EDUCITY, A PROJECT FOR A SUSTAINABLE SMART LEARNING CITY ENVIRONMENT – PRELIMINARY RESULTS

Rita Rodrigues[1,2], João Ferreira-Santos[2], Julia Draghi[2], Margarida M. Marques[2] and Lúcia Pombo[2]
[1]*Research Center on Didactics and Technology in the Education of Trainers*
[2]*(CIDTFF), Department of Education and Psychology (DEP), University of Aveiro, Portugal*

ABSTRACT

To drive effective change towards sustainable development, several courses of action have been devised, and education was pointed as a way to attain this goal. Recognizing the impact of learning in context, it is essentialto develop innovative educational proposals that bring schools into other social contexts. This study aims to present, albeit preliminarily, the potential of the EduCITY smart learning city environment for Education for Sustainable Development. The research explores mixed methods to analyse students' perceptions of one component of the smart learning city environment, the EduCITY app, which supports mobile educational games, and its potential to promote learning about sustainable development. To this end, an analysis of data collected during five educational game activities supported by this app was conducted. Data was collected anonymously through a post-game questionnaire, and through automatic app logs of game performance. Participating students recognised the value of the EduCITY app in promoting education for sustainable development. There was also a positive trend in promoting learning about sustainability through the scores andnumber of correct and incorrect answers per game. This article presents indicators of the value of the EduCITY project in promoting sustainable smart learning city environments, specifically through the use of the EduCITYapp and its multimedia resources. Future work includes the co-creation of games with students, teachers and citizens towards education for sustainability to gather data to assess whether the EduCITY smart learning cityenvironment can promote changes in citizens to empower them towards sustainable development.

KEYWORDS

Education for Sustainable Development, Mobile Learning, Game-Based Learning, Augmented Reality, Smart Learning City Environment

1. INTRODUCTION

The current era faces significant change and challenges in social, cultural, technological, and environmental domains (UN, 2015). Responding to these multiple challenges, various players and international organizations are turning to Education as an agent of transformation (Morin, 2002).

Technological advances have brought new potentialities to Education (OECD, 2022), as, e.g., the use of mobile devices is blurring the spatial boundaries of schools (Scavarelli et al., 2021), and capitalizing on new learning dynamics (UNESCO, 2021). One highlighted focus areas is the field of Education for Sustainable Development (UNESCO, 2021). This emphasis stems from the urgent need to change habits, and raise awareness of the emergent issues. Alongside formal activities in Citizenship Education and informal educative awareness-raising, bringing the school closer to students, and their families, daily lives has proved to be a fundamental change factor (UNESCO, 2021). The development of new educational strategies that take place outside the school environment makes Education closer to reality and involve those contexts in new dynamics (Pombo & Marques, 2019; Sebastián-López & González, 2020). These new dynamics are based not only on new trans- and interdisciplinary conceptions of curriculum development but also on new learning approaches, such as Game-based Learning (Pombo, 2022). By adding other technological possibilities, namely Augmented Reality (AR) resources, it is possible to develop educational solutions that are both engaging and innovative.

Building on EduPARK success (funded by FEDER and FCT), which won the prestigious 2018 Team Award for Innovation in Teaching & Learning from the European Consortium of Innovative Universities (ECIU), the

EduCITY aims to promote sustainable cities via a smart learning city environment supported by a mobile app featuring AR and challenge-based location games. The app is fed by a game creation web platform for users without programming skills. Games validated by the EduCITY team become available to all. This innovative pedagogy fosters "learning by doing", where AR mobile games enable environmental awareness in the city (Pombo, 2022). This work focuses on the app component. It allows the exploration of AR content deployed through image-based markers, such as natural markers (e.g., tiles) or markers in plaques installed for that purpose (Pombo, 2022). This AR technology and other multimedia content, such as 3D objects, videos, or images are supported by mobile devices, which are accessible and have high potential for educational purposes (Schaal & Lude, 2015; Sung et al., 2016). The EduCITY app relies on games that employ cross-subjects questions gradually revealed along previously planned paths. This approach potentially promotes engagement and motivation, considering the main factors that impact student performance during the learning process (Fatih, Kumalija & Sun, 2018). Mobile AR and other multimedia content serve as effective pedagogical tools for Education for Sustainable Development, enabling students to learn and reflect on their behaviour through games. Anonymous data collection on game performance, combined with the results of the anonymous questionnaires offer insights of, e.g., participants' awareness and behaviours change towards sustainable development. Although the EduCITY smart learning city environment is still in development, game playing activities with the app prototype have already been carried out with students from different educational levels, which are presented in the following sections.

