EduCITY as a smart learning city environment towards education for sustainability - work in progress

Lúcia Pombo; Margarida M. Marques
Research Centre Didactics and Technology in Education of Trainers (CIDTFF)
Department of Education and Psychology, University of Aveiro,
Campus Universitário de Santiago, 3810-193 Aveiro,
Portugal
Lpombo@ua.pt; marg.marq@ua.pt

Abstract: Education for sustainability is a relevant goal worldwide. One way to promote it, according to the literature, is to explore emergent active learning approaches, such as mobile learning, augmented reality, and games. This work-in-progress study presents an approach to develop a smart learning city environment towards changes in citizens' sustainable development competences, the EduCITY. Its innovation is to address a new action-oriented transformative pedagogy for the development of key sustainable development competencies, by using smart technology, as mobile Augmented Reality games grounded on challenging paths in the city, co-created by the community. The project fits a pragmatic paradigm, where mixed methods are used in a design-based research approach, comprising successive evaluative cycles for refinement and improvement of the technological prototypes: the app and the game creation web platform. The evaluation of the technology-enhanced intervention is made through observation and inquiry techniques. Several outputs of the project were already developed, even though some will be continuously updated throughout the project, namely, the project's website, and the technology component of the smart learning city environment. Future work includes several cycles of analysing and testing the technological prototypes and the development of games with students, teachers, and other non-programmers for education for sustainability.

Introduction

Education for sustainability is a relevant goal worldwide. One way to promote it, according to the literature, is to explore emergent active learning approaches. Previous studies have revealed the validity of mobile devices (Ayeni & Olugbuyi, 2022), augmented reality (AR) (Velázquez & Méndez, 2018), and games (Katsaliaki & Mustafee, 2012) in education for sustainable development, due to their positive outcomes, even though also acknowledging the new challenges they might pose (e.g., Ayeni & Olugbuyi, 2022).

Considering the case of mobile learning, as an illustrative example, in a case study where the analysis was made on a focused group discussion, team work and semi-structured individual interviews made during a students' world contest devoted to "Educational Mobile App as a Tool to Achieve SDGs", Kim (2020) points out that mobile learning can contribute to achieving the goals of the 2030 Agenda for Sustainable Development by improving access to education; increasing its quality, and by building and scaling up collective partnership. Moreover, Hoque and collegues (2022) conducted a systematic literature review to point out renewable energies trends in secondary education. They identified mobile learning as the most widely employed emergent approach to address global educational challenges, claiming that it ensures quality education for all.

Mobile devices are increasingly combined with AR technology to provide new and more effective educational experiences. It was the case of the study by Velázquez and Méndez (2018), in which the authors produced augmented worksheets for a technology learning unit and conducted a quasi-experimental study. In this study, one 3rd year class used the AR material for learning and another similar class followed the "business as usual" classroom practice. The study revealed that the explored AR technology supported proactive learning in the classroom, and that for teachers to be able to produce such teaching materials, teacher training is needed, particularly in the context of education for sustainability.

According to a review of serious games on sustainable development (Katsaliaki & Mustafee, 2012), these are usually freely available and may be accessed online, which increases the number of potential users. Moreover, these games are frequently single-player sandbox simulations with 3D graphics. Also, a frequent option is to target these games to youngsters, who become decision makers in the context of solving environmental problems.

When considering the trilogy of mobile AR games aiming at sustainability education, the literature does not have much to offer currently. In one of the few studies located, the authors developed a mobile AR game, the

AReGB Game, to support civil engineering students in learning about green buildings (Jamaludin & Omar, 2022). After experimentation of the app, 30 students answered an evaluation questionnaire. The results reveal students' perspectives, and they considered that the app aided and enhanced their learning of the fundamentals of green building technology, whilst generating a visual experience that is dynamic and modularly comprehensive. In the same line of work, the EduPARK app provided innovative, attractive, and interdisciplinary teaching strategies to promote authentic interdisciplinary learning. The app is interactive, integrates AR technologies, and sustains a game-based learning approach. It was designed to be explored by educational stakeholders from all school levels and the wider community, in the green park Infante D. Pedro, in Aveiro (Portugal) (Pombo & Marques, 2019). The app prompts users to observe this outdoor environment and to access AR content through image-based markers. Steaming from EduPARK's success emerged the EduCITY project, which aims to promote quality education for sustainable development through a smart learning city environment that comprises a mobile AR game app and a web-based game creation platform.

