societies

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Gamification in Ecology-Oriented Mobile Applications—Typologies and Purposes

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Abstract: Mobile applications viewed as digital social change tools are focused on sustainable development, particularly in topics that address ecology and the environment. In this research, the aim is to systematize a review of the 10 most downloaded mobile applications in this context, but deepening on those that use game elements in their interface, organizing them according to components, mechanics and playful dynamics. Findings demonstrate the role of levels and achievements as more repeated dynamics, and challenges and feedback as more relevant elements in gameplay, and finally, emotions and narratives as components of the gamified experience. The incorporation of these elements in mobile games shows that digital gamification in the environmental context is organized from an alternative perspective, where argumentation, the succession of events, the progressive incorporation of difficulty and the interaction with the computerized system modify the traditional view that sees gamification as a superficial system of points.

Keywords: gamification; ecology; sustainable development; mobile apps; smartphones; environmental protection

Citation: Torres-Toukoumidis, A.; León, D.V.; De-Santis, A.; López-López, P.C. Gamification in Ecology-Oriented Mobile Applications—Typologies and Purposes. *Societies* **2022**, *12*, 42. https://doi.org/10.3390/soc12020042

Academic Editors: Rodica Milena Zaharia, Tudor Edu and Razvan Zaharia

Received: 30 January 2022
Accepted: 28 February 2022
Published: 8 March 2022

1. Introduction

Continuous digitalization of communication has led to the development of mobile applications, at such a level that in 2020 more than 3 million applications are available in the Google Play Store, 2 million in the Apple App Store and almost one million in the Windows Store, with 218 billion downloads annually worldwide [1]. The escalation of its use produced by the acceptance and interest on the part of users who own mobile devices, especially on the part of new generations [2], has advocated that different sectors such as entertainment [3], health [4] and education [5] are attracted by this expanding market.

Mobile applications have set up a scenario supported by the new media system and the emerging development of the technology industry [6] in which smartphones and their components: intelligent screens, cloud storage and portability [7] facilitate access to information and communication, interaction and participation among users, and approximation to knowledge [8]. Therefore, technological industry oriented to mobile applications has diversified to such an extent that both leisure and learning present special interest in the adaptation of their content to these platforms [9], generating multiple benefits in society, highlighting the teaching of foreign language [10], creating health patterns [11], generating fidelity to products and services [12], improving the nutrition of young people [13], promoting tourism [14], among others.

In relation to mobile applications for the community, the user experience has been optimized with the incorporation of responsive designs [15], geolocation [16], augmented reality [17] and gamification [18]. The latter, the main object of this study, is defined as the use of game elements in non-playful contexts [19], i.e., various mechanics, dynamics and components belonging to games are incorporated with the purpose of generating changes in people's behaviors, in fact, its success has been demonstrated both in the educational and commercial fields; its application in education has made it possible to reinforce the teaching-learning process by increasing the interest and qualifications of students [20,21]. For its part, in the commercial sector, gamification has served internally to improve the performance of its employees, facilitate training processes and, therefore, obtain better business results [22], also, externally, it has also been shown that, by integrating it into the consumer experience, it has led to greater loyalty, commitment and awareness of the brand [23].

Beyond education and commercial areas, where gamification has been internalized and well accepted, initiatives have also been observed in the field related to ecology and environmental sustainability in favor of the reduction of carbon emissions [24], reduction of gasoline consumption [25] and its multiple applications in the sustainable development goals -SDG- directed towards tourism [26].

Understanding the relevance of mobile applications, several questions are presented in this research: Which are the purposes of gamified mobile applications in environmental sustainability? What game elements combine gamified mobile apps and environmental sustainability? Which are the common patterns between gamified mobile apps in the environmental context? Are gamified mobile apps using traditional game elements or are the innovating on it?

Recognizing these questions, the following research is articulated as follows: The theoretical framework addresses the connection between technological development and environmental sustainability and the incursions of gamification. Next, it continues with the description of the objectives and method, emphasizing the selection of mobile applications and the criteria established for their analysis. Subsequently, the results are presented according to their link with ecology, and the different components, mechanics and dynamics of gamification. Finally, a reflection is made on the findings and the paradigm shift on the use of gamification towards less traditional elements.