The aim of this article is to analyse, albeit preliminarily, the potential of the smart learning city environment, created under the EduCITY project, for Education for Sustainable Development. It is organized into four sections. The first, the Introduction, contextualizes and introduces the aim of study, briefly showing the links between the different analysed themes and introducing one of the smart learning city environment components, the EduCITY app. The second section is focused on the methodological options, presenting data collection and analysis processes and tools. This section also deepens the research context, including the EduCITY app, the games implemented with students, and the multimedia resources integrated into the games. The third section presents the preliminary results and their discussion, using graphics to facilitate the reading and interpretation of data. Analysing preliminary data makes it possible to evaluate, validate, and improve the app's features and games. The fourth section focuses on the conclusions, with special emphasis on the value of the EduCITY app. Proposals for future research are also presented, based on the development of the app and new games.

2. MATERIALS AND METHODS

This paper reports a mixed methods study that aims to analyze students' perceptions regarding the EduCITY app and its potential to promote learning about sustainable development. To answer the research question "What are the students' perceptions about the value of the activity to promote sustainable development after playing with the EduCITY app?", the research team organized five activities for students to play a game in April and May 2023. These activities involved 132 students (from school-year 7 to 11), from four different schools located in Aveiro, Vila Real, Porto, and Cinfães. In each activity, students were organized in groups of 2-5 elements, according to the availability of adults to accompany the students in the activities. Three different games were used in the five activities, depending on the age of the students: "EduCITY on the UA campus", "UA Informa" and "Recursos Naturais por Aveiro" [Natural Resources in Aveiro]. All the games and multimedia resources were developed by the EduCITY team, except the "Recursos Naturais por Aveiro game. This later game was co-created by an 8th-grade class under the supervised teaching practice of the Master's course in "Teaching Biology and Geology in the 3rd Cycle of Basic Education and Secondary Teaching" at the University of Aveiro. In each game, a path in Aveiro city was defined, questions and answers were formulated, and associated multimedia resources were produced.

The games were played by 132 participant-students and all agreed to participate in this study. According to the defined exclusion criteria, 24 questionnaires were excluded and a total of 108 questionnaires were considered valid. The exclusion criteria were: questionnaires answered incompletely; questionnaires with the same answer selected to all the sentences, questionnaires with several answers to the same sentence. Regardless of the chosen game, each group played the game for an average of one hour using a smartphone of the project, as the app was not available in the stores yet. The games were previously downloaded to mobile devices and no internet connection was required to play *in situ*.

This section comprises three subsections: i) a description of the EduCITY app and the games implemented; ii) a description of the types of multimedia resources integrated into the EduCITY app; and iii) data collectionand analysis approaches and tools.

2.1 EduCITY App

Having as the main challenge the promotion of smart and sustainable cities, the EduCITY project (https://educity.web.ua.pt/) creates a disruptive smart learning city environment. The most visible component is the mobile app that supports active location games with challenges and multimedia resources. This app is available in Portuguese and English, and it is one of the main outputs of the project (Pombo, 2022).

Designed for user-friendliness, the app is fed with co-created games and multimedia resources to be explored while touring the city. These games are co-created by educational stakeholders (teachers and students of all levels, from Basic to Higher Education) and the wider community in training courses and workshops. Any interested user can create a game in the web-platform that is immediately available to be tested in the app through a specific code. To be publicly available, games are submitted for validation by the EduCITY team. The platform collects anonymous game logs for the game creators to be able to analyse and decide on eventual improvements to conduct (Pombo, 2022).