This brief paper presents a work-in-progress in the context of the EduCITY project. It presents an approach to develop a smart learning city environment towards changes in citizens' sustainable development competences. Next section presents a brief description of the EduCITY context, to sustain a better comprehension of the work being developed. The following section presents the "EduCITY methodological approach", where it is explained the project's framing in a pragmatic paradigm, where mixed methods are used in a design-based research approach, and a rigorous and iterative ADDIE process to develop smart learning city environment sustained by an app and a game creation web platform. The evaluation of the technology-enhanced intervention is made through observation and inquiry techniques. Moreover, the "The EduCITY work in progress" section presents the products achieved so far. Finally, future work is also presented, allowing to better understand the innovation brought about the EduCITY project.

The EduCITY context

The EduCITY - Smart and sustainable cities with Augmented Reality mobile educational games made by and for the Citizens is a research and training project, funded by Foundation for Science and Technology (FCT), whose feasibility is supported by a multidisciplinary team from four research units with know-how in Education, Training, Sustainability and AR mobile games. Most EduCITY team's researchers have participated in the previous project, the EduPARK (edupark.web.ua.pt), funded by FEDER-FCT. It sought to use outdoor learning strategies, by means of an interactive mobile AR app that supports geocaching activities in formal, non-formal and informal contexts, in the Aveiro city park (Pombo & Marques, 2019a, 2019b). The project was the 2018 winner of the prestigious ECIU Team Award for Innovation in Teaching & Learning, in a competition with other respected European technological universities (Pombo & Marques, 2019a, 2019b). The jury has highly valued: i) the team for being multidisciplinary; ii) the project being based on scientific literature; iii) the innovative use of familiar technology, adding AR to an educational app. The committee appreciated this innovation and recommended the team to work further on this idea and design more applications contributing innovatively to emergent societal challenges (V. van der Chijs, personal communication, October 25, 2018).

From the need to enlarge EduPARK's scope, EduCITY emerges by opening the boundaries of the park to the city, and to other cities, seeking to strengthen networking with other partners (schools, municipalities, and enterprises) fostering knowledge further and enabling opportunities for everyone to contribute to sustainable cities, in a social constructivism approach. The EduCITY intends to enhance sustainable cities through the creation of a disruptive smart learning environment, sustained by a mobile app with active location games based on challenges, with AR educational resources, such as simulations based on data from environmental sensors, 3D animations, informative spots, among others. These games can be co-created by teachers and students of all levels, from Basic to Higher Education, and the wider community in training courses and workshops organized for that purpose. The games comprise enjoyable and interdisciplinary challenges to be explored by any citizen while touring the city. This innovative pedagogy uses real-world pervasive and familiar technology (mobile devices) for 'learning by doing', where the AR games allow environmental awareness in the city, which acts as a living laboratory of experimentation, and citizens act as "active scientists" and agents in sustainable changes.

In terms of research, the team intends to investigate how does EduCITY promote changes in knowledge, skills, values and attitudes in citizens to empower them towards sustainable development? The methodological approach is explained in the next section.

EduCITY methodological approach

EduCITY fits a pragmatic paradigm, where mixed methods are used in a design-based research approach, which is a useful framework for developing technology-enhanced learning environments, such as mobile learning delivered by mobile handheld devices (De Villiers & Harpur, 2013; Parker, 2011). This includes a rigorous and iterative ADDIE process, where each letter corresponds to a certain phase, as follows: A - Analyse the literature; DD - Design & Develop the smart learning city environment technological prototypes (a mobile app for Android and iOS, and an easy-to-use open access web platform to create games for the app); and IE - Implement & Evaluate the smart learning city environment by validating it with the expert consultants and testing it with users, through observation and inquiry techniques. This comprises successive evaluative cycles for refinement and improvement of the technological prototypes. After a functional and mature technological version of the prototypes, the technology-enhanced intervention will be available for the public. Outreach activities for creating and playing the games will be promoted and it will involve schools, public and tourists. Here data will be collected to gather information to respond to the research question stated above. The project is in progress, and next section will demonstrate some of the most important outputs already completed or in development so far.