2. Theoretical Background

The 2030 agenda for sustainable development presented by the United Nations includes the reduction of ecological impact and environmental justice by promoting the conservation movement and awakening public awareness of pollution problems that have occurred since industrial development [27]. Although there is abundant literature on the situation, many of them mention that technology played an essential role by generating both a negative and a positive influence on the environment [28].

Particularly, the negative aspects are the increase in pollution produced by electronic device waste, including manufacturing waste, programmed obsolescence, transport and overproduction [29]. While positive aspects are concentrated in productive investment in developing countries, and reducing carbon emissions in industrial processes through the transformation of smart cities [30], it has also facilitated the development of less invasive alternatives such as crude oil extraction, allowing the progress of renewable energies [31]. The use of new technologies has also involved the creation of instructive and persuasive designs for environmental awareness, achieving a transition towards the formation and understanding of ecological phenomena [32].

This last indicator referring to the positive impact of new technologies towards awareness, promotion and formation of the biocentric sustainable vision has plentiful scientific literature referring to innovations, projects and advances presented by the academic community.

Among it the implementation of courses to professors of subjects related to technology on the impact of sustainable education, demonstrating an increasing awareness with

responsible acts towards the environment [33]; urban ecology workshop using geographic information systems through computerized modeling, improving the scientific self-efficacy and the environmental responsibility of participants [34]; revision of the characteristics referred to web-based organizations such as Kids Across de World, Global Nomands Group, World Wise Schools and Roots and Shoots, summarizing initiatives for a positive change in the environment [35]; project-based learning using wireless networks to experience and learn about different plant typologies [36]; analysis of the persuasive power of social networks in young people on environmental commitment and consumerism [37]; impact of immersive technologies on pro-environmental behaviors [38]; initiation and adoption of green technologies in higher education [39]; preliminary analysis of the opportunities for incorporating Human-Computer-Interaction into learning communities on topics such as electrical waste and electronic equipment, climate change and device procurement policies [40]; use of immersive virtual environments to provide the promotion of physical activity in simulated nature by measuring psychophysiological response [41]; review the possibilities of technology, particularly social media to meet Malaysia's environmental challenges [42].

From the technological development and its connection with the environment awareness presented above, the opportunities offered by mobile applications were observed during the second decade of the XXI century with the aim of exalting the importance of environmental sustainability as a space systematized by academic and scientific studies. In this context, some advances stand out, such as Smiling Earth, a mobile application designed to contribute to climate change by raising awareness among citizens about the carbon footprint and the daily consumption of energy and transport [43], measuring its effectiveness for environmental education [44], and annexing the Google Maps application to reduce local pollution [45].

In addition to those mentioned, there are several mobile applications. The selection of those with more downloads will serve to clarify their correspondence to this research in which gamification is added as an add-on.

Environment Sustainability in Mobile Gamification

Regarding the use of gamification, Regarding gamification, it is denoted as an idea initiative to explore the environment and create a sustainable society [46], its adoption has been towards the "green" issue has been so relevant that some theorists are already beginning to use the term "ecogamification" which refers to the use of gamification in the creation of experiences that manage to create ecological habits in the population [47], being applied in the selection of healthy food [48], saving fuel while driving [49] and motivating corporate social responsibility [50].

Also, gamification it is presented as a playful alternative within mobile applications that enhances the influence on environmentally friendly behaviors [51], exhibiting benefits with respect to its incorporation in mobile apps: WasteApp for waste management [52], MEECO for eco-conscious habits [53], AppEAR for mapping quality of aquatic habitats [54] among others.

However, these cases have been studied in a particular way delving into unique characteristics of each experience. Hence, this research intends to contrast the different designs and interfaces embedded in the process of creating ecological oriented mobile apps and its multiple purposes.

3. Materials and Methods

The aim of this research is to compare games elements patterns and of ecology-oriented mobile apps. The specific objectives are 1. Examine the purpose of gamified ecology-oriented mobile applications; 2. Identify the gamification components of mobile applications aimed at the environment; 3. Contrast the incorporation of gamification in mobile applications towards environmental care, and 4. Determine the inclusion of gamification dynamics in the selected mobile applications.

