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Using PBL to design a gamified application prototype: the case of waste picker's children financial education

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Abstract

The dumpsite of Brasilia, Brazil, was shut down in 2018, and since then the waste pickers had to adapt their lives to a new reality. Before then, they used to earn money working autonomously by picking valuable waste amidst the waste mountain. But now, they were reallocated in modern recycling cooperatives, and thus receive incomes regularly and at the end of the month, with a significant impact in their family's financial management. This new labour organization demands new ways or managing finances, with the support of software applications that brings financial education to waste pickers and, in this case, to their children. This paper describes the process of designing an application in this context. It took place through the union of various courses that use the Problem Based Learning (PBL) methodology, at the Production Engineering course of the University of Brasilia. We present here the results of students of Production Systems Project 2 (PSP 2) team, whose objective was to plan, specify, validate, and prototype the interface of a gamified financial education application for children of waste pickers. A literature review about interface development, mobile learning and gamification was conducted, then a user's journey was defined, and user's interaction and the scoring system was set. Software requirements were defined in a vision document use case diagrams and the application's interface was prototyped. Thus, this article discusses what would be the best way to use game techniques to boost financial learning in the context of the children of waste collectors.

Keywords: Mobile Learning, Gamification, Financial Education, Interface Development.

1 Introduction

In 2018, the largest dumpsite in Latin America was closed (SLU, 2018), as stated in the annual report of activities of the Brasilia Urban Cleaning Service. Thus, the entire waste collection system of Brasilia (Brazil) and the lives of those involved in this process have undergone drastic changes. The waste picker's families who make their living from the dumpsite had to adapt to a new reality. In this context, the University of Brasilia identified the opportunity of offering financial education to those families. Financial education in Brazil is neither present in the family universe nor educational institutions such as secondary schools (D'Aquino, 2007), and this is also a necessity for waste pickers children. Thus, we proposed to develop a prototype of an application that would foster financial education to these youngsters. There are several ways to promote education, but, in this case, create an approach that could motivate the waste picker's children, via a gamified approach was the goal of this paper. The use of gamification for education purposes has increased (Lee and Doh, 2012) and our methodology consists of using game elements out of context, to motivate individuals to action, thus helping them to solve problems, and promoting learning (Kapp, 2012).

Four teams from 4 different Production Engineering PSPs courses (i.e., Production Systems Projects) of the University of Brasilia (UnB) were the main collaborators to made up designed the prototype of the project. The courses apply Problem Based Learning (PBL), and each team is responsible for a part of the solution. The PSP 3 team developed the content that would be in the app, PSP 2 designed the interface, PSP 5 did the quality control of the prototype developed by PSP 2, and the PSP 8 team managed the integration of the project. These courses, provided by the Dept of Production Engineering of the University of Brasilia, have as main goals to: apply PBL in a transversal and integrated form.

The four teams interacted through a PBL methodology, then the teams were capable to jointly find a solution to bring financial education to the children of the garbage collectors. Throughout the project, the teams

discussed the main aspects of the problem and formulated hypotheses for solving the problem together with the stakeholders. Also, the development of soft and hard skills by the students who participated in the project was a relevant outcome of the use of PBL. Thinking, decision-making, adaptability, teamwork, and stress management were the main soft skills developed during the build-up of this paper.

This paper focuses on the results of the PSP2 team is presented in 5 topics: i) the literature review which provides a better technical basis for the development of a solution; ii) the methodology used in the research for the creation of a product that combines a mobile application, financial education, and gamification; iv) results and v) conclusions.

2 Literature Review

A literature review was conducted to show an overview of the subject matters and methods within each existing field, to understand the state of the art and how it could relate to the objective of this work.

2.1 Financial Education

Lührmann et al (2015) point out that the low level of financial education of adults is correlated with bad financial aspects, such as fewer savings and less wealth. The authors evaluated the effect of financial education on adolescents, and this study revealed that it significantly increases their interest and self-rated financial knowledge. According to Lührmann et al (2015), this is a major result because increasing the interest of adolescents is the first step in increasing engagement with financial issues in the future. Soares & Costa (2012) present a financial education game developed to be used as a tool for teaching financial concepts for children of employees of a Steel Mill in Brazil. They pointed out that many authors sought to correlate the Level of Financial Education with possible future impacts on consumer behaviour.