The EduCITY work in progress

The EduCITY website, https://educity.web.ua.pt/, available in Portuguese and in English, was one of first outputs of the project, and it intends to feature contents, such as: information about the EduCITY and its team; app download with the produced educational games; access to the platform to create games; details about the city, including a 360◦ virtual visit, maps with interesting points to visit and real-time data from environmental sensors with up-to-date graphs; information for teachers and the wider community about outreach activities; scientific results from papers publication and oral communications; evidences of concluded activities; news on institutional media, mass media, interviews, and a space where anyone can leave a message for the team.

The project brand (logo and mascot) was also created (Figure 1) and registered to protect intellectual properties. The logo includes typical elements of Aveiro city, such as the traditional boat ‘moliceiro’ in the lagoon, as Aveiro is a city with channels and the mascot, a pink flamingo.

Figure 1- The EduCITY logo and mascot.

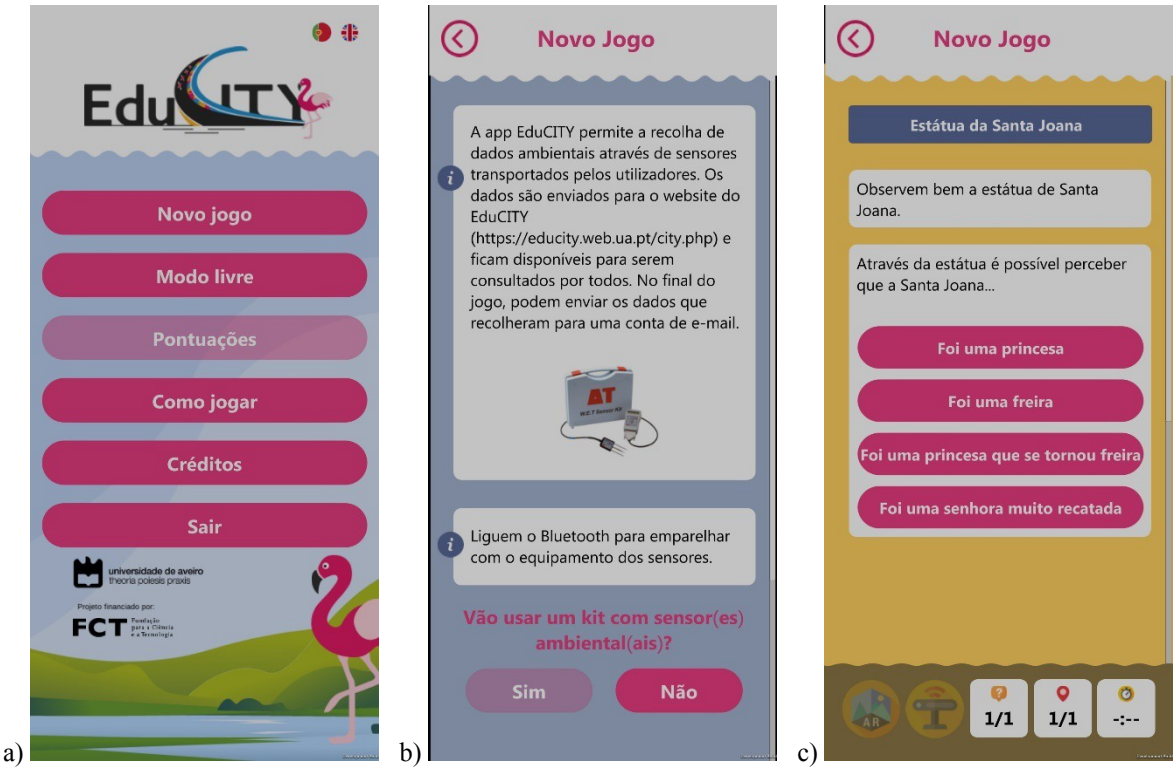
The friendly mascot is one of the bird species that can be seen in most of the lagoon natural spaces, even near the University of Aveiro, the host of the EduCITY project. Flamingo’s population has been growing in the last few years, and it has aroused the interest of many passers-by and tourists who observe these peculiar birds. The mascot was created with different expressions, revealing diverse moods, because it guides players during the games, providing constructive and adaptative feedback. It can be surprised, sad or happy, and it will be animated in the app, to improve users’ motivation and interest.

