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The Beauty and Pleasure of Understanding: Engaging with Contemporary Challenges Through Science Education (Proceedings of ESERA 2019)

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The Proceedings of ESERA 2019 is an electronic publication for revised and extended papers presented at the ESERA 2019 conference in Bologna, Italy during the 26-30 August, 2019. All papers in the eProceedings correspond to communications submitted and accepted for the ESERA 2019 conference. All proposals to the conference went through a double-blind review process by two or three reviewers prior to being accepted to the conference. A total of 1314 proposals (out of which 65 were symposia) were presented at the conference and in total 238 papers are included in the eProceedings.

The authors were asked to produce updated versions of their papers and take into account the discussion that took place after the presentation and the suggestions received from other participants at the conference. On the whole, the eProceedings presents a comprehensive overview of ongoing studies in Science Education Research in Europe and beyond. This book represents the current interests and areas of emphasis in the ESERA community at the end of 2019.

The eProceedings book contains eighteen parts that represent papers presented across 18 strands at the ESERA 2019 conference. The strand chairs for ESERA 2019

co-edited the corresponding part for each strand 1 to 18. All formats of presentation (single oral, interactive poster, ICT demonstration/workshop and symposium) used during the conference were eligible to be submitted to the eProceedings.

The co-editors carried out a review of the updated versions of the papers that were submitted after the conference at the end of 2019. ESERA, the editors and co-editors do not necessarily endorse or share the ideas and views presented in or implied by the papers included in this book.

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WITHIN THE PROCEEDINGS:

Part 7: Discourse and argumentation in science education

Part 8: Scientific literacy and socio scientific issues

Part 9: Environmental, health and outdoor science education

Part 10: Science curriculum and educational policy

Part 11: Evaluation and assessment of student learning and development)

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Part 13: Pre-service science teacher education

Part 14: In-service science teacher education, continued professional development

Part 15: Early years science education

Part 16: Science in the primary school

Part 17: Science teaching at the university level

Part 18: Methodological Issues in Science Education Research

CHARACTERISING THE EDUCATIONAL POTENTIALS OF MOBILE APPLICATIONS RELATED TO ECOLOGY

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Ten free-download mobile applications (apps) to be used for Ecology teaching and learning have been characterised. The analysis has included not only their technological characteristics but also their ecology content as well as the didactic aspects proposed by such apps. The technological resources studied have shown a high degree of usability, but two-dimensional images with low or null degree of realism have prevailed. Most of the apps have shown a wide variety of contents in their proposal. Few apps included activities for users, and when they did include them, the activities were limited to closed-ended questions or games. In most cases, no assessment activities that would enable meta-reflection were presented. The scientific thinking skills that were mostly promoted were: categorising observations, recognising patterns and thinking about causes and effects. As a result of the systematic analysis of the apps, they can be classified into three large groups: 'simulations', 'gaming apps' and 'encyclopaedia apps' in which different levels of interactivity, multimedia content, breadth, skills involved and cognitive demand prevail.

Keywords: ICT Enhanced Teaching and Learning, Secondary School, Multimedia and Hypermedia Learning

INTRODUCTION

Ecology is the epistemological support for understanding environmental problems, and it feeds school knowledge with a complex, open, multidimensional vision of science. In this context, ecology offers a systemic, non-mechanistic perspective: working with complex entities, the global vision of the world and the integration of analysis with synthesis, with a strong tendency towards multi- and inter-discipline (Hill, Wilson & Watson, 2004). However, at school, ecology concepts are usually presented as a set of dogmas; students deal with topics such as the ecosystem or ecological relationships as closed, static concepts, with one single possible formulation (Gonzalez del Solar & Marone, 2001). Without doubt, this way of teaching makes it difficult for students to acquire ecology school knowledge in line with scientific knowledge, and limits their capacity to establish relationships and combine contents.

For more than 15 years, the use of ICT as Ecology learning mediators has been proposed, with the development of specific computer programmes that enable the simulation of population and community dynamics, among other things. Nowadays, educational systems face the challenge of incorporating mobile phones in the classroom. In this scenario, mobile phones have long ceased to be mere communicative mediators to become centres of information, communication, audio and video recording and editing, and resource and content repositories.