To achieve these objectives, a preliminary qualitative-inductive analysis was used to establish the first approach to the phenomena, events and environments that are part of reality [55]. According to this, the design concentrated on a content analysis that involves the systematized review of mobile application software with a hermeneutic and explanatory perspective [56]. From that, collection tools were selected:

- Non-participant observation: the researcher is a passive spectator of the phenomenon studied, and is limited to recording the information without interacting and avoiding any relation to the phenomenon or person he/she is investigating. In the conduction of the research, indirect observation was used where reality itself is not observed, but a selection of documentary sources, information or content such as photos, videos, files, audios, press, etc. [57] In this case, the visualization and interaction with 10 mobile applications without interfering in the design of its interface.
- Documents: information available on any subject that is practically impossible to know and consult in its entirety [58]. This data compilation tool is necessary with the selection of mobile applications while maintaining a rigorous process based on the number of downloads.

In the methodological procedure, the main applications with more downloads in Google Play (Android) and AppStore (iOS) were reviewed using as a search criterion: "ecology" or "ecología" obtaining more than 300 applications in total by applying a triple screening that consisted of three phases: more downloaded applications, gamified applications and applications with better rating. In the first phase, 100 more downloaded apps were obtained, in the second phase were selected the 50 apps that used game elements both in their interface and in their content, and in the third phase a sample of 10 apps with better ratings by users was estimated (Table 1).

Table 1. Mobile apps selected from Google Play and AppStore.

N°	Mobile App	N° Downloads	Average Rating
1	EcoClicker	1,000,000+	4/5
2	Desafío Ambiental	50,000+	4.6/5
3	Save the Earth	50,000+	4.6/5
4	El Defensor de la Naturaleza	50,000+	4.4/5
5	Greenpeace Apptivista	50,000+	4/5
6	Mi Planeta Tierra	50,000+	4.3/5
7	Go Green Challenge	10,000+	4.1/5
8	Zero Waste	10,000+	4.2/5
9	Save the Eco	10,000+	4.1/5
10	Ecodivertidos	10,000+	4/5

The 10 mobile applications chosen for the study were downloaded in November 2020, and were examined until April 2021 taking into account the theoretical coding, conceptualized as a structure of codes and categories arising from previous research [59], stablishing two sets of criteria, the first referring to the environmental purpose and the second a taxonomy of game elements. For the first set of evaluation criteria, the following indicators were considered [60]:

1. Environmental protection: applications that seek to raise awareness about the prevention and protection of the environment, including information to reduce the impact of pollution.
2. Educational strategies: incorporate learning activities in the application aimed at caring the environment.
3. Water care: specific initiatives towards water care.
4. Ecological sustainability: management and profile of users for biological maintenance and conservation.
5. Environmental campaigns: communicate good ecological practices and promote the proper use of renewable energies

As for the criteria that respond to the assessment of the elements of games, there are several taxonomies that allow to categorize them, for this research the following revision [61] has been taken into account, in which each of them is described, opting for the following classification [62]:

1. Components: intention and purpose of the activity; tables of positions, points, medals, collections and levels are arranged.
2. Mechanics: elements that influence the behavior of users; it is oriented to triumph, challenges, rewards, randomness competition and cooperation.
3. Dynamics: result of behaviors and interactions between users that are motivated by the components and mechanisms; it refers to relationships, narrative, emotions, restrictions and progression.

Taking into consideration both sets of analysis criteria, it was proceeded to review each of the 10 mobile applications selected in a shared Excel document, where each of the researchers submitted their assessment being contrasted for their final explanation.

4. Results

The results section is organized in 4 sections, the first one referring to the purpose of these mobile applications, detailing their orientation towards environmental protection, educational strategies for ecology, water care, sustainability and environmental campaigns. The next three parts of these results present the findings obtained for the elements of gamification: components, mechanics and dynamics used by these applications, specifying from an inductive vision, the implication of each one in the ludic experience.