2.2 Gamification

According to Nakashima (2017), the use of scoring and ranking approaches helps in teaching by leaving users enthusiastic and motivated in learning, and as it progresses, increases the competitiveness of users. The application developed by Nakashima was based on gamification to perform a behavioural change in users. Zakaria (2020) also corroborates the view of behavioural change provided by gamification, by exposing the benefits of a different learning methodology, which can make learning more enjoyable to the user. These authors believe that the use of the application enables creative and intuitive skills which encourage students to learn a theme attractively and effectively.

2.3 Mobile Learning and User Experience

Maciel (2013) addresses the user experience of a mobile app for adult literacy in Brazil. The author states that the era of mobility in which we live today allows the development of applications for education. By combining mobile technology and education, a new category called Mobile Learning was proposed which allows people to learn anytime and anywhere. This approach seemed interesting because it is a natural evolution of technology. In Brazil, the mobile learning application area still growing, and the study conducted by Maciel (2013) revealed some interesting considerations: (1) it is important to provide training for family and friends who support the user and (2) the voice guide of the app has positive impacts because it makes interfaces more humanized. When it comes to user experience, Lu (2011) also points out that users want to discover things instead of reading instructions or relying on memory, meaning that they want to interact with the system easily and fluidly.

3 Project Methodology

The application was projected by using gamification to meet the target audience to engage and motivate users of the platform, based on Zichermann (2011). Therefore, by using elements of games, such as the use of strategies, thoughts, and varied mechanics outside the context of games, one provides motivation, helps users solve future problems, and promotes learning, according to Kapp (2012).

3.1 Research Method

The User Interaction Plan of the application was built to promote competitiveness and a sense of belonging to the community of the users (to promote competitiveness and join the user into the network of users of the app), by using these tools: ranking and private chat. The Scoring System, a vital part of gamification, was designed based on the elements described by Klock et al. (2014), which suggests the increase of motivation and engagement of the app's users, such as levels, scores, achievements, and ranking. Klock et al. (2014) also argue that when working with a scoring system and levels of experience, the user is encouraged to meet their goals and make achievements in the application, thus seeking to complete the activities proposed in modules of the application.

In addition, a literature review was performed via a bibliometric search on the Web of Science platform, to better understand the state of art. The search was based on the subject of apps that use gamification, and the following keywords were used: "App" AND "Gamification", and for the topic of Financial Education the terms "financial education" AND "teenager*" were used. These terms were chosen to help understand how personal finance education is generally approached and also to understand what the results of gamification-based teaching apps are. The bibliographic search was based on scientific papers published from 2010 till 2020.

Gamification was the first phase of the project. It aimed to explain and document the initial concept of the application, in a specific and subdivided way. Thus, three artifacts were developed: the User Journey, the User Interaction Plan, and the Application Scoring System. As evaluation criteria, all was evaluated and approved by the initiative's stakeholders, especially the PSP 5 team, that was responsible for the quality control.

The User Journey is a general mapping of the processes carried out in the app, from the first access until the end of the game, which has the adolescent target of the project as an actor. We used the Business Process Model and Notation (BPMN) methodology in an online software for diagram creation so that the team members could work simultaneously.

The User Interaction Plan had the purpose of establishing different ways of interaction among those who use the platform, thus ensuring reciprocal influence, greater engagement, a sense of belonging to the application community, and promoting competitiveness. Many proposals were raised based on existing systems that already meet this objective, so two strategies were selected: ranking and private chat.

The elements described by Klock et al (2014) were used for the Scoring System, a vital part of gamification. They argue that when working with a scoring system and experience levels, the user is encouraged to meet their goals and accomplish achievements in the application, thus seeking to complete the activities proposed in modules of the application. The scoring system was elaborated to foster motivation and a way to monitor how users progress and learn the themes. It also followed common strategies and characteristics of games, such as the attribution of points, rewards, and classification by several points. The structure was based on six topics: Levels, Module Scoring, Extra Points, Store, Ranking, and Achievement Gallery.