Therefore, taking advantage of this device in the teaching and learning processes has many more advantages than one can imagine. This study is then based on two important premises: the availability of this educational tool and the ability of students to use it (Cantillo Valero, Roura Redondo & Sánchez Palacín, 2012). However, despite their ubiquity and the types of learning they can reinforce, these technologies are often not allowed or ignored in formal education systems. This represents a missed opportunity, as the potential of mobile phones can be significant and will continue to grow (Villalonga & Marta-Lazo, 2015).

In view of the prevailing need to incorporate mobile technologies in classrooms and considering the advantages of mobile apps that have been studied for the teaching of other biological contents, it is of interest to investigate the potentials of ecology-related mobile apps.

METHOD

The keywords 'Ecology', 'Ecology Teaching', 'Learning Ecology', 'Ecology Education' (both in English and in Spanish) were used in the search. Ten free-download apps developed for Ecology teaching and learning for the Android operating system (the main one used in Argentina) were selected for the analysis. The chosen apps, which were available in the Google Play Store digital platform, were the following: The Rain Forest Game, TaddyPole, Ksolve-Ecology, Ecology and Evolution Test - ECO, Ecology and Biosphere, Cours d' Ecologie, Ecosystem, Ecology Nuggets, Perspectives in Ecology, and Trilha Ecológica.

A methodology based on content analysis (Bardin, 1986) was followed, and those apps that included biodiversity and ecosystem structuring contents were selected. A qualitative analysis tool was developed, and categories contained in three dimensions were defined for such tool.

The 'ICT' dimension included the technical characteristics of each app taking up the categories proposed by Fernández-Pampillón Cesteros, Domínguez Romero & de Armas Ranero (2013); Martínez, Mir & Garcia Romano (2017) and Oliveira & Galembeck (2016). The 'Content' dimension analysed the depth with which the central Ecology topics were presented; to such end, the ideas presented by Adey (1997) and Bermudez & De Longhi (2006) were taken into account. As regards the 'Didactic' dimension, the pedagogical-didactic potentials of the apps were analysed according to the categories suggested by Vázquez-Alonso & Manassero-Mas (2018). Aspects emerging from the analysis were included in the tool, which was validated by means of a revision process carried out by experts in the field of Ecology.

RESULTS

Eight of the ten apps that were analysed were in English, one in French and one in Portuguese. With respect to the 'ICT' dimension, in general, the apps did not require Internet connection for their use. Usability was high, as the contents that were searched could be found quickly and the interface was intuitive. The multimedia content mostly included content with decorative or ornamental audio, 2D images with illustrative purposes and strong predominance of text. The degree of realism was low or null in most of the cases (Figure 1).

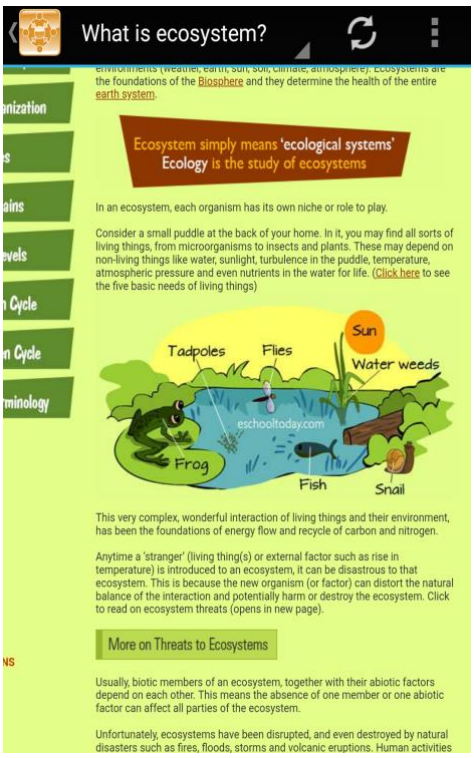

Figure 1. Example of an app that featured ornamental audios, illustrative images and predominance of text (Image taken from the Ecosystem app).

Interactivity was predominantly low, given the fact that the user's actions are limited to selecting steps to move forward in only one direction within the framework of the app proposal. Only one of the apps enabled to modify the values of different variables, and to observe different results according to the selection (Figure 2 a and b).