4.1. Mobile Applications Directed Aimed at Ecology

To achieve the objectives set out in the research, the 10 main mobile applications related to ecology were reviewed (See Figure 1). Indeed, 50% of mobile applications are geared towards protecting the environment, providing skills for their instruction; encouraging the care of green areas such as forests, rivers, and fields; promoting the recycling of plastics, paper, glass, and batteries, among others; reducing toxic waste that can cause harmful effects on the health of people and animals by establishing reliable information on daily news of the environment, air quality of the residence, noise pollution detector, events on the environment, etc.

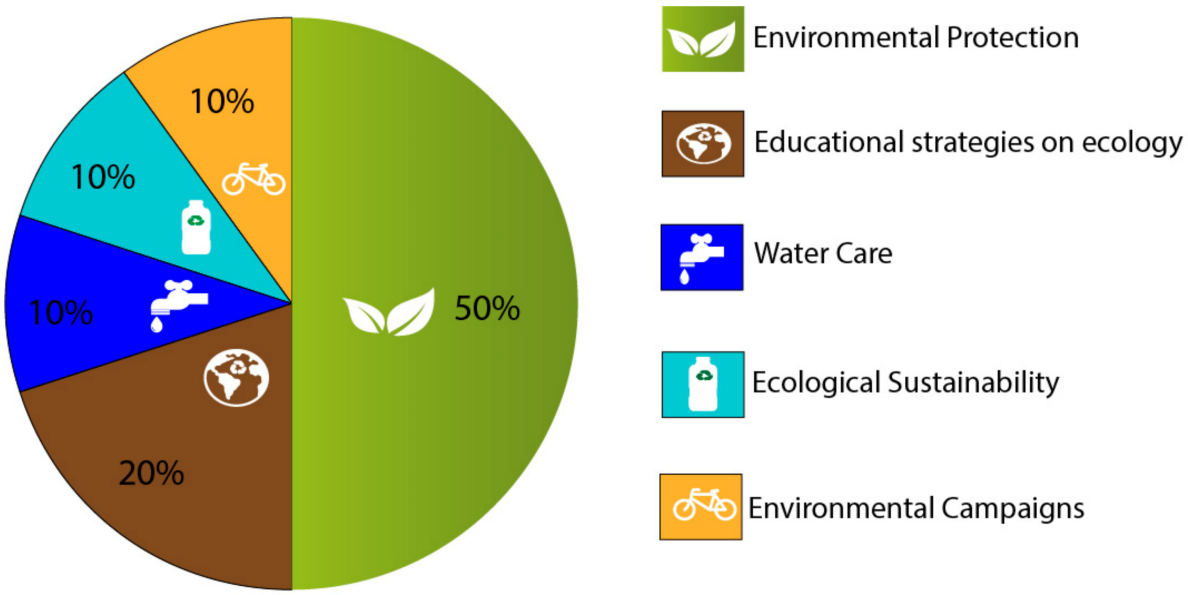

Figure 1. Applications aimed at Ecology.

On the other hand, the criterion called educational strategies on ecology with 20%, where a teaching-learning process is configured to train users on: projects that help maintain an ecological balance in the soil, atmosphere and plants, forest protection, use of public transportation, collection of waste and renewable sources of energy; environmental projects aimed at maintaining the ecological balance of oceans, seas, lakes, rivers, fish and marine mammals; floating plants, protection of freshwater sources, prohibition of trawling and coastal clean-up activities; environmental projects aimed at maintaining the biodiversity of the earth, animal populations, preservation of species in danger of extension, care of protected areas; natural reserves and projects aimed at interacting with society, creation of educational programs and active volunteers to solve ecological problems.

The care of water represented with 10% of the sample refers to gamified applications that demonstrate the most common ways in which people waste water, while 10% concentrated to the criterion of ecological sustainability; it is intended to constitute a profile of "sustainable person"-saving energy, ecological diet-, help the environment and be part of an environmental group. Finally, 10% refers to environmental campaigns to collect signatures in order to support requests to defend the environment and fight environmental crimes.

