evidence in published or grey literature describing the use and impact of gamification on TB care and prevention in Vietnam. Therefore, we decided to develop our app according to a framework suggested by [10], in which the components of a gamified system are identified, providing researchers with a guideline for successfully developing a gamified system in a user-centered way.

In the following, we briefly present these components. According to [10], a gamified system consists of gamification design elements and the target system. To achieve a meaningful interaction between the user and the gamified system, the selected design elements must be aligned with the user, the selected technology, and the task to be performed. Design elements include gamification objects and mechanisms. Gamification objects represent the fundamental elements of a gamified system like visual assets, characters, or scripts, while gamification mechanics define the rules within the system as well as the actions, behaviors, and control methods available to the player [24]. User-System Interactions refer to the dynamics caused by the gamification design elements and user actions. Interactions can be triggered, e.g., through the targeted use of the design elements. The resulting forms of interaction are either "user-to-system", "system-to-user", or "user-to-user". Meaningful Engagement represents the desired outcome of a gamified system. Unlike classical games, which are primarily intended to be enjoyable for the player, gamification induces behavioral changes [9]. Meaningful engagement stands for extending instrumental outcomes with experiential outcomes, leading to a dual-outcome system [10]. While instrumental outcomes are oriented towards a functional purpose [10], experiential outcomes relate to the state engagement with something in the sense of being totally absorbed or deeply focused [10]. A high level of engagement can result in a positive subjective experience, enhanced learning, and a sense of behavioral control. Eventually, certain Gamification Design Principles need to be fulfilled as they directly

impact the success of a gamified application. The first three principles target the design of the gamified system. Here, the gamified design elements being either a gamification object (badge) or a part of a gamification mechanic (awarding a badges) must match the targeted task (Principle A), the users' characteristics (Principle B) and the target system technologies (Principle C). Regarding the user-system interaction, [10] emphasize that the gamified design elements must match the desired user-system interactions (Principle D), as well as the expected recurrence of system use (Principle E). Finally, to obtain meaningful engagement, enhanced experiential outcomes should be associated with higher levels of instrumental outcomes (Principle F).

### 3. Data Collection and Analysis

**Literature search.** In the following, we briefly describe the core elements to be considered when developing gamified applications. The elements were identified through a literature search within the Basket of Eight IS journals, the AIS eLibrary, and Google Scholar using the search term "abstract:gamification", resulting in a total of 478 papers. These papers were screened by analyzing titles, abstracts, and keywords [25], [26]. We thereby focused on papers that either address the direct application of gamification elements or discuss the use of gamification elements in the healthcare sector, resulting in a total number of 34 papers. From these papers we identified four elements of gamification, considered relevant for the design of our application, namely *competitive elements*, *motivational elements*, *cooperative elements* and *elements aiming to create interaction*. Table 1 shows the elements of gamification, examples for each element, as well as respective exemplary citations from the literature.<sup>1</sup>

**Table 1. Elements of gamification derived from literature.**

| Elements of Gamification | Examples of gamified elements             | Exemplary quotes  |
|--------------------------|---|---|
| Competitive elements     | Challenges; leaderboards; badges; scores. | "[...] there is a trend towards using public displays of progress and rewards, like leaderboards and badges as mechanic elements. Accordingly, the most popular dynamic elements are challenge and competition" [23, p. 13] |

<sup>1</sup> The overview of the analyzed literature can be found [here](#).

|                              |   |   |
|------------------------------|---|---|
| <b>Cooperative elements</b>  | Commenting; kudos; experience sharing           | “From a social perspective, gamification has a huge potential as regards improving communication and bilateral encouragement among users by means of social-sharing (e.g. posts) and instant messaging” [8, p.41] |
| <b>Motivational elements</b> | Achievement; quizzes; goals; progress bars      | “Progress bars can create a feeling of achieving something, just by performing several actions [...] every feedback mechanism has to be evaluated in the working context” [26, p.6]                               |
| <b>Interaction elements</b>  | Feedback options; schedules; channels; reminder | “Applying gamification to routine reminder tasks, fitness schedules, dietary planning could motivate people to participate and engage in setting goals and objectives for themselves” [27, p.1]                   |