To conduct the task concerning literature review to analyse the problem, the team produced a book (Figure 2) about education for sustainability within the context of Aveiro city. The book is like a tour in the city and presents some efforts towards sustainability. It comprises four chapters: 1) On the way to sustainability; 2) Aveiro: Cultural Heritage; 3) Aveiro: Natural Heritage; and 4) Aveiro: examples of good sustainability practices.

Figure 2- The EduCITY book about education for sustainability.

The book intends to be of interest to a wide audience, not just to academics and, above all, it intends to be useful to ordinary citizens who, by getting to know their city's heritage better, will be able to adopt more sustainable attitudes (Pombo et al., 2022).

The technology-enhanced intervention includes a user-friendly mobile app (Figure 3) with co-created games and appealing AR resources, with paths and challenges, targeting educational stakeholders and the wider community. In the initial screen of the app, one can start a new game, access the free mode, check the score previously achieved, and learn the game rules (how to play), as shown in Figure 3, a).



a) b) c)

Figure 3- EduCITY mobile app screen examples: a) initial screen; b) screen with information regarding the use of environmental sensors; and c) screen with a multiple-choice question.

For each game, the user can see information, such as the school level or school subject, number of points of interest or if it includes AR and sensors. After selecting a new game, the user must indicate if environmental sensors will be used (Figure 3, b). If that is the case, the user is prompted to connect a sensor kit and the app will collect sensor data regarding: i) particulate matter and others, ii) NO_2 and others, or iii) noise. That data is collected and aggregated in graphs in ThingSpeak (https://thingspeak.com/), and will be made available in the EduCITY website (https://educity.web.ua.pt/), for the community to have access.

The AR experiences are possible through 2D markers, such as architectonical tiles or trees identification plaques. Other types of AR triggering, such as GPS triggered or markerless, are being studied under EduCITY as well.

During the game, the user is “accompanied” by a friendly Flamingo mascot, to find points of interest in the city to observe, to access information in multimedia format, including AR, and to answer multiple-choice questions (Figure 3, c). After selecting an answer option, differentiated feedback is shown. The last screen displays the score achieved, the number of questions answered correctly, time of play, etc.

The games are co-created by non-programmers in an open and easy-to-use web platform (Figure 4). Each user must create an account to be able to use it. With this tool the user can define written information, such as the initial message of the game, and multimedia resources, such as specific digital content used to create AR experiences, to include in each phase of the game. For each point of interest in the city, defined by the user, he/she: i) introduces information regarding how to find its location and why it is interesting, and ii) creates multiple choice

question(s), including the answer options and feedback to provide the players, accordingly to game performance. The number of answer options can vary from two to four, and the correct options can also vary in this range.