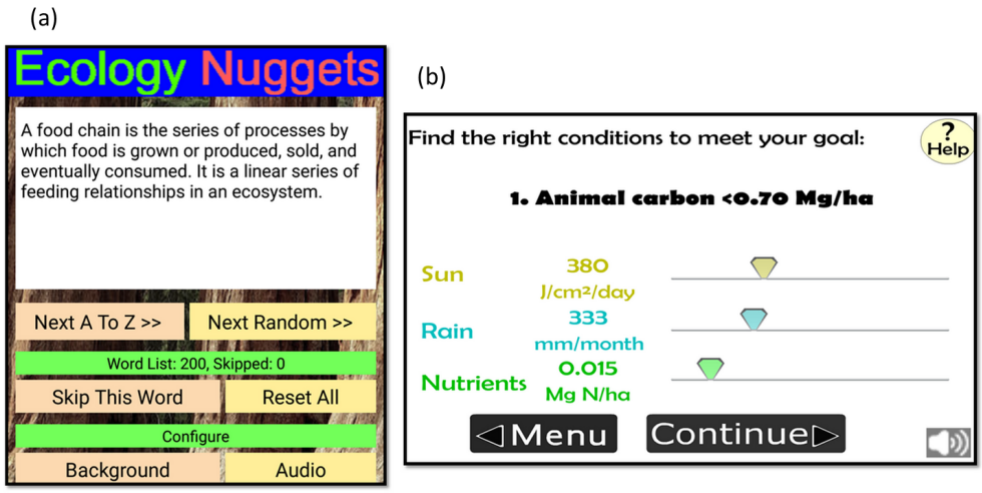

Figure 2. Example of an app with low interactivity (a) and an app with high interactivity (b) (Images taken from the Ecology Nuggets and The Rain Forest Game apps, respectively).

In relation to the 'Content' dimension, the Ecology branches that were most frequently found in the apps were General Ecology and Community and Ecosystem Ecology. Most of the apps included a wide variety of contents in their proposal, and only a couple of them focused on specific concepts (Figure 3 a and b).

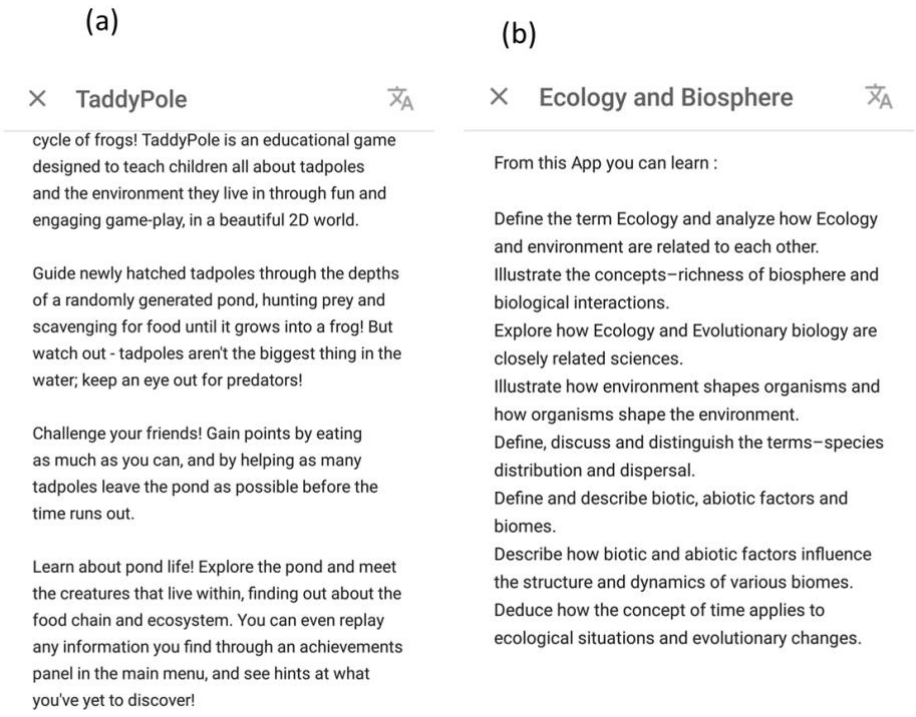

Figure 3. Example of an app with low breadth centered on the topic wetland ecosystem (a) and an app with high breadth that includes numerous topics (b) (Images taken from the TaddyPole and Ecology and Biosphere apps, respectively).

The biodiversity and ecosystem structuring contents were dealt with at different levels of complexity in the apps analysed, finding cases in which the description of elements and relationships present in the ecosystem were presented from an additive point of view that may reinforce students' prior ideas, and biodiversity was explained from a perspective that does not recognise its different levels of expression. However, some apps address a higher level of complexity and describe the variety of life, including species, ecosystem and genetic diversity (Figure 4 a and b).