**Interviews.** To elaborate on the functionalities of the app and the gamification elements to be integrated, we conducted a first round of semi-structured interviews with experts from various fields of medical research and practice.<sup>2</sup> The duration of the interviews ranged from 32 to 77 minutes. Interview partners from different disciplines were selected to counteract a potential participant bias and achieve the greatest possible coverage of relevant topics [28]. We included interviewees working in direct contact with people suffering from TB in Vietnam, institutions dedicated to fighting TB, and experts who could contribute valuable insights due to their expertise and research focus. To ensure that the patients’ perspective was considered, a former patient, who now works in an institution fighting TB, was also part of the interviewees. A list of the interviewees, their qualifications and experiences are provided in Table 2.

**Table 2. List of interview partners**

| Number | Qualification and experience  |
|--------|---|
| No. 1  | Director of Advocacy and Strategy at an NGO fighting TB in Africa (former TB patient); 13 years of experience |
| No. 2  | Program director of a non-profit organization working in the field of TB; 9 years of experience               |

|       |  |
|-------|--|
| No. 3 | Medical doctor working at Médecins sans frontières; 15 years of experience   |
| No. 4 | Chairman of an NGO fighting TB in Vietnam; 10 years of experience  |
| No. 5 | Data manager at a medical research institute; 6 years of experience  |
| No. 6 | Technical officer at partnership fighting TB; 15 years of experience   |
| No. 7 | Professor of medicine at Brown university; 33 years of experience  |
| No. 8 | Vice President of a health organization aiming to reduce the burden of diseases in low-and middle-income countries; 10 years of experience |
| No. 9 | Postdoctoral research fellow at a medical research institute; 2 years of experience  |

A total of nine in-depth interviews were conducted, lasting between 40 to 90 minutes each. To extract and analyze information from the interviews, the transcripts were coded using open, axial, and selective coding. The authors analyzed and coded the interviews. After one discussion round, four selective codes were identified, being (1) problem identification; here, we assigned all information dealing with the problems of a TB patient and the challenges associated with them, (2) support opportunities; comprising all mentioned support options, (3) features of the app; including all possible app-specific features to support TB patients. and (4) the elaboration of the gamified elements to be included. Here we subdivided the information obtained from the interviews into opportunities for stigma reduction derived from the interviews, aspects that must be considered in the design of the app as well as limitations that may occur. The coding results served us to structure section 4 of our paper.

## 4. Findings

In this section, we present the results of the interviews, based on which we elaborated the features and functionalities of the app. We first present the main challenges TB patients face, followed by the identification of support opportunities and the resulting features and functionalities of the app (4.1). Next, we include gamified elements (4.2) to eventually present the design concept of the app (4.3).

To ensure that important statements made by our interviewees can be assigned to the interviewees, we

<sup>2</sup> The interview agenda along with the questions asked can be found [here](#).

labeled them with I1 to I9 according to the numbering of the interviewees in Table 2.

#### **4.1 Identifying the core features of the application**

**Observing the patients' challenges.** The main challenges for patients mentioned by our interviewees were stigma, lack of knowledge, economic burden, lengthy treatment, adverse events, lack of support, non-recognition, and pill burden (amount of medication to be taken at the same time each day). In particular, all interview partners mentioned the problem of stigma (I1-I9). Further, knowledge about the disease is relatively limited among the population, particularly concerning the prevalence of TB (I1; I9).

