The OH!BUG App: Learning to Identify Plants Through Their Characteristics

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Abstract. Urban migration has resulted in a disconnection from the natural world and consequently a lack of knowledge about other living beings. Since the creation of Sustainable Development Goals (SDGs) there have been made efforts to inform and educate citizens, especially the youngest, in pro-environmental attitudes and behaviours by promoting critical thinking about our world through environmental education. With the continuous digitalization of information, mobile apps and games with narratives around climate change and environmental issues, have gained a place in this mission. In this paper, we present the creation process and the results of the first usability tests of the OH!BUG app, a digital product developed to connect young learners to plants, by helping them to identify the species through their characteristics.

Keywords: Mobile Application · Sustainable Development · Environmental Education · Biodiversity · Species Identification · Gamification

1 Introduction

At the same time as the world's population tends to move away from natural environments, living mostly in urban areas [1], humanity faces sustainability challenges that require the protection and preservation of the ecosystems that are essential to life on planet Earth. The industrialized world and urban migration have led us to a disconnection from other living things which has implications for our understanding of them [2]. Reports show that biodiversity is declining faster than at any other time in human history with an irreversible effect of species extinction, which makes ecosystems more fragile and less resistant to disruptions [3]. Human activities and decisions have been recognized as a part of the problem [4] so it became clear, over the last few decades, that it's fundamental to promote pro-environmental and sustainable values, attitudes and actions in our society.

To answer this problem, the United Nations has defined a global agenda to reach until 2030 that includes a framework of sustainability goals that has been universally accepted and includes the need to take action in raising awareness for environmental issues and

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climate change [5]. Among them, goal 15 points out the importance of managing and restoring forests, combating desertification and reversing biodiversity loss, reinforcing the idea that living species such as humans depend on the balance of nature and its ecosystems.

On the other side, the Sustainable Development Goals (SDGs) acknowledge the potential of education as a means to achieve sustainability referring in Goal 4, Quality Education, the need to "ensure that all learners acquire the knowledge and skills needed to promote sustainable development" [5].

Education has been revealed to be a key factor to respond climate change as long as behavioural change cannot occur without environmental knowledge [6]. As the United Nations themselves refer:

> "Sustainable development cannot be achieved by technological solutions, political regulation or financial instruments alone. We need to change the way we think and act. This requires quality education and learning for sustainable development at all levels and in all social contexts." [7].

However, studies reveal that have been discrepancies and deficits in Education for Sustainable Development (ESD), for example, UNESCO reports that only 20% of teachers can explain well how to take action against climate change [8]. This could be linked to the fact that the concept of sustainability has been taught from a particular point of view [9] rather than allowing students to reach their own conclusions based on critical reflection which leads to a disconnection between environmental education and personality responsibility [10]. For this reason, it has been considered a reassessment of the educational efforts to improve the process of teaching environmental education [11].

So, in the last decade, we have assisted a new approach to ESD by adopting progressive pedagogical methods such as critical thinking, participatory decision-making, value-based learning and social learning so that learners understand of the world based on their own observations and develop competences to take action [12]. These methodologies attempt to go beyond the "exposure to information to the transformation of values and behaviours in order to contribute to solutions for environmental problems" [13]. Environmental awareness and education must approach real-life problems that are easier for people to relate to, by reflecting on their surroundings and learning from their own experiences [14].

At the same time, technological developments gave us the opportunity to create new forms of engaging young learners in environmental subjects based on these new pedagogical methods. Smart technological tools have proved to be an important and alternative resource concerning to achieve the SDGs goals [15] with the potential to engage and educate young learners in scientific concepts and topics, promoting their motivation, curiosity and critical reflection on the environment [16].

This paper presents the case study of the mobile application OH!BUG, an app developed to connect young learners and the natural world of plants. The theoretical framework addresses the technological development of mobile apps and their role in achieving environmental sustainability to change environmental values and behaviours in younger citizens. Following we explain the thinking process of designing the OH!BUG app, the

implication of scientific research to build an identification system using the characteristics of different species and the feedback of young citizens on the first version of the application.

1.1 Species Identification and Sustainable Development

As Kaplan and Kaplan [17] referred to in their book "The Experience of Nature: A psychological perspective." people often see Nature or the natural world as an external part of human beings, something away from us. Recognising the role of biodiversity as a fundamental part of life on planet Earth and the need to protect the diversity of living species is a starting point to understanding the complex concept of sustainability [18]. Although the knowledge about biodiversity and its importance is seen as a basic link to achieving sustainable development or an essential goal in environmental education [19], over the last few decades we assisted a phenomenon of significantly decreasing understanding of ecological processes and the natural world referred as ecological illiteracy [20]. An environmentally literate citizen "is an individual who is, most importantly, informed about environmental issues and problems and possesses the attitudes and skills for solving them" but also someone who "takes action in terms of changing his or her own behaviours in order to remediate or prevent further environmental problems" [19].