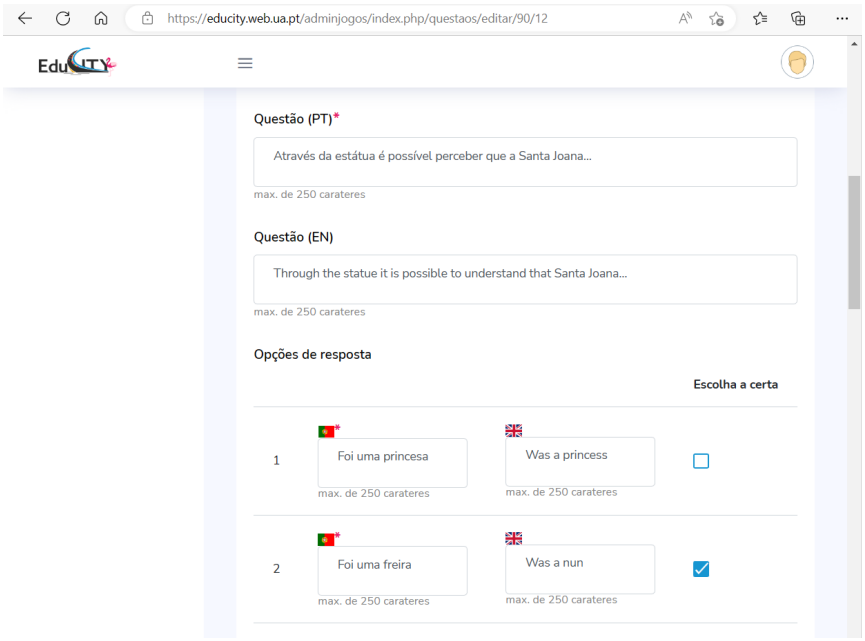


Figure 4- EduCITY web platform example: question creation.

Multimedia resources can be included to contextualize the players, to give information, to support the visualization of difficult concepts, among other aims. For that, a content repository (video, audio, 3D models, …) is integrated in the web platform, which is fed by the research team and by the platform users.

Both the AR markers and the digital content for AR experiences are created by the EduCITY team. They can, however, be also created by users, for greater flexibility and project sustainability after the funding period. The users can create three types of AR experiences, such as associating a 3D object to a marker, subtitling an image, or creating a button screen with information.

Participatory dynamics are supported by the platform. Each user can invite other authors to co-create content and games. This allows citizens (educational stakeholders, academy and the wider community) to contribute to activities and challenges to be integrated as games in the app.

Games are always available for their creators in the app, through a specific code. To be publicly available, games can be submitted to validation by members of the research team. The platform collects anonymous game logs for the game creators to be able to analyse and decide on eventual improvements to conduct.

Future work

This work-in-progress study present an approach to develop a smart learning city environment towards changes in citizens' sustainable development competences. It is expected that the EduCITY will produce a technology-enhanced intervention, using a mobile app with AR challenging games, co-created by citizens through an open and easy-to-use platform supporting participatory dynamics. With this tool, citizens will be able to explore AR games in strategic paths in the city. The games will be grounded in city-based aggregating topics, promoting education in context and lifelong learning. This new knowledge in addition to the technology-enhanced practical solution, the smart learning city environment, can be replicated elsewhere, challenging conventional thinking about how people can learn about their city and change their habits towards sustainable and resilient cities (Pombo & Marques, 2019b).

The EduCITY innovation lies in: a) the use of the territory as a living experimental laboratory, moving Education to a real-life context; b) the use of widely-used smart technology with AR mobile games; c) community participation, giving opportunities for all to actively contribute, in a social constructivism approach; d) wide knowledge sharing between the university and the community; e) the applicability of this approach to any city to build a digital, green and healthy future for everyone.

The development of a technology that can support such innovative smart learning city environment is a challenging and ambitious endeavour. Here, citizens are asked to commit and engage in the transformation of their city towards sustainability, for the benefit of cities' increased quality of life. In such a challenging proposal, several difficulties are foreseen, as issues regarding AR triggering and interactivity, and connectivity with environmental sensors. These must be addressed during the design-based research, in order to achieve a mature, easy-to-use and fully functional solution.

Future work involves several cycles of analysing and testing the prototypes. After a functional and mature technological version, several activities, such as training courses or workshops, will be organized for game co-creation by the community, particularly educational stakeholders, as students and teachers. Afterwards, the games created through participatory dynamics need to be tested and explored *in situ*, so outreach activities will be promoted involving schools, public and tourists in playing the game. In this phase data will be collected to gather information to respond to the research question: how does EduCITY promote changes in citizens to empower them towards sustainable development?

These experiences enlarge the creative, multi/interdisciplinary response that seeks to provide situated learning opportunities for all through the creation of participatory dynamics involving the academy and the community. The project mission is much more than a traditional Research & Development project. Here citizens commit to transformation and engage in it for the benefit of cities' quality of life and sustainability.