The consequences of stigma manifest as exclusion from the social environment, loss of employment, and, for women, the difficulty of finding a husband. Moreover, patients run the risk of self-stigma, in which they consider the illness to be their own fault causing them to isolate themselves due to shame and fear of spreading the disease (I6; I9). Another critical aspect is the economic burden, which manifests in direct and indirect costs. Direct costs include fees that need to be paid, although the treatment and medications are mostly free (e.g., fees for hospital admission and specific tests) (I7). Additionally, transportation costs need to be considered as clinics must be visited daily over a long period (I1; I3; I4). Along with the direct costs, transportation also implies indirect costs since the time patients spend going to the clinic directly affects their ability to (find) work. Also, patients are often unable to work due to the extreme side effects of TB, such as hearing loss, blurry vision, long-term psychological consequences, and kidney failure (I6). Many patients have to take their medicine in the morning, which causes them to feel tired or nauseous and sometimes makes them vomit, making a normal daily routine impossible (I1; I4; I6; I7; I9). Another aspect is the long duration of treatment in connection with the patients' mental health (I1; I3), particularly the need to stay compliant with treatment (I4). While it is not reprehensible to occasionally not take one's medication for other diseases, interruption should be prevented because non-compliance can lead to MDR-TB (I7). In particular, the treatment works very quickly so that the first symptoms disappear after 1-2 months, patients feel cured, which in turn may cause them to discontinue therapy (I4). This happens because patients are not informed sufficiently on why they must continue and complete the treatment (I7). Eventually, a lack of support was mentioned. Psychological and emotional support is essential since

patients are under extreme pressure due to the long-lasting treatment and stigma.

**Identifying support opportunities.** The interviewees mentioned the following types of support: direct support, education, communication, vouchers, involving others, and economic support. Immediate support can be given by a doctor or by a community worker. However, capacity problems have to be considered along with adequate training for community workers (I1; I3; I7; I9). In addition to direct support from professionals, the formation of peer groups, like those implemented in TB clubs in Africa [6], was addressed (I2). Patients who have already experienced specific adverse effects can share their experiences with other patients, thereby supporting them in enduring the treatment (I2). In this respect, education on the disease and adverse events play a major role. The interviewees mentioned that many adverse events are normal to occur in different stages of the disease. By learning about adverse events, patients understand how to handle these effects (I4; I6; I7). The next aspect raised by the interviewees addresses patients' empowerment through open communication. By giving patients the tools to educate others about the disease and showing them how to tell others that they have TB, there is an opportunity to raise awareness and reduce stigma (I1; I2; I7). Eventually, the provision of vouchers was discussed. By subsidizing travel costs to the clinic, support through nutrition vouchers, and the provision of internet volume, the economic burden of patients may be decreased, making it easier for them to cope with the disease and adhere to the treatment (I3).

**Possible features of a system.** Five interviewees mentioned two-way communication between a patient and an expert to be a helpful feature. Two-way communication could be performed through chat functions but also via phone or video calls (I9). Direct support can be a great help, especially for outpatients as well as patients dealing with problems arising from side effects. However, in this case, the doctor would get many requests, which might cause a negative impact on other tasks that needed to be performed (I2). Here, community health workers or other support staff of the healthcare system could help. Interviews with patients have shown that patients build an extremely close connection to the healthcare workers supporting them (I1). Unfortunately, healthcare workers and support staff are also often overloaded with requests (I1; I2). Here it would be necessary to offer a digital solution to treat more patients at the same time or more effectively (I1; I5). In addition to the involvement of people from the medical field, a frequently mentioned aspect was inter-patient support. Community-building is beneficial as it allows patients to support people

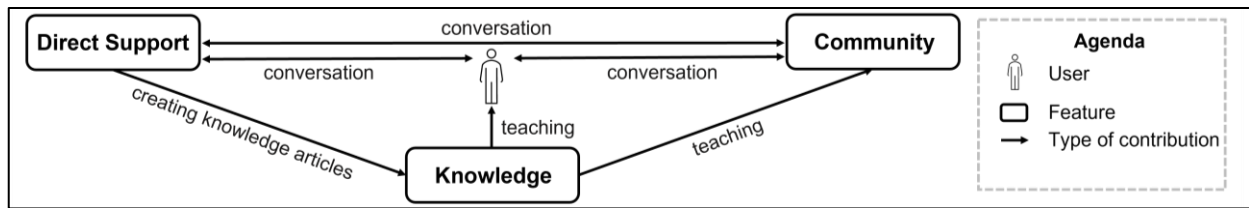


Figure 1. Basic design concept of an app to fight TB stigma.