Skills such as the identification of species are important for people to develop an interest in environmental issues and sustainability [21]. This could be related to the simple reason that the identification of plants requires to have contact with the natural world. This kind of experience may develop a "possible emotional and/or cognitive relationship between the individual and nature" [2] and therefore with environmental issues.

1.2 Mobile Apps and Games for ESD

In a digital era of information where we use technological devices every day, mobile apps and games gain users' attention with billions of apps downloaded worldwide in online stores [22]. The rising of new forms of communication has been reflected in the daily life of our society, with apps and games transcending to sectors beyond entertainment [23]. Some of these mobile applications include gamification methods and mechanisms, with the use of game elements in contexts considered non-game ranging from themes such as productivity, finance, health, education and sustainability [24]. In education, studies report a significant increase in motivation and learning achievements of students using digital game-based applications [25]. That's why gamified mobile applications and games have gained popularity in educational programs as an alternative tool to traditional methods of teaching, having the potential to engage young learners on issues related to climate change and sustainability [6]. For that reason, we have witnessed in the last few years a growing development of mobile apps and games with narratives around climate change and environmental issues, such as the need to protect wildlife, reduce atmospheric pollution, litter and energy consumption, food waste or management of natural resources [26].

Apps and games have the ability to engage users in environmental behaviours users by reducing the perceived risks of those same behaviors and giving tangible pro-environmental goals to achieve [27]. These apps and games often appeal to users' emotions as part of the gamified experience, promoting sensitivity towards ecology and developing empathy with the visualization of different negative scenarios and future implications of their acts [28]. On the other hand, some apps try to have a positive approach to sustainability placing the users in the role of a scientist giving them the mission to search and discover scientific observations of living beings such as animals and plants, allowing them to participate in collective data in the fields of biology and ecology [29].

2 The OH!BUG App

By acknowledging the background theoretical framework, we decided to develop a mobile app that aims to engage young users in the role of an explorer by encouraging them to identify the plants in their surroundings.

The OH!BUG app was originally designed in 2020 during the Startup Voucher Portugal Program 2019–2022 in which the designer of the OH!BUG app participated and was later developed in collaboration with a outsourcing development team in 2021. The OH!BUG app is now available in Google Store and App Store.

At the origin of the mobile app is the constructionism methodology, as it is believed that app users can (re)construct their knowledge about plants as they build their maps. Starting from the idea that if we recognize the plants that we observe in our daily lives and realize their value, we will be more sensitive to their existence and will be able to protect and preserve them. Furthermore the OH!BUG application aims to contribute to environmental literacy by teaching about the different characteristics of plants, shapes and colours, to understand the diversity of the living beings that share this planet with us.

The target audience for this mobile application is children from 8 years old. However, it can be used by younger children as the description of different plant characteristics is always accompanied by several illustrations (Fig. 1). To appeal to this specific audience, the design of the application uses colourful graphic elements and visual references from the natural world such as insects. The insects play a role in the narrative of the application and are used as avatars, comparing the users to little bugs on a journey of discovering plants and being an important part of the well-being of the ecosystems.

2.1 Georeferenced Map

Users have access to a personal georeferenced map where they insert the plants that they can identify. The plants identified by the users are shown by the location where they were found through an icon where can access their name and information (Fig. 2). The user can search for how many specific species they have found to see their geographical distribution on the map.

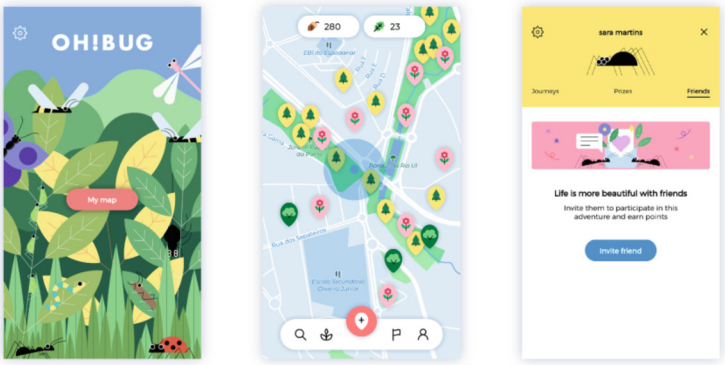

Fig. 1. Colourful illustrations are used in OH!BUG application aims to attract young users.