This innovative pedagogy uses real-world pervasive and mobile devices for “learning by doing”, where the AR games allow environmental awareness in the city, which becomes a living laboratory of experimentation, and citizens act as “active scientists” and agents in sustainable changes (Pombo & Marques, 2019).

The app features a mascot, "Mr. Pinky" the flamingo, guiding players through the game journey. “Mr. Pinky” directs players to the points of interest in the city, gives access to multimedia content, and supports players’ in answering multiple-choice questions. In the EduCITY app, multimedia resources serve various purposes, such as, to contextualize the players, provide information, and visualization of difficult concepts.

It is important to highlight that for this study, three different games integrated into the EduCITY app were considered. The “EduCITY on the UA campus” game (see Figure 1) was the first one to be tested by students. In this activity, 27 secondary teaching students from Aveiro explored the UA Campus, visited nine points of interest, and answered 24 questions. All students agreed to participate in this study and answered the questionnaire, but 2 questionnaires were excluded. After this first activity, some corrections were made, such as the improvement of the questions itself for increased clarity, and the enhancement of the multimedia resources. The revised game was implemented again with 35 students from Vila Real. Once more, all students agreed to participate in this study and answered the questionnaire, but 10 questionnaires were excluded. This game was also played by 32 students from Porto. Again, all students agreed to participate in this study, but 4 questionnaires were excluded. This game was played by 94 participating students, but only 78 questionnaires were considered for this study.

Figure 1. Students playing the “EduCITY on the UA campus” game

The “UA Informa” game was developed in collaboration with the UA Informa project (https://www.ua.pt/pt/uainforma). Thus, all the resources developed by UA Informa were integrated into the EduCITY app. This game follows a path through the UA Campus with 11 points of interest and 33 questions on the multimedia resources or the local context of each point of interest. This game was implemented with the smallest group, consisting of 10 students from Cinfães. One of the questionnaires was excluded.

The “Recursos Naturais por Aveiro” game was co-developed by 28 students from an 8th-grade class and 2 future-teachers under their Masters’ Teacher Education course. The aim was to promote the 8th-grade student's ability to question, work collaboratively, and learn about natural resources and their sustainable exploitation.

All students participated in this study, but 7 questionnaires were excluded.

All games integrate challenges and multiple-choice questions aiming to promote learning related to the following topics: recycling, renewable energies, food waste, and ocean plastic pollution, articulating curricular contents of Science, Mathematics, Education for Citizenship, and cultural aspects of Aveiro city. Players always get immediate constructive feedback to their answers, after selecting the correct or incorrect answer(s). The feedback is developed to explain the correct answer or to give further information on the topic.

AR integrates virtual information that complements the observable reality in some specific locations and multimedia resources (images, videos, and audio) that are conceived to support students in answering correctly the questions, in an appealing way (Pombo & Marques, 2019). Immediately after finishing the game, symbolic EduCITY prizes were given to the teams with the best performance and the students participating in this study voluntarily answered an evaluation questionnaire.

2.2 Multimedia Resources Integrated into the EduCITY App

Depending on their purpose, multimedia resources can take different formats including image, video, audio,and in the case of AR, 3D models. Multimedia resources are used to motivate students to learn about sustainable development, and games become more attractive with virtual elements combined with the real elements of the city. The images, videos, and audio are associated to the questions' introduction and/or feedback. For the development of these resources, a bibliographical search is made, and reliable information websites are consulted, to guarantee the quality of the content.