To plan the app, a vision document was written to provide a high-level system view and more detailed technical requirements of the application, such as scope and non-scope, app building team, functional and non-functional requirements (represented visually in use case diagrams), constraints, and a primary interface prototype.

The vision document was essential to present to the stakeholders (teachers and other students) the steps taken so far, to elicit the functional and non-functional requirements via literature review, to meet the expectations, to adapt them to stakeholders' suggestions, such as in the application's boundaries and the interfaces, to build the application's prototype. All these outcomes are presented in the Project's Results section of this paper.

The prototype was implemented based on the outputs of the Gamification phase and the vision document, thus representing the proposal visually and meeting the experimentation phase of the solution. The Canva® platform was used to create the application designs, and the Marvel App platform was used to create the interactive mock-up. Furthermore, the prototype was inspired by applications that present analogous educational requirements, such as Duolingo and Trivia Crack, and games like Two Dots.

4 Project Results

The application's functionality objectives were aligned with the literature review, the mapping of the processes present in the prototype, the interaction plan between users, the scoring system, and finally, the model's interfaces were developed. The PSP5 team was responsible for validating every product used for the development of the prototype, along with a teacher they used PBL to analyse if the requirements defined for development were in fact what the stakeholders needed and they checked the quality of the products.

4.1 User Journey

Figures 1 and 2 represent the User Journey's diagram, which was divided in two parts for easier visualization.

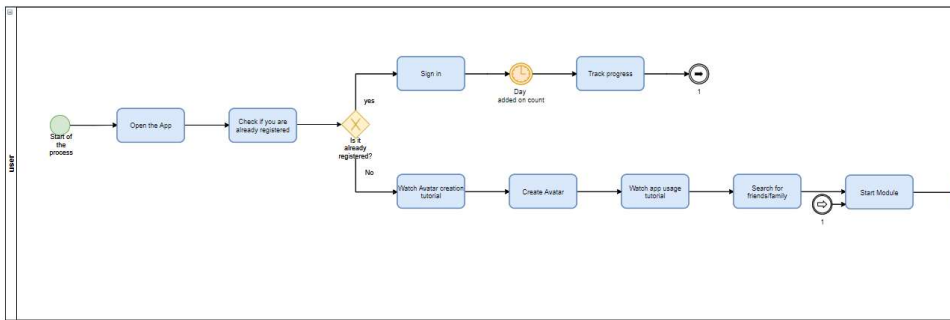


Figure 1. Part 1 of the User Journey.

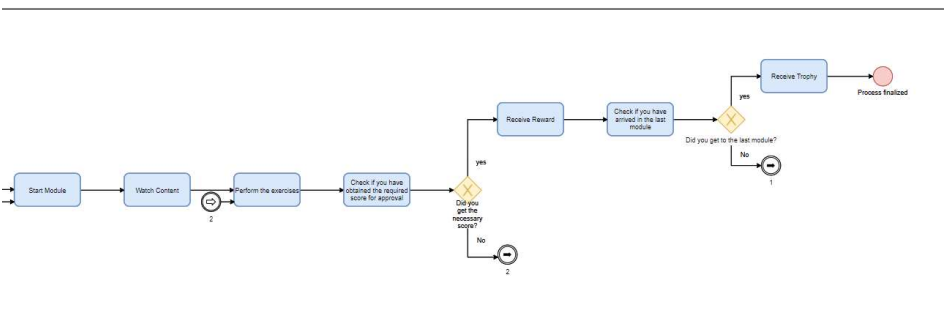


Figure 2. Part 2 of the User Journey.

First, the user must login or register via a profile creation tutorial, via an avatar. Then the user must watch the tutorial on how to use the app, and once he has completed all the steps, the user can start to use the app, thus beginning with the modules of activities proposed. If the user is already registered in the system, he/she will have to login to enter the teaching environment of the app. The user can track his/her progress from the point where he/she stopped and thus begin to perform the modules, represented in the diagram by the link. It is important to note that for each login made with a difference of twenty-four hours, 1 day will be counted in the user's progress, thus being able to display this sequence of days in his profile, receiving a reward for consecutive use.