Regarding the 'Didactic' dimension, it was found out that, in general, activities are not included in the proposals offered by the apps. In those cases in which activities were actually included, none of them was collaborative, and they focused on the development of close-ended questions or game-type instructions (Figure 5). In most instances, no assessment activities that would enable meta-reflection were presented. Finally, it can be stated that the scientific thinking skills that are mostly promoted by the apps are: categorising observations, recognising patterns and thinking about causes and effects. Moreover, the apps mainly require defining concepts and classifying.

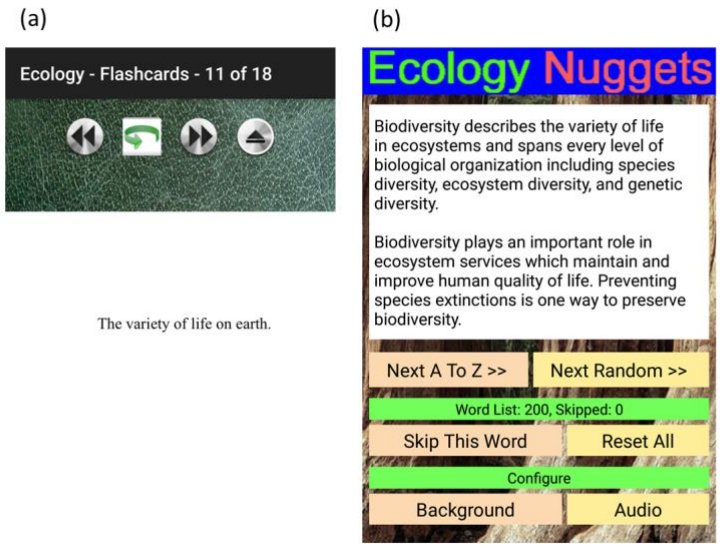

Figure 4. Example of an app that addresses biodiversity structuring content at a low level and in an additive way (a) and an app that presents a higher level of complexity (b) (Images taken from the KSolve-Ecology and Ecology Nuggets apps, respectively).

Figure 5. Example of an app that presents activities focused on closed questions (Image taken from the Ecology and Evolution Test - ECO app).

As a result of the systematic analysis of the apps, they can be classified into three large groups: 'simulations', 'gaming apps' and 'encyclopaedia apps', as shown in Table 1. Interactivity decreased considerably from an app that enables to simulate phenomena to another one with an encyclopaedia-type approach. In simulation and gaming apps the multimedia content was used to explain the topics whereas in encyclopaedia apps the multimedia content had an

ornamental purpose. Simulations and gaming apps centred on specific topics, while encyclopaedia apps presented a wide content breadth. Expected skills and cognitive demand showed significant parallelism, with higher values in simulation apps.

Table 1. Characteristics that are fostered in each type of app. (+++): High level. (++): Intermediate level. (+): Low level.

Category	Simulation	Gaming	Encyclopaedia
Interactivity	(+++)	(++)	(+)
Multimedia content	(+++)	(++)	(+)
Breadth	(+)	(+)	(+++)
Skills involved	(+++)	(+)	(+)
Cognitive demand	(+++)	(+)	(+)

DISCUSSION AND CONCLUSIONS

The results found in this study regarding the 'ICT' dimension were similar to those reported by Martínez, Mir & Garcia Romano (2017) and Oliveira & Galembeck (2016). On the other hand, taking into account the ideas proposed by Vázquez-Alonso & Manassero-Mas (2018) and Hill, Wilson & Watson (2004), just a few apps are aimed at developing more complex skills and at transmitting a vision of ecology closer to the scientific one.

Considering the availability of mobile devices, we suggest the design and selection of apps that enable students to take an active role in their learning. In this sense, this research provides valuable information to interdisciplinary teams working on the development of user-centered mobile apps that want to contribute to the education of people, so that they not only have "ecological awareness" but also "ecological knowledge" (Bermudez & De Longhi, 2008) Furthermore, given that teaching requires a constant planning process and that mobile apps alone do not guarantee learning, the categories of analysis presented in this work can be useful for teachers who want to design teaching sequences and activities with these technological resources.

As for further work in this research line, it would be of interest to incorporate other structuring contents of Ecology such as the notions of environment and sustainability, or general Biology apps, which may contain sections devoted to Ecology.

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