During the game path, the students have to search for AR markers that contain information that supports the answer to specific questions. The AR markers can be natural, or they can be installed on EduCITY information plaques. The natural markers are, typically, photographs of cultural heritage (e.g., tiles), of city signals (e.g., information signals at the entrance of museums), among others. They give access to a variety of content, usually based on text and images. The AR markers installed on plaques include information about plant species. All plaques have the same content layout – AR Book – but the information in each one varies according to the plant species, such as the scientific and common names, the information about the plant, leaf, flower, and fruit, its family (in biological classification), its origin and some curiosities (Figure 2). These plaques are installed at the University of Aveiro and across Aveiro city.

Figure 2. An example of a plant species AR Book content, triggered through 2D marker detection

In more detail, when selecting the "Plant" button information about the plant is displayed, such as its height and the trunk. The "Leaf" button displays a description of the leaf, including its morphology. It can also contain a photograph or a 3D model of the leaf. The same applies to the flower and the fruit. To produce the 3D models of the leaves, each was photographed from both sides without zooming and on a white base. Then the model was assembled using the Blender program. Furthermore, the 3D models of the flowers and fruits (Figure 3) were made with the Polycam Pro app, a 3D capture app (Figure 3). On the right side of the board, the "Origin" button indicates the origin of the species plant, mentioning whether it is a native or exotic species. This information is supported by a map with the respective distribution highlighted. The "Ecology" button presents the habitat and the months in which the species is in the flowering or fructifying states, with illustrative photographs. The "Curiosities" button contains a variety of information, including the meaning of the scientific and common names, and other facts, e.g., its medicinal use.

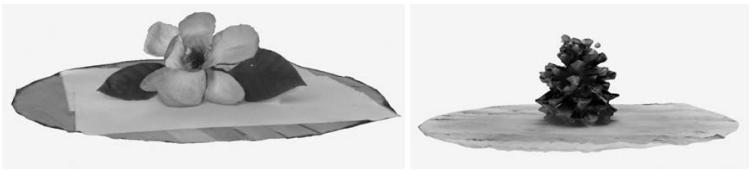


Figure 3. Examples of 3D capture using the Polycam Pro app

The AR multimedia resources can be created by the EduCITY team and also by other users, such as teachers and students without programming skills, for project sustainability after the funding period.

2.3 Data Collection and Analysis

Data was collected anonymously through a post-game questionnaire and automatic game performance logsof the following games: "EduCITY on the UA Campus", "UA Informa" and "Recursos Naturais por Aveiro". Due to the nature of these activities, it was not possible to arrange a pre-test date.

The questionnaire was divided into four sections: A. Value of the activity in promoting learning about sustainable development; B. Evaluation of the EduCITY application; C. Global appreciation of the activity; and D. Profile of the respondents. This study focuses on section A, which requires students to select one option from a 5-point Likert scale of their level of agreement (strongly disagree, disagree, neutral, agree, strongly agree) with eight statements. The sentences collect data on: knowledge, skills, values and attitudes towards sustainability. The sentences are antagonistically worded, i.e., each topic has one sentence positively worded and the other negatively worded, to support the identification of a lack of seriousness in completing the questionnaire.

Game performance logs included scores, the number of correct and incorrect answers for each question, and the playing time. This data was collected directly from the app in an anonymous manner and provides indicators of the game's ability to support learning. This quantitative data was analyzed using descriptive statistics and presented in graphs. The results of both data collection methods were triangulated to analyze the value of this game (Creswell & Creswell, 2023) in promoting conservation attitudes. The results are presentedand analyzed in the following section.