The next step the user will take after the login step is completed is watching the audio-visual educational content. After that, the user will do exercises on the presented topic, with 10 exercises per module, where a right answer equals one point and a wrong answer equals zero points. The user must obtain a score equal to or greater than seven points to finish the module's tasks. At this point, the diagram shows the second exclusivity gateway, represented by the question, "Did the user get the required score?" If the answer is "no", the user must restart the module and attempt to obtain the required score, represented in the diagram by link 2. If the answer is "yes", the user will receive a reward.

After completing the module on the specific topic, the user will go through the other modules proposed by the app until reaching the last module. The last exclusive gateway of the diagram is shown at this point, where it presents the question: "Have you reached the last module?" If the answer is negative, the user will go back to link 1 (already shown) and must start the module again. If the answer is affirmative, the user will receive a

trophy, informing that he/she has successfully completed the modules on the proposed subject, thus ending the process and looping at each module of financial education subjects.

4.2 User interaction plan

The user interaction plan is composed by the ranking system and the private chat. The ranking system makes it possible to classify users, based on their scores so that each user has access to the names of the top ranked users. This alternative has the objective of generating greater adherence and commitment to competition game in the app.

Private chat is a feature used in many mobile apps. Its implementation aims to generate a multifunctional app, by enabling more than one alternative of use for the user. In addition, the private chat will provide direct interaction between users, so that they can exchange information and help each other in the quiz exercises.

4.3 Scoring System

A scoring system was developed to offer points for each day the app is used, to win prizes and medals, to observe the position in the ranking, to level up according to the accumulation of XP points, and to customize the avatar by exchanging the cans (a score symbol, based on soda cans) obtained for products offered in the store. The system was developed to create competitiveness and motivate the use of the app continuously.

The user must create his/her avatar when registering and logging into the game for the first time, and this avatar will represent them in the app. All avatars start at level 1, with the possibility of reaching level 100, and the user must earn a certain number of Experience Points (XP) to advance to the next level.

The module scoring system will be used to establish the ranking between the users of the application, and each module will have a certain number of exercises so that users may earn cans and XP as they complete them. The metal cans represent points and the user will receive 7, 5 or 3 cans when he/she completes the exercise on the first, second or further attempts, respectively. They user will earn 50 XP regardless of how many attempts he/she needs to complete the exercise. They will earn 5 Cans and 200 XP after completing the module's task, as well as a medal for each module. These medals will be displayed in the user's Achievement Gallery.

An online store where the points earned (represented by cans) may be used will be available. Users have the possibility to exchange the cans that they obtained to customize their avatar. The items will be unlocked for purchase as the user levels up. The system is weekly updated and creates a Ranking by using the amount of XP users obtained. The first, second and third place in the weekly ranking will receive 40, 30 and 20 cans, respectively, as a bonus. The Achievements Gallery is where the user can check all the awards received in the app and what other achievements they can still pursue. This gallery shows the medals gained at each module and the special medals from both the Temporary Challenges and the Daily Sequence.

4.4 Requirements listing

Initially, a high-level requirements list was created in the solution preparation phase within the vision document to specify the needs requested, and then to develop the use case diagram and to create the prototype interfaces.

The project requirements were divided into two parts, based on Pressman (2009): the functional requirements, which refer to all the features that the application must present, described in Table 1, and the non-functional requirements, which refer to the services and restrictions presented by the system, described in Table 2 and the requirements in both tables were validated by the stakeholders.

Table 1. List of the application's functional requirements.

Nº	Name	Functional Requirement's Description
RF001	Register and log in	It allows performing user registration by storing information, user and password, or linking to the user's social networks.

RF002	Diversify Modules	It allows diversifying the modules related to pre-defined financial education topics - What is Financial Education, Revenue vs. Expenses (fixed, variable, casual), Banks and Retirement Planning.
RF003	Level modules	It allows offering different levels of difficulties taking into account the specificity of each module. It presents educational content.
RF004	List modules	It allows listing the modules learned by the user to indicate the progress.
RF005	Manage search	It allows searching for a user to be able to add them as a friend.
RF006	Show score	It allows displaying general and friends ranking.
RF007	Create Profile	It allows creating a custom avatar.
RF008	Edit Profile	It allows changing avatar characteristics.
RF009	Manage profiles	It allows managing the registration of categories by administrators.
RF010	Manage modules	It allows managing the registration of modules by administrators.
RF011	Guide user	It allows offering spoken instructions to improve user's understanding, especially for those who cannot read.
RF012	Orient user	It allows to present feedback to the user's actions, with messages that encourage the user to make the correct answers, but that does not discourage him/her when reporting errors.
RF013	Consecutive days of use	It allows to present the user the number of consecutive days of use of the application.
RF014	Purchase products for customizing Avatar	It allows displaying a virtual shop that enables exchanging points conquered by the user for artifacts for the avatar.
RF015	Perform knowledge test	It allows applying a knowledge test at the end of each module, based on the contents taught in that specific module.
RF016	Show private chat	It allows viewing the private chat between two users.