affected by the same disease as themselves (I1; I3; I4; I6; I7). Using inter-patient support can help patients to connect by sharing experiences, hence directly helping other patients in an informative and emotional way. Additionally, patients could help build databases that provide information and experience reports about the treatment, how to deal with side effects, etc. (I8). Also, a section with frequently asked questions and the corresponding answers as well as a dynamic way of conveying knowledge in the form of a decision tree could be offered, where based on the answers to prior questions, information can be offered tailored to the patient's concerns (I9). Quizzes can be seen as a complement to knowledge transfer. The app can ask the user about available treatment options, or how it is spread (I6). Playfully, the user is encouraged to deal with the disease, thereby closing knowledge gaps. Here, too, content can be tailored to the user using targeted queries. Moreover, to secure the continuation of the treatment, interviewees referred to the possibility of having a count for treatment days, including an overview of the remaining duration until the disease is defeated. This feature would address the problem of the long treatment phase and may keep the patient motivated (I1). The interviews also revealed the possibility of supporting users monetarily or with goods to improve their economic situation (I3; I4). The first topic discussed was the implementation of cash transfers to improve the general living situation for the patient. Due to job loss or moving to a lower-paid job, many patients face problems. Direct support for these people would most likely provide a lot of added value. However, it is difficult to transfer money, as only a small percentage of Vietnamese have an e-wallet, and over 80% prefer cash [29]. Here vouchers could support app users with ride-sharing services, public transport, internet volume, or delivery services.

**Decision on features.** This part of the paper deals with the selection of features to be implemented in the app. We decided to only implement the most important features in this first iteration. Further features will be added during further research, based on end-user feedback. The following features will be integrated into the app: community building, a knowledge base for patients, quizzes, and direct contact options with a psychotherapist. Since a well-developed application needs to be built on a coordinated concept, the next

step is to categorize the components of the system and connect them to each other. The components of the system are shown in Figure 1.

The core idea of the application is to always have the user in the center. The first feature introduced is direct support, where the user is provided a contact person in case of problems or need for mental help. An aspect that needs to be considered here is that contact options must be free of charge (I9). In addition to directly involving psychotherapists and physicians, it is suggested that healthcare workers should also be involved in this function (I9). The second feature, which was often estimated to be important, is creating a space for community-building. Chat rooms present a promising approach since they are easy to implement, require few resources, and, in the best case, quickly develop group dynamics. Chat rooms are to be used primarily for the exchange of information between patients. Nevertheless, experts need to monitor them to correct misinformation at an early stage (I7). The last feature to be developed is a knowledge base for the user providing information on TB (I7). Besides building a knowledge database, conducting quizzes provides an opportunity to enrich people's knowledge playfully. Studies in this area have revealed positive results, showing that people participate enthusiastically in quizzes, which positively influence learning behavior [30] (I6).

#### 4.2 Including gamified elements

To work out a suitable gamified system several aspects retrieved from the interviews need to be taken into consideration. Therefore, we classified these aspects into three main topics, being *opportunities, considerations, and limitations*. These topics will be addressed in the following.

**Opportunities.** The first opportunity mentioned relates to the motivational elements of the first-time usage of the application. In this context, some respondents indicated age to be a limiting factor, whereas others emphasized that age can also be an opportunity. Often older people are curious about new technology and, unlike young people, see it as new and exciting. Since TB primarily affects older people, one should take advantage of this issue (I6). One way to harness this curiosity would be to implement a virtual

coach to quickly educate and guide users on the benefits of the application. Here, coaching would take place at the beginning, creating a connection to the application for the users right from the start.