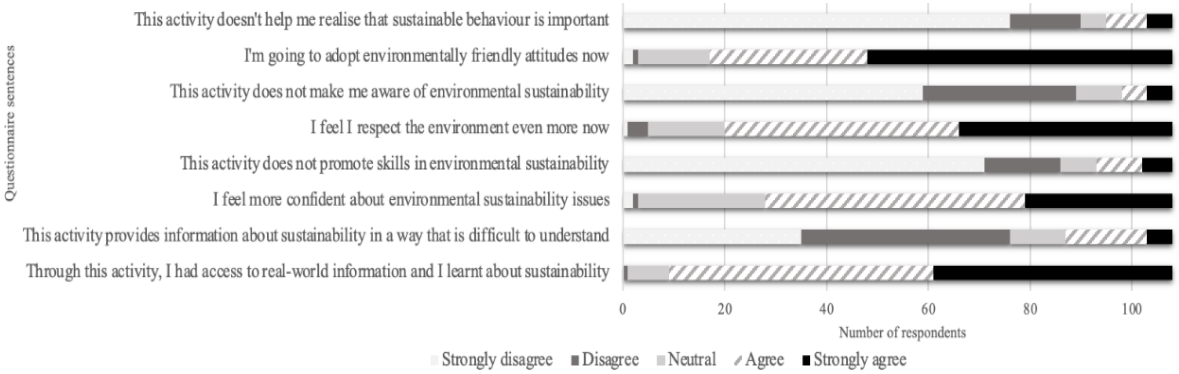
3. PRELIMINARY RESULTS AND DISCUSSION

At the time of the activity, students were attending grades 7 to 11 in the Portuguese Education System: 7.40% in grade seven; 59.25% in grade eight; 1.85% in grade nine; 23.15% in grade ten, and 8.33% in grade eleven.

Graphic 1 reveals the student's opinion about the value of the activity to promote Sustainable Development learning. In the sentence "Through this activity, I had access to real-world information, and I learnt about sustainability", 48.1% of the students agreed, 43.5% strongly agreed, 7.4% had a neutral answer, and 0.9% disagreed. No student strongly disagreed with this sentence. The associated sentence, about whether the activityprovides information about sustainability in a way that was difficult to understand, 38.0% of students disagreed,32.4% strongly disagreed, 14.8% agreed, 10.2% had a neutral answer, and 4.6% strongly agreed. Overall, the majority of the students (strongly) agreed with the positive formulated sentence and (strongly) disagreed withthe negative one, indicating that the activity supported knowledge learning on sustainability.

In the sentence "I feel more confident about environmental sustainability issues", 47.2% of the students agreed, 26.9% strongly agreed, 23.1% had a neutral answer, 1.9% strongly disagreed and 0.9% disagreed. In the opposite sentence, regarding the activity not promoting skills in environmental sustainability, 65,7% of the students strongly disagreed, 13.9% disagreed, 8.3% agreed, 6.5% had a neutral answer, and 5.6% strongly agreed. These results reveal a smaller tendency of students acknowledging the activity's power to promote sustainability skills.

ISBN: 978-989-8704-55-9 © 2024



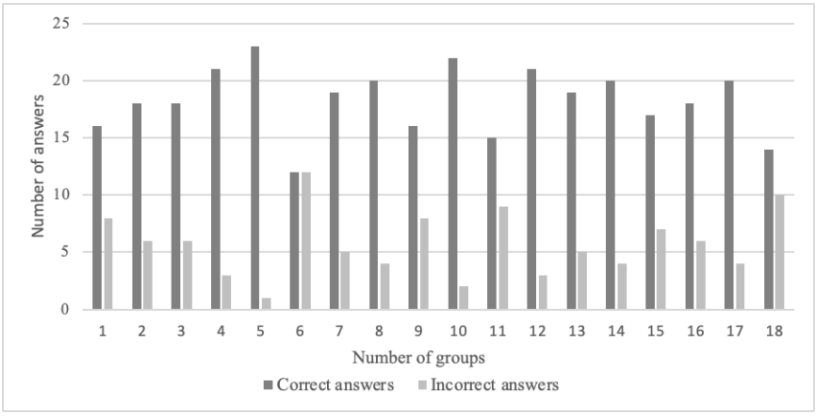
Graphic 1. Students' opinion about the value of the activity to promote sustainable development learning

In the sentence "I feel I respect the environment even more now", 42.6% of students agreed, 38.9% strongly agreed, 13.9% had a neutral answer, 3.7% disagreed, and 0.9% strongly disagreed. On the associated sentence, about the activity's incapacity to make students aware of environmental sustainability, 54.6% of students strongly disagreed, 27.8% disagreed, 8.3% had a neutral answer, 4.6% agreed, and 4.6% strongly agreed. These results reveal a tendency for students to consider that the activity promotes sustainability-related values.