4.2. Analysis of Gamification Components in Mobile Applications Related to the Environment

The components are related to the intention and purpose of the activity, hence the 10 games reviewed for this research are determined as follows in Figure 2:

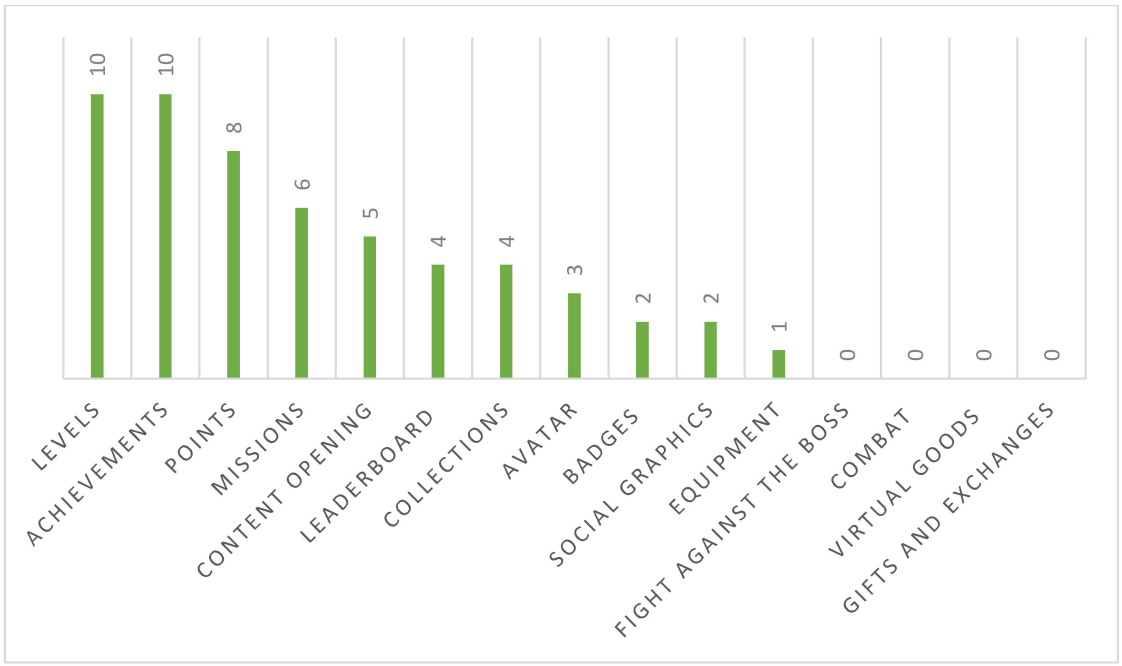

Figure 2. Components according to gamification processes.

Gamification components used by all the mobile applications have been the levels and achievements, this means that one way to improve gamification is by building two elements that imply progress. On the other hand, levels are substantially considered essential, since they stimulate users by providing new challenges with different conflicts, while achievements are concrete goals established intrinsically by users in the ecological field, in short it is derived to protect the environment, promoting a metamorphosis of "a greener world". At the same time, these are accentuated at the end of the activity within a certain time, so they are usually rewarded. Additionally, among the reward elements—points, medals and leaderboards—the only one that is common is that of points, allowing to measure and recount the success within the games. Whereas, fighting a boss, combat, virtuous goods and exchange of gifts are game elements endorsed by taxonomy but totally

excluded in the immersion of the experience; hence, it is inferred that although competition is promoted, the interaction aims to omit violence and socialization between users.

4.3. Gamification Mechanics in Mobile Applications Related to the Environment

On the other hand, the mechanics of games define those elements that affect the behavior of users (Table 2). It is determined as follows:

Table 2. Hierarchical order of gamification processes directed towards game mechanics.

Mechanics	Hierarchical Level
Challenges	10
Feedback	10
Progression	8
Rewards	7
Triumph	6
Randomness	5
Possession	3
Transaction	1
Cooperation	0
Competition	0

As seen, the elements of the mechanics of the most repeated games are: challenges and feedback. Challenges are considered as the effort of users to overcome the objectives presented in the environment-based games (Table 3). Feedback allows users to know their performance in activities and assess the opportunity to continue participating. It is worth mentioning that the feedback is done directly with the automated system within the interface and not with other users.