Table 2. Non-functional requirements listing.

Nº	Name	Description
RNF001	Accessibility	The user interface must be easy to learn, use and understandable for the illiterate.
RNF002	Responsiveness	The system must be navigable by cell phone and other devices
RNF003	Off-line usability	The application must work offline.
RNF004	Synchrony	The application must remain in sync whenever connected to the internet.
RNF005	Transparency	Data synchronization between server and application must be transparent to the user.
RNF006	Size	The application must not occupy more than 50 MB of cell phone storage.
RNF007	Performance	The application must not overload the cell phone system.
RNF008	Multimedia utility	The application must be able to present audio-visual content (image and sound).
RNF009	Reliability	The application must record the users progress made.

The use case diagram shown in Figure 3, was designed out the functional requirements list, and the understanding of the business model.

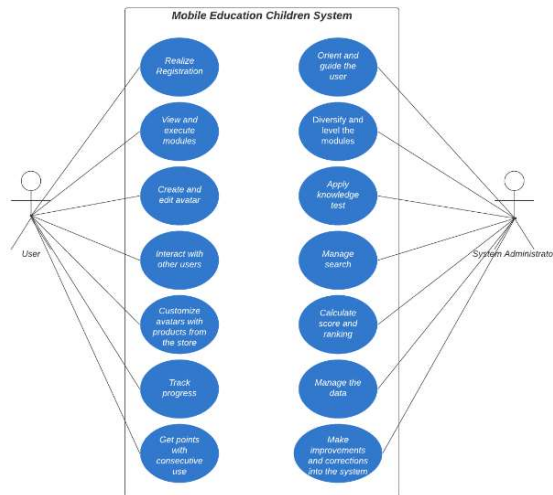


Figure 3. Use-case diagram.

The use-case diagram represents the interaction between the user and the system administrator, and their main assignments within the application.

4.5 Prototype Interfaces

The application interfaces were designed, according to the particular needs of the main users of the system, and based on the functional requirements and the use case diagram. Some special options were conceived, considering that the user could be illiterate or functionally illiterate. Therefore, the system offers solutions that allow this user to understand the information exposed by the system, the options to listen to the texts present on the screen and choose the correct alternative among the colors presented in the options of the answers to the quiz.

The system offers the creation of avatars, communicating from chats, locating users, the option of logging in via social networks and find mutual friends who use the app as well, in order, to bring users closer together and to boost the use of the application through virtual human interaction.

The functionalities can be seen in Figure 4, which show the interfaces designed for the prototype.