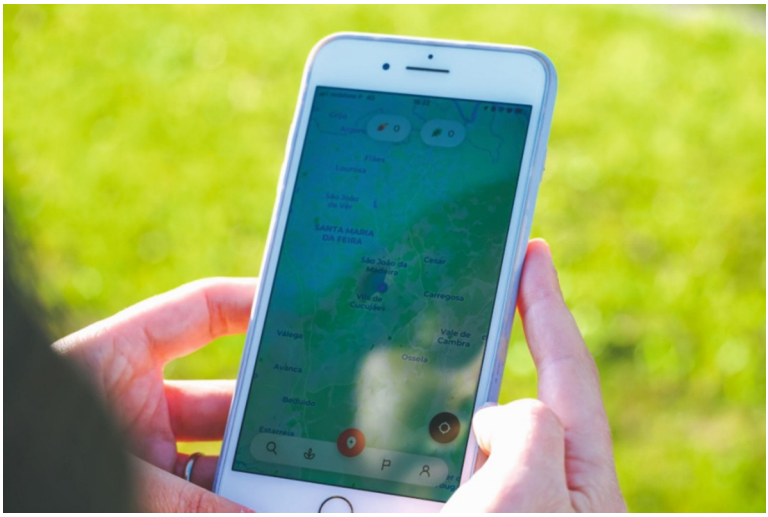

Fig. 2. Georeferenced map in the OH!BUG app.

2.2 Designing a Species Identification System

The species identification system in the OH!BUG application is inspired by the dichotomous scientific method of species identification. Dichotomous keys are usually used in botany or zoology to classify or identify living organisms and are based on a decision between two alternatives in a series of questions until the species name are identified [30]. The selection of possible answers is based on the physical characteristics of the species, which requires attention to the detail of the plant and the critical thinking of the observer.

The identification of species in the OH!BUG app is carried out through an interactive system of filters by a combination of characteristics - the type of plant, type of leaf, flower, fruit and habitat (Fig. 3). For each section there are several options to be selected

according to the physical aspect of the plant, for example, in the type of leaf, the user can choose between Entire; Lobed; Dentate; Long; Compound; Palm Tree or Needle. The selection of these distinguishable aspects of the plant allows the user to be presented with a list of possible results that fit each pattern.

As species identification is often seen as a difficult process because is compared with the learning of new words of a new language [30], the OH!BUG app uses illustrations and icons to help the user to identify the most detectable elements of the plant. Visual communication is used to simplify the complex information related to botanical subjects and demystify the challenging process behind plant identification. Icons are an essential part of the identification system because they represent a quick and easy way to convey information and make decisions about the plant found.

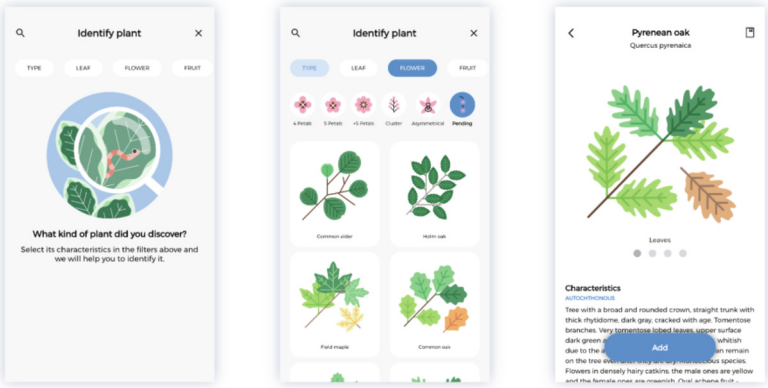

Fig. 3. Final design wireframes of the identification system in OH!BUG application.

2.3 Gamification

Gamification has been used in mobile apps to motivate users in non-game activities by communicating their progress in the accomplishment of sustainable actions [32]. So as a form of engagement, gamification mechanisms and components were included in the OH!BUG application such as points, levels, rewards, challenges and avatars. The integration of game elements in the application aims to turn the process of identification playful and fun, providing a ludic experience that appeals to the user's emotions in the achievement of progressive states in the game.

For each plant that users insert in their map, they gain points and level up the game. The levels of the game are shown in the user's journey on their profile. While challenges are based on concrete goals or tasks that users must complete. These challenges increase in difficulty, beginning with tasks such as "Identify a tree" to "Find a species with lobed leaf". The conclusion of a challenge ensures a reward that users can access in their profile.

The gamification methods and dynamics are limited only to the user and cannot be seen by other participants of the OH!BUG application. However, this represent a potential

grow for these gamification systems in the future, with the collaboration between users, creation of team players or even collaborative maps.