Table 3. Challenges established through gamification processes.

Challenges	Action
Action	Know pollution problems of the City/Country, presenting tips and environmental publications
Power	Reduce energy consumption by 20%, switch to cheaper bulbs, turn off lights and dry your hair and clothes in the "air".
Green	Recover water waste, take care of existing plants, plant a tree in three different places, do not litter along the way and take short showers.
Recycle	Donate items that are no longer needed, vintage stores, buy environmentally friendly products and organize waste according to its type.
Health	Do more sport, eat less meat

The challenges proposed by the different types of games are essential to help the environment in an entertaining and interactive way, stimulating the teaching-learning process. In the challenge of reducing energy consumption by 20%, for example, the user is motivated to reduce the production of non-clean energy, promoting consumption to care the environment of -20.0 Kg CO_2, -16.0 Kg waste, supported by the use of game elements.

4.4. Gamification Dynamics in Mobile Applications Related to the Environment

The dynamics of the game are considered as behaviors and interactions between users that are encouraged by components and mechanisms. This is the most abstract section and it depends on the nature of the users and the attitude they have towards the objects. The dynamic is made up of emotions (10), narrative or plot (10), restrictions (6) and relationships (3). Continuous emotions and narratives are the most common used in games.

Emotions (10 apps) can be considered as the sense of curiosity about environmental reality to achieve a specific result, although the type of emotions promoted during the gamification experience is not deepen, it provides an idea of the positive emotions linked to eco-logical care. For its part, the narrative or plot (10 apps) facilitates the presentation of a narrative throughout the experience, allowing to maintain a similar plot line during the story, being a repeated element in all the mobile applications. In the third instance, the constraints (6 apps) are modeled through the rules, introducing time limitations and a restricted space for interaction. Finally, the relations (3 apps) that are engaged in this dynamic are aimed at interaction with other users, in short, the gamified experiences analyzed do not enhance the need for direct connection with other players, on the contrary, it is glimpsed as individual challenges that centralize the actions.

5. Discussion

The 10 most downloaded games on mobile devices related to ecology provide a series of findings that motivate reflection and academic debate in the field of sustainable development and games studied. In the scope of sustainable development, gamified applications are not attractive to users, since they do not reach one and a half million of downloads, a number that allows to raise some questions: Why does the user not prioritize gamified applications connected to sustainable development? Is the content presented by these applications connected to the current reality of ecology? Are these applications taken into account in schools and colleges?

In short, these applications will have to restate the approach, prioritizing the search for learning about information; hence, the idea is to propose an ecological objective accompanied by clear and defined learning outcomes, omitting saturation of ideas and excessive repetition of the same content, and formulating innovative options such as 360° vision of gamified applications, virtual reality, among others. In this way, game elements with greater precision can be incorporated, addressed to the purpose of each game. Also, with clear exceptions such as those designed to the care of water-ecofriendly- or energy saving-environmental challenge -, most contain a holistic and generic view of the environment, making it difficult to build a symmetrical gameplay that allows to understand the purpose of the mobile application beyond a mere entertainment.

Regarding game studies, three topics require attention: average gamification components, lack of direct interaction between players and prospective blended post-pandemia. In the first instance, the average of gamification components incorporated in each experience has been 5 items, however, there are cases such as the app My Planet Earth that included only 2 gamification components -achievements and levels-, while Go Green Challenge has 6 components—points, missions, opening of content, social graphs, levels and achievements-. Although it depends on the argumentative line that each gamified application has, the effectiveness and the goals of each application should avoid excess of gamification elements, in fact, it is recommended that before applying them, their use is clearly justified in accordance with the objectives determined by the mobile application [63]. To conclude this section, it should also be mentioned that although an assessment of the aesthetic dimension of mobile applications was made, it can be established as an audiovisual technical phase of the experience: graphic details, chromatic contrast and sound that does not directly involve game elements, but, on the contrary, includes audiovisual and media constructs that affect the user's perception. After all, aesthetics was analyzed in this research, demonstrating two groups: the first with a chromatic palette contrasted with warm colors, accentuating effects of pollution. Instead, applications such as Eco-Clicker, Defender of Nature, Go Green Challenge and Zero Waste are presented with a combination of cool colors, especially green, a color commonly identified with ecology, a slowed-down and parsimonious music, boasting the benefits of environmental care.