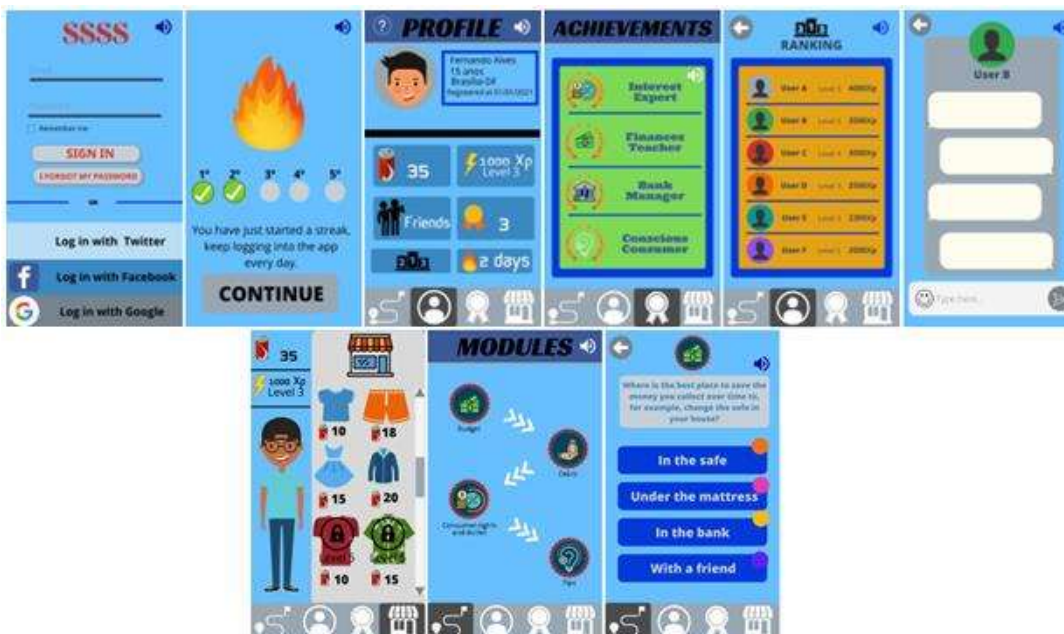


Figure 4. App interfaces (1-9) developed using PBL.

The interfaces 1 to 3 shown in Figure 4, represent, respectively, the login screens, the daily access control system, and the general profile, which shows the user's personal information and those related to the progress in the application gamification system. It is also possible to access the achievements, the ranking, and the chat, by clicking on the medal and podium symbols, and on the "Friends" button, respectively, by the profile screen.

In the interfaces 6 to 9 from Figure 4, the screens demonstrate that in addition to the features described above, the application also allows the user to create his avatar, track the progress, listen to the questions and its answers options, as well as mark the correct one, by using the colors that are associated with each alternative.

5 Conclusions

After the change in the way waste pickers work, it is remarkable the importance of providing financial education to them and their families, so that they can adapt to their new way of working, organize financially and not to have problems with financial institutions. For this purpose, a prototype of a mobile app was created in order to provide financial education to the children of the waste pickers through a gamified interface, as a result of this project.

Besides the main project objective, this work also had the purpose of developing students through problem-based learning (PBL). This goal was also achieved through the integration between the classes of Production System Project of the Production Engineering course of the UnB of students from different semesters, as well as the contact with the waste pickers and the immersion in their reality, which enabled a greater autonomy of the students in the resolution of conflicts during group work and a greater deepening of the concepts taught in the classroom.

The PBL methodology was used during the project to promote several skills, among them an effective communication between the disciplines and in the tutorials provided by the teachers and students, generating an effective problem solving and resulting in several lessons learned. The technical learning in the elaboration of the BPMN mapping and the capacity for collaboration and organization are highlights, as well as the evaluation of the students of the PSP5 discipline, which was essential when validating the quality of the project as a whole through formal technical instruments for improvement. For the elaboration it was necessary a process of individual self-learning among the participants despite the integration of approximately 20 students from different semesters and an international working group, in the moment of teamwork, everyone was able to contribute with their critical thoughts and creativity.

The prototype was developed in a conducted experiment, but it was not validated with the children of the collectors, who are the target audience, due to the social isolation imposed because of the COVID-19 pandemic. It is also necessary to validate the prototype with the waste pickers' children in the future, in order to make the app as intuitive as possible for them. However, the app was validated by the PSP5 team, that was responsible for the quality control of the prototype.

The work was developed in the relevant and authentic context of community partnerships in the real world challenge of waste disposal process. This is a fertile ground that fostered the development of PBL in terms of proposing a tool to help waste pickers acquire financial literacy. This context provided triggering points to be reflected by students in order to design a feasible Project, in terms of identifying what were the users' requirements, what questions should be answered in the case, potential solutions, comparative studies, efficient brainstorming and discussions.

Thus, students were able to develop important skills as critical thinking while proposing feasible solutions to user's needs, communication via formal means with projects stakeholders as well as a lot of freedom and creativity while proposing software requirements and capturing the state of the art via collaborative research of existing solutions. Teachers and tutors were able to apply constant feedback and revision via a set of group presentations that took place in three parts of the semester, helping evolve students' outcomes via public presentations.

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