3 Results

Based on the results obtained in a pilot study, the Beta version of the mobile app was developed. This version was tested in July of 2021 with 3 children from the 3rd grade to 6th grade and the results obtained allowed the mobile application to be improved, to obtain a version close to the final one.

Usability tests were realized using a high-fidelity prototype including all interactive features of the OH!BUG app. The tests include an introduction about the purpose of this study and a quick explanation of how to proceed, followed by a script with multiple tasks to complete. To simulate the identification of the plants were shown a sequence of pictures with key elements that allowed the identification of common trees and shrubs. In the end, the participants had to answer a questionnaire about their experience using the application, based on the five-level Likert scale (Fig. 4). The results were positive in the answers given by the participants, giving rise to the following diagram:

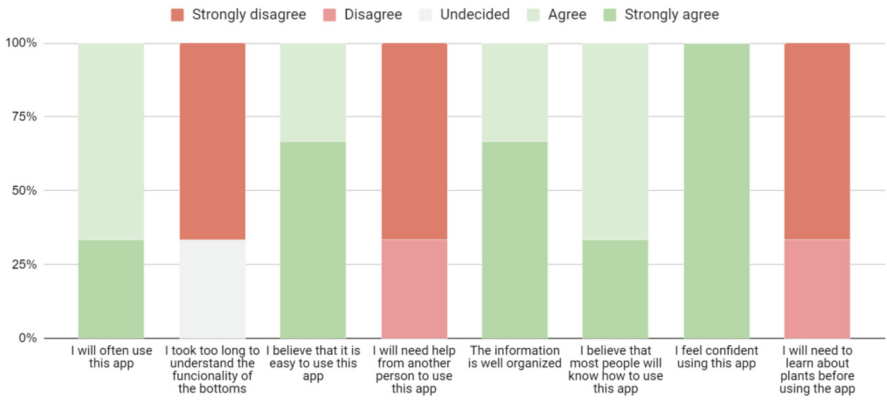

Fig. 4. Answers of the participants to the usability questionnaire.

At the same time, the test was observed from an external point of view making it possible to analyse the reaction and emotions of users attempting to complete the requested tasks and classify them within the following parameters: completed without difficulty; completed with some difficulty; undecided; completed with great difficulty; does not complete the task. The majority of the assignments were completed quickly without apparent difficulty and the use of the application took place continuously and fluidly. However, just one participant was able to identify all of the plants without any help. The remaining participants showed difficulties in interpreting the images in order to characterize the different properties of the plants. Besides that, the participants show a preference for the use of the interactive system of plant identification, referring to it as fun and colourful showing the plant's characteristics with simplicity and creativity.

The fact that they had to interpret the image of the plant and search for the right icon or characteristic in the system, by comparing different illustrations and the possible results presented, reveals to be a game side of the app that was not considered at the beginning of its creation.

4 Limitations

Although the results of the usability test were useful to review specific aspects of the application that should be improved, both in terms of the graphical look and the user's experience, there are a few points that should be considered in future research related to the OH!BUG app. First, this initial study used a small sample for testing the technology and covered an age group very close. With this limitation, it became difficult to compare different points of view on the application and the results were quite similar. A larger sample of users should be used in further studies to achieve significant statistical results and allow a detailed comparison of distinct approaches to the OH!BUG app. Another aspect to be enforced in future groups of participants is the cross-cultural and generational diversity to understand the effectiveness of the application in different cognitive and social developments.

A second limitation was the content of the usability test itself. The following researchers should explore the different triggers in the emotions of the participants, detecting points of opportunity and curiosity or even frustration and anxiety of the user. The emotional response to the app is necessary to improve both design and functionality but also to enhance the communication of botanical information.

The final limitation regarding this study is that gamification is not included in the questionnaires, despite being a fundamental part of the design of the application. The game-based elements and dynamics that are included in the OH!BUG defines an opportunity to study the effectiveness of gamification in mobile apps oriented to environmental education and ecological literacy.

As previously mentioned, the OH!BUG application is still in its Beta version which implies that the application itself has limitations and issues to solve. Currently, the database contains 38 registered species that are found mainly in Portuguese territory, where the application was developed. However, we assume these limitations as research opportunities and possibilities to grow and improve this digital product.

5 Conclusions

Taking into consideration the presented theoretical contextualization, ecological knowledge can guide citizens to have pro-environmental attitudes and actions by helping to understand the importance of ecosystems and biodiversity. This way, the objective of the OH!BUG application of teaching about vegetal species reveals to be promising in a way that can lead users to care for and preserve the plants identified. The interactive identification system reveals to be an essential feature of the app because of its playful and game-like design. Future research must cover a wider and more diverse audience of participants, their emotions and their response to the gamified mechanisms of the app.

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