Next, the long-term course of treatment and the resulting changing challenges, symptoms but also priorities of patients must be considered. With symptoms receding after about two months of treatment, the patients are eager to return to everyday life. For the gamified system, this presents both opportunities and challenges. In the beginning, the user's high level of attention can be taken advantage of to get him/her to ask for help on the platform, while during treatment, effort needs to focus on maintaining usage of the application, thereby incentivizing the patient to share his/her experiences. An opportunity arises here if the dynamics of users among themselves are taken into account, e.g., by using elements that promote competition or cooperation. Notably, elements promoting competition must be treated extremely carefully as every person reacts differently to them, and the use of competition, along with the resulting feedback for the losing person, can cause a negative framing and make the user feel bad about him/herself (I4, I6). However, there is an opportunity to foster collaboration by having users support and interact with each other. (I3; I6; I7). One approach would be to introduce a buddy system in which pairs are formed to support one another (I3). The use of cooperation in gamification has been extensively researched proving positive outcomes. However, various influencing factors such as the context, the target group, and possible negative effects must always be taken into consideration. [31]. One opportunity mentioned is the use of user feedback. Three interviewees mentioned that users should be encouraged to give each other feedback, thereby motivating one another (I4). Here, design elements such as Kudos, comment functions, or social profiles offer suitable solutions [10]. Another possibility is to link gamification objects directly to enablers. For instance, by rewarding successful treatment steps, e.g., 30 days of treatment adherence, with monetary payments or vouchers for a ride-sharing service. Furthermore, badges can be awarded allowing users to publicly communicate their achievements (I3).

**Considerations.** In addition to the opportunities that resulted from the interviews, considerations arose that need to be taken into account when developing the application. Five aspects emerged, which deal with the need for interaction, possible feedback the need for differentiation, the importance of framing, and the socio-cultural influence. The main aspect to be considered is to create a real *conversation* between the user and the system. The interviewees pointed out that

it is not sufficient to work with simple one-way feedback, although this approach can produce positive results and encourage and motivate the user in the short term (I2; I3). Instead, the user needs to be involved in a *feedback cycle* to ensure lasting engagement (I6; I7) and to prevent that elements are integrated, which potentially have a negative impact on patient treatment adherence (I6; I7). Particularly, since TB is a severe disease and can lead to highly negative effects in the case of a relapse of the patient, possible negative impacts need to be examined carefully (I4; I7). Examples mentioned in the interviews include the use of fear as a motivator, negative feedback, and competition. Another important consideration when choosing the elements of the application is *differentiation*. Three of the interviewees explicitly mentioned that a general characterization of TB patients is not possible. Here, factors such as age, anxiety level as well as economic and family-related circumstances must be considered individually (I6). Hence, based on how the user behaves and reacts, different dynamics must emerge within the system [23]. Particularly, to prevent a relapse, it is necessary to query the user's reaction and create a personalized solution. stressed the need to pay close attention to word choice when framing. When considering how things are named and how things are described, it is important to look at the context of the disease. Patients could be set back with incorrect labels or through negative framing (I1). In research, the influence of framing is being explored and should be considered when developing an app [32] (I6).

The last aspect mentioned to consider is *age*. As the proportion of people with TB is largest in the 55+ age group [33], it is necessary to make the app accessible to older generations (I2). Accessibility can be achieved, e.g., by designing a colorful application using large and obtrusive fonts. Further, the focus of the design should be on minimizing the use of text (I9).

**Limitations.** Interviewees pointed out that there may be no access to the Internet or no stable connection, especially in rural areas (I9). In Vietnam, approximately 69% of the population currently have access to the Internet [34]. For those without pervasive access, it's important that the gamification dynamics also function without Internet access, plus that the app automatically updates data as soon as Wi-Fi access is available. Hence, when selecting the gamification elements, the task-technology fit needs to be appropriate. Also, access to a smartphone is necessary. Because TB particularly affects vulnerable people in poor economic situations, not everyone will have access to the application. Since often at least one person in the family owns a smartphone, at least partial access to the application is possible (I3; I8). Here,

however, the fact that the user is not permanently accessible must be considered. Since assistance should be offered primarily to vulnerable groups, a long-term challenge is to find ways to create permanent access for these people.