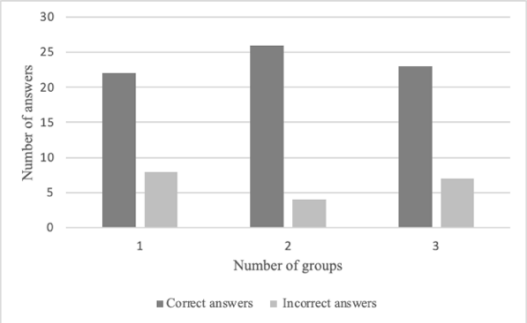
In the sentence "I'm going to adopt environmentally friendly attitudes now", 55.6% of the students strongly agreed, 28.7% agreed, 13.0% had a neutral answer, 1.9% strongly disagreed, and 0.9% disagreed. In the related sentence, regarding the activity not supporting awareness on the importance of sustainable behavior, 70.4% of students strongly disagreed, 13.0% disagreed, 7.4% agreed, 4.6% had a neutral answer, and 4,6% strongly agreed. These results reveal a positive perception regarding the awareness power of the game playing activity of environmental sustainability attitudes.

Considering the analysis of game logs, three different graphics were developed, corresponding to the three played games. Graphic 2 represents the game logs of the 18 groups that played the "EduCITY on UA Campus"game, showing the correct and incorrect answers, per group. The collected data reveal, overall, that students were aware or were able to learn about the game Sustainable topics, since all groups answered mostly correctly,except one group (group 6), whose correct and incorrect answers were in the same number (12).

Related to the "UA Informa" game, Graphic 3 presents the results of the 3 groups of students that played the game. The data shows that the 3 groups achieved a good game performance considering the number of correctanswers. Although all the groups demonstrated good performance, the group with the highest number of incorrect answers selected 8 incorrect answers in a total of 33 (group 1).

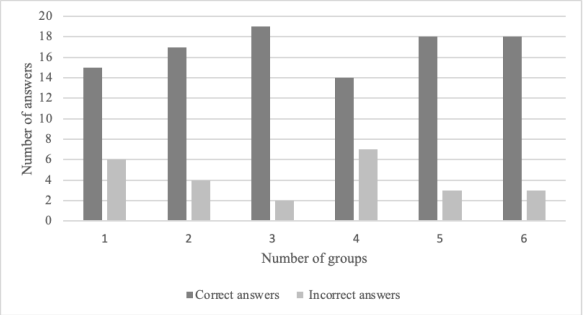


Graphic 2. Summary of student's game results of "EduCITY on the UA campus"



Graphic 3. Summary of student's game results of "UA Informa"

Graphic 4 reveals the game logs considering "Recursos Naturais por Aveiro". Once more, results indicate that students had a good performance based on the high number of the right answers. It is important to highlight that this game was co-created and played by the same students.



Graphic 4. Summary of student's game results of "Recursos Naturais por Aveiro"