During the research, multiple obstacles were presented, among them, the limitations advocated by the pandemic to review the selected mobile applications; then another obstacle is that due to the dynamism of the mobile applications, some were updated

during the review period, which meant repeating the analysis process. Finally, being an analysis of gamified experiences, the elements are dynamic and sometimes with a parallel configuration, i.e., when the user advances, probable he/she will immediately receive points, hence it required doing the process multiple times to detail the correct visualization. Despite these obstacles, it is recommended for future research to deepen on the perception of players, compiling their experiences, tastes and peculiarities during their participation. Also, another recommendation would be to select each application according to the public and its impact at a global level in order to really see if they have actually meant a paradigm shift in environmental maintenance. Finally, learning must also be essential in mobile applications dedicated to this topic, hence experts in education, through a transdisciplinary vision, should access them and disseminate the advances from an academic view.

6. Conclusions

Taking into consideration the general objective proposed in this research, which is summarized in analyzing 10 mobile applications oriented to environmental sustainability according to their games and their use, several advances are conceived according to the specific objectives set out above.

Firstly, when examining the purpose of gamified mobile applications oriented to ecology, and taking into account only those most downloaded, it is observed that most respond to a general character of environmental sustainability, while very few applications respond to concrete actions such as waste reduction and water maintenance. In addition, most have a mainly informative characteristic and not educational. Regarding the second objective based on the identification of the gamification components of mobile applications aimed at the environment, a quite positive but atypical situation in gamification is observed, since it breaks with "superficial pointsfication" [64], in which it is assumed that gamification is based solely on the use of reward systems. Otherwise, most gamified experiences in the environmental context use levels, achievements and missions and do not only focus on points, medals and leaderboards. In the third objective, the mechanics applied are compatible with the components, i.e., challenges, progression and feedback are incorporated; the latter is configured mostly between the user and the platform, confirming its importance in mobile games [65]. In short, the relevance of the study aimed to demonstrate that digital gamification in the environmental context is structured in a different way, where the traditional way in which extrinsic and behavioral motivation elements do not prevail as the basis of the experience, but other dynamics and mechanics are incorporated, such as levels, progressive increase of difficulty, missions, challenges and feedback that allow to boost the participation through fun, therefore, from intrinsic motivation.

Specifically, the built-in game dynamics that receive special attention are emotions and narratives. The first seeks to promote sensitivity towards ecology to externalize emotions both with the use of avatars and with the visualization of chaos and possible improvements that can be achieved in the environment. As for narratives, these incorporate a sense of gradual progress, increasing the difficulty or responding to a cumulative sequence of events.

Paradoxically, the use of all ecology-oriented mobile applications requires an energy source that at a massive level is known to have a negative effect on the environment, therefore, as a reflection it is recommended that both for communities with limited access to electricity, future researchers are encouraged to investigate gamified initiatives that can be used without internet and that serve to improve environmental care in communities.

The limitations of this research focus on increasing the review time of the mobile applications, extending the sampling and including new criteria referring to the users' perception of the use of these applications. For future research, this first exploratory review allows scholars from different multidisciplinary lines to investigate the computer design of these gamified experiences, provide a sociological review among others. In addition, researchers could also extend these criteria to playful virtual reality platforms aimed at environmental issues.

Author Contributions: Conceptualization, A.T.-T. and D.V.L.; methodology, D.V.L.; software, D.V.L.; validation, D.V.L. and A.D.-S.; formal analysis, A.D.-S.; investigation, A.T.-T.; resources, A.T.-T.; data curation, P.C.L.-L.; writing—original draft preparation, A.D.-S.; writing—review and editing, P.C.L.-L.; visualization, A.D.-S.; supervision, P.C.L.-L.; project administration, A.T.-T.; funding acquisition, A.T.-T. and D.V.L. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: The study did not require ethical approval.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The data presented in this study are available on request from the corresponding author.

Conflicts of Interest: The authors declare no conflict of interest.

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