### 4.3 Introducing the final design concept.

Adding gamified elements to the application following the framework, we orient the reasoning for choosing certain elements on the framework for designing gamified information systems [10]. Accordingly, figure 2 shows the final design concept including the gamified elements to be integrated.

by other users. Giving kudos may empower the person to continue helping others in the future. Another aspect is the promotion of knowledge acquisition. A combination of objects, mechanics, and underlying design principles should ensure that the user actively engages with the knowledge base. The first object is the division of knowledge into topics. Instead of simply having a collection of articles relating to various TB aspects, the user is given an all-encompassing explanation of a specific topic using predefined collections of articles. The advantage is to show quantifiable progress, e.g., by using a progress bar. With the use of classes, the user can set personalized goals, or the application can do this for

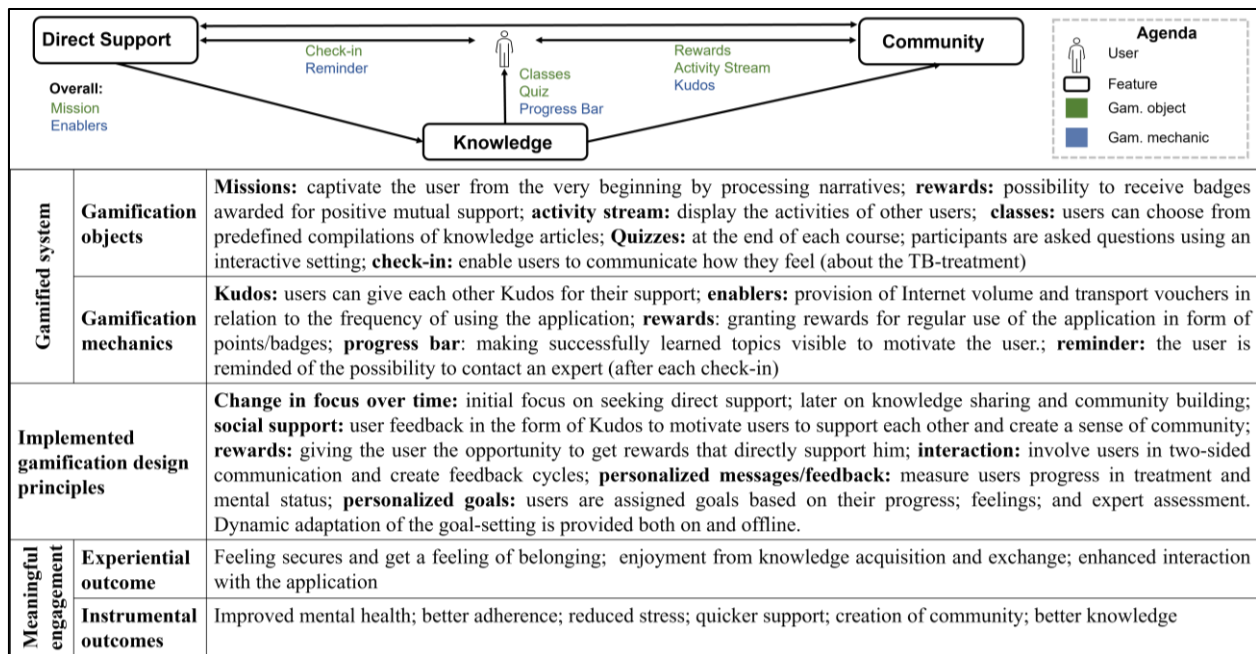


Figure 2. Design concept of a gamified application to fight TB stigma

In the following, the selected elements are described, along with a rationale for their selection.