4. CONCLUSION

The results of this study, although preliminary, support the assertion that the EduCITY smart learning city environment, through the exploration of the app and games, enables dynamic learning approaches and brings real context to learning purposes. This is related to the arguments described by Scavarelli et al. (2021), which implies the importance of bringing educational activities into outdoor environments, an issue also highlighted by UNESCO (2021). In addition, it can be shown that the app and its games empower students on Sustainable Development issues, namely, the adoption of new environmentally friendly attitudes. It is also understandable that the positive results may be related to the engagement shown by the students, e.g., when exploring AR resources and visualising videos and images. This is demonstrated by the fact that some questions can only be answered correctly after learning the information on the multimedia resources, e.g., "How long does it take for a plastic bottle to decompose?". Therefore, exploring the EduCITY app allows the exploration of Sustainable Development issues from different digital contents, such as AR. This feature adds new layers of information to reality, and can be used as a pedagogical tool, bringing innovation, richness, and variety of content that can be used through an interdisciplinary and holistic process (Morin, 2002). The design and development of the paths, the selection of the points of interest, and the questions make it possible to enhance these characteristics. In terms of the research question, the five activities developed within the EduCITY app for the collection of data that shows a positive trend about the features of the app itself and the EduCITY project, specifically in terms of Education for Sustainable Development. By using accessible technology, this app brings citizens closer to the development of smart learning city environments. And, since one of the objectives of EduCITY is to promote Sustainable Development, it can be assumed that this objective is being achieved.The results also demonstrate the importance of educational apps, such as EduCITY, in providing innovation and engagement

in sustainable development learning.

Future work includes the organization and development of several activities with different co-created games involving different partners, such as schools, municipalities, and enterprises. During this phase, data will be systematically collected to gather information to assess whether the EduCITY app can promote changes in citizens to empower them towards sustainable development.

ACKNOWLEDGEMENT

This work is financed by Portuguese funds through FCT – Fundação para a Ciência e a Tecnologia, I.P. within the framework of the EduCITY project "PTDC/CED-EDG/0197/2021". The first author's work is funded by FCT with a research grant (BI/UI57/8275/2022); the second author work is funded by FCT with a research grant (2023.00257.BD); the forth author work is funded FCT under the Scientific Employment Stimulus - Individual Call (2022.02153.CEECIND).

REFERENCES

Creswell, J. W., & Creswell, J. D. (2023). *Research DeCsign: Qualitative, Quantitative, and Mixed Methods Approaches* (6th ed.). SAGE Publications, Inc.

Fatih, Y., Kumalija, J. & Sun, Y. (2018). 'Mobile learning-based gamification in a history learning context', in *14h International Conference Mobile Learning 2018*, Lisboa, pp. 143–147.

Morin, E. (2002). *Os sete saberes para a educação do futuro*. Edições Piaget.

OECD. (2022). *Trends Shaping Education 2022*. OECD Publishing. https://doi.org/10.1787/6ae8771a-en.

Pombo, L. (2022). Exploring the role of mobile game-based apps towards a smart learning city environment – the innovation of EduCITY. *Education and Training*. https://doi.org/10.1108/ET-06-2022-0238

Pombo, L., & Marques, M. (2019). An app that changes mentalities about Mobile Learning – the EduPARK Augmented Reality Activity. *Computers*, *8(2)*(37). https://doi.org/10.3390/computers8020037

Scavarelli, A., Arya, A., & Teather, R. J. (2021). Virtual reality and augmented reality in social learning spaces: a literature review. *Virtual Reality*, *25*, 257–277. https://doi.org/10.1007/s10055-020-00444-8

Schaal, S., & Lude, A. (2015). Using Mobile Devices in Environmental Education and Education for Sustainable Development - Comparing Theory and Practice in a Nation Wide Survey. *Sustainability (Switzerland)*, *7*(8), 10153– 10170. https://doi.org/10.3390/su70810153

Sebastián-López, M., & González, R. de M. (2020). Mobile Learning for Sustainable Development and Environmental Teacher Education. *Sustainability*, *12*(9757), 1–13. https://doi.org/10.3390/su12229757

Sung, Y. T., Chang, K. E., & Liu, T. C. (2016). The effects of integrating mobile devices with teaching and learning on students' learning performance: A meta-analysis and research synthesis. *Computers and Education*, *94*, 252–275. https://doi.org/10.1016/j.compedu.2015.11.008

UN. (2015). *Transforming our world: the 2030 Agenda for Sustainable Development (A/RES/70/1)*. UN General Assembly. https://doi.org/10.1163/15718093-12341375

UNESCO. (2021). *Reimagining Our Futures Together: A New Social Contract for Education.* https://en.unesco.org/futuresofeducation/