Acknowledgements

EduCITY is funded by Portuguese funds through FCT - Foundation for Science and Technology within the framework of the PTDC/CED-EDG/0197/2021 project. The work of the second author is funded by national funds, through University of Aveiro, in the scope of the framework contract foreseen in the numbers 4, 5 and 6 of the article 23, of the Decree-Law 57/2016, of August 29, changed by Law 57/2017, of July 19.

References

Ayeni, M. F., & Olugbuyi, P. O. (2022). UTLILIZATION OF MOBILE LEARNING IN THE TEACHING OF SCIENCE FOR SUSTAINABLE DEVELOPMENT. *European Journal of Education Studies*, *9*(5). https://doi.org/10.46827/EJES.V9I5.4386

De Villiers, R., & Harpur, P. A. (2013). Design-based research-the educational technology variant of design research: Illustrated by the design of an m-learning environment. *Proceedings of the South African Institute for Computer Scientists and Information Technologists Conference on - SAICSIT '13*. https://doi.org/10.1145/2513456.2513471

Ho, S. J., Hsu, Y. S., Lai, C. H., Chen, F. H., & Yang, M. H. (2022). Applying Game-Based Experiential Learning to Comprehensive Sustainable Development-Based Education. *Sustainability 2022, Vol. 14, Page 1172*, *14*(3), 1172. https://doi.org/10.3390/SU14031172

Hoque, F., Yasin, R. M., & Sopian, K. (2022). Revisiting Education for Sustainable Development: Methods to Inspire Secondary School Students toward Renewable Energy. *Sustainability 2022, Vol. 14, Page 8296*, *14*(14), 8296. https://doi.org/10.3390/SU14148296

Jamaludin, S. A., & Omar, P. U. (2022). Experiential learning in green building technology. *Jurnal Kejuruteraan, Teknologi Dan Sains Sosial*, *8*(1), 404–414. https://www.puo.edu.my/webportal/wp-content/uploads/2022/10/39.-EXPERIENTIAL-LEARNING-IN-GREEN-ID115.pdf

Katsaliaki, K., & Mustafee, N. (2012). A survey of serious games on sustainable development. *Proceedings - Winter Simulation Conference*. https://doi.org/10.1109/WSC.2012.6465182

Kim, J. (2020). Voices of youth in reconceptualising and repositioning the role of mobile learning for sustainable development, *26*(4), 711–727. https://doi.org/10.1080/02681102.2020.1749537

Parker, J. (2011). A design-based research approach for creating effective online higher education courses. *26th Annual Research Forum: Educational Possibilities*. http://researchrepository.murdoch.edu.au/5566

Pombo, L., Ferreira-Santos, J., Draghi, J., Lopes, L., Marques, M. M., Lopes, M., Sá, P., Beça, P., Rodrigues, R., Tavares, R., Pinho, R., Ribeiro, S., Rodrigues, S., & Carlos, V. (2022). *Aveiro, cidade sustentável: EduCITY* (L. Pombo (ed.)). UA Editora. https://doi.org/https://doi.org/10.48528/jtw2-k945

Pombo, L., & Marques, M. M. (2019a). Learning with the Augmented Reality EduPARK Game-Like App: Its Usability and Educational Value for Primary Education. In K. Arai, R. Bhatia, & S. Kapoor (Eds.), *Computing Conference, 16-17 July* (Vol. 997, pp. 113–125). Springer. https://doi.org/10.1007/978-3-030-22871-2_9

Pombo, L., & Marques, M. M. (2019b). An App that Changes Mentalities about Mobile Learning—The EduPARK Augmented Reality Activity. *Computers*, *8*(2), 37. https://doi.org/10.3390/computers8020037

Velázquez, F. del C., & Méndez, G. M. (2018). Augmented reality and mobile devices: A binominal methodological resource for inclusive education (SDG 4). an example in secondary education. *Sustainability (Switzerland)*, *10*(10). https://doi.org/10.3390/SU10103446