The gamification objects and mechanisms concerning the community consists of a combination of rewards, kudos, and activity stream. Looking at the proposed objects, working with rewards can increase interaction within the community, where a user collects badges for supporting other users. In addition, we suggest using an activity stream. This is the display of the activities of other members in chronological form. This can entice users to become more involved if they see that others contribute to the community. Furthermore, this may motivate users to participate because s/he knows that others see what s/he is doing within the community. Kudos is the passing of recognition from one user to another. For example, if someone has helped another person substantially, the giving of kudos creates awareness of the action taken

him/her. Another aspect is the integration of quizzes, e.g., at the end of a class, the user can be quizzed about what s/he has learned in an interactive setting. The last feature that is directly enriched by gamification is the direct support by experts. The first point of entry from which the system can connect the user with an expert is the check-in. By asking the user at the beginning how s/he is doing, the app can refer directly to the appropriate expert based on the answer. Another possibility is to work with reminders and show the user that s/he can get support from an expert. Nevertheless, it is challenging to keep a balance between the promotion of requests and the necessity. The problem that could arise, e.g., with a point system or badges, is that the user is motivated to send unnecessary requests to the experts. Using the wrong incentives could lead to a system overload without adding value to the user. In addition to the elements of the gamified system that



relate to one of the three main features (direct support, knowledge and community), there are further higher-level objects and mechanics. Here, it is necessary to consider the meaningful engagement, i.e., the desirable experiential outcomes and desirable instrumental outcomes. To react to the long-term treatment, missions can be implemented into the application. Missions open the possibility to bind the user to the app from the beginning and to motivate him/her to get acquainted with the functionalities of the app. Another aspect is the benefit of enablers. The app users have different economic problems while dealing with the disease and often belong to vulnerable groups. Enablers give the opportunity to attach internet volumes and vouchers for public transport as rewards. For example, users can trade their collected badges for vouchers. In this case, it should be made sure that this happens at short intervals so that the user receives as much added value as possible, and the economic situation really improves for him/her. By linking enablers and the gamified system, a new kind of motivation is achieved for the user since s/he now works for a quantifiable advantage in the real world. A final design principle is the parallel use of online and offline capabilities. As mentioned in the previous section, the internet connection may be interrupted at times. To ensure that the interaction with the user does not suffer, it is necessary to provide feedback and ensure the app's usefulness even without an internet connection.

## 5. Discussion and Conclusion

Tuberculosis is one of the deadliest diseases worldwide. A major reason for the spread and often fatal course of the disease is the lack of medication adherence. While existing measures focus on controlling medication adherence, additional measures need to be developed that directly address the reasons for medication non-adherence. Based on expert interviews, we identified reasons for medication nonadherence being primarily lack of information on the importance of regularly taking the medication and stigma. Building thereon, we developed the design concept for an application containing various functionalities to enhance medication adherence. Subsequently, we integrated gamification elements allowing us to employ a variety of mechanisms that motivate patients to persevere through treatment and to empower each other to openly confront the disease, thereby combating stigma. The elaboration of components for the app is to be seen as the first step of a larger research project to develop an actual application to be applied in Vietnam. Although the evaluation of the interviews

allowed us to design a concept for the application, it needs to be developed and tested in several iterations on site. Therefore, we plan to conduct further interviews with TP patients, family members as well as group interviews onsite. Further, we will extend interviews with doctors, experts in the field of gamification and community health workers to refine the design of the app.

Further research is needed around gamification for patient support. Pursuant to the support options listed in this paper, we believe that the impact of framing on patient treatment adherence needs to be analyzed further. Current research, e.g., analyzes the effects of framing on physician decision-making and society's response to (impending) disease [32], [34]. However, in the context of education and treatment adherence of tuberculosis, no research on framing has yet been conducted. Our interviews revealed that framing can have a tremendous impact on patients' adherence to treatment. Hence, we see the need, to analyze the possible positive and negative impact of framing, especially regarding the implementation of gamified elements. Another research area is the analysis of how education can help to combat stigma of TB patients. While there is research on the stigma of TB patients in certain regions [35], we did not find comprehensive studies on how to actively combat stigma of TB patients using information campaigns or similar. Eventually, we see potential in comparing existing research approaches to fight TB with those used to treat other diseases. Researchers can, e.g., investigate whether and how the knowledge gained here can be applied to other stigmatized diseases and, apply the approaches from this work to their own.

## 6. References

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