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The use of Escape Room as an alternative teaching strategy for sustainable mobility

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Abstract

Gamification and Escape Rooms (ER) are becoming useful tools to encourage attitudinal and behavioural changes and increase learning. In the field of sustainable mobility their use is not widespread and is, in most cases, related to digital games and mobile applications aimed largely at an adult audience. In this study, we explore the potential of this tool to encourage the learning of sustainable mobility concepts in children between the ages of 10 and 13. The experience created, through the resolution of tests and puzzles, has led the 105 students involved to experience, in a playful environment, the formation and learning of sustainable mobility concepts. To measure learning, a pre- and post-experience questionnaire has been provided and the results have been classified with some characteristics of the students such as gender and mobility habits. The analysis of the questionnaire data using multinomial logit models has allowed us to determine which variables affect the probability of answering correctly before and after the experience. In the results obtained we can observe that gender, bicycle use, public transport or the presence of many cars in the family are relevant variables when it comes to having knowledge about mobility issues and that the ER experience has favored a change, although minimal, in the acquisition of sustainable mobility concepts.

Keywords: Sustainable Mobility; Escape Room; Education; Learning; Multinomial Logit.

1. Introduction

The UN Sustainable Development Goals (SDGs) are being referred to more and more frequently in education programs. To integrate, disseminate and consolidate the fundamentals of the SDGs in people, recent years have seen a growing interest in the use of gamification strategies, mostly related to digital games, mobile applications and generally aimed at an adult audience (Poslad et al., 2015; Wells et al., 2014).

Gamification is considered one of the most popular persuasive tools and is becoming a phenomenon that is

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becoming more and more involved in our lives.

Among the different definitions found in the literature we can summarize that gamification uses elements of game design in non-game environments (Larson, 2020) to foster interest, satisfaction and above all to promote behavioral change (Andersson et al., 2018).

Wang et al. (2022) conducted a literature review on the use of gamification in the field of transport and found several topics of interest such as studying traveler behavior, encouraging the use of sustainable modes of travel, promoting safe driving, reducing carbon dioxide emissions and energy consumption. There are some successful examples that leverage gamification to promote sustainable lifestyles in children and parents (Ferron et al., 2019). Although these studies bring new developments to the field, studies on how children disseminate and acquire knowledge on sustainable mobility issues appear to be scarce (Sipone et al., 2021).

Among the many gamification techniques that support, facilitate knowledge acquisition, create engagement and promote positive behaviors, a new approach is gaining increasing interest from researchers: we are talking about the use of the Escape Room (ER) (Bassanelli et al., 2022). In the field of sustainable mobility itsuse and studies are scarce. In this study, we explore the potential of this tool to encourage the learning of sustainable mobility concepts in children between 10 and 13 years old by creating a face-to-face ER with several tests based on sustainable mobility concepts. For this purpose, an initial and final questionnaire has also been created and given to the students before and after the experience. Our aim is to see which factors influence the acquisition of these concepts and whether the ER activity is a good tool for this purpose. After an initial introduction, in the second section we willreview the literature on ER and its applications in education. In section three, we will describe the experience and methodology used. In section four we will analyze the results and finally, in section five we will present the conclusions of our study.

2. State of art

Educational ER represents an innovative teaching technique within the context of gamification(Zoi Karageorgiou, 2019). ERs are action team-based games in which players face challenges to complete a mission in a limited amount of time (Nicholson, 2015). In addition to having become one of the most demanded leisure activities, their potential has led them to make the leap into education and their application provides a new way to engage students in their learning environment (Kinio et al., 2019). Its popularity stems from the fact that it has great potential to enhance student learning through highly engaging experiences and apply to a wide variety of subject areas and educational levels (Fotaris & Mastoras, 2019; Sanchez & Plumettaz-Sieber, 2019).

ER is a form of active learning strategy that transforms the learner from a passive observer to an active participant. According to Brown et al. (2019), ER is a very effective and efficient learning method that allows students to retain and apply the knowledge acquired in class. Moreover, it motivates players to study because it is fun and enhances teamwork.

Educational ERs are developed for a specific target group with well-defined learning objectives. Like recreational ERs, in educational ERs students are faced with solving puzzles, challenges and quizzes linked to curricular content and skills, through a playful approach. Specifically, educational ER relies on the autonomous work of students to solve a real or fictitious problem posed by the teacher (Wynn & Okie, 2017). Students have to find a solution collaboratively, in a process that favours the acquisition of skills and learning outcomes.

Due to its novelty, studies on ER as a tool in the field of education are increasingly evolving. Also, as far as the authors are aware, they are non-existent in research in the field of transport in general and in the learning of sustainable mobility concepts in particular.

The different studies that have been conducted describe experiences in the use of this type of activities in a wide variety of fields: medicine (Guckian et al., 2020), computer networks (Ho, 2018), mathematics (Fuentes-Cabrera et al., 2020) or to support the development of generic skills (Craig et al., 2020). These studies have provided strong experimental evidence that educational ER can produce positive impacts on students' engagement (Jambhekar et al., 2020) and their learning (Huang et al., 2020). There are studies using ER focused on climate change (Ouariachi & Wim, 2020) and sustainability (Ceccarini & Prandi, 2022) with children, but none that discuss sustainable mobility and support learning about its topics with children and adults.

3. Methodology

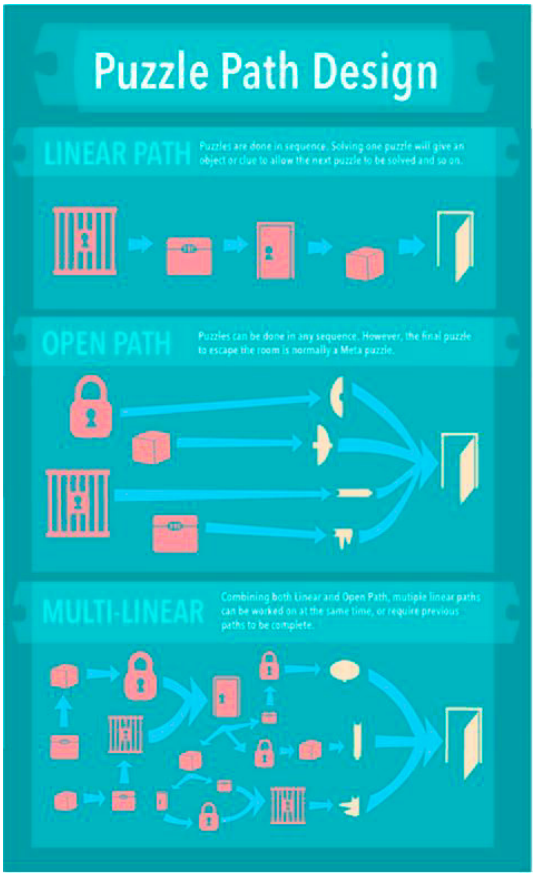
There are different steps to follow when designing an ER. We must remember that an ER has as its main characteristic the resolution of problems, challenges or activities that are generally called puzzles. The way of organizing the puzzles identifies the type of structure that characterizes the ER (Wiemker et al., 2015) (Fig. 1):

a) Open structure: the challenges are not ordered and can be solved in any order the group decides.

b) Sequential structure: the challenges are ordered and a sequence must be followed to reach the set goal.

c) Multilinear structure: it is a combination of the two previous ones, as it introduces challenges that must be done in an orderly manner and others that are not.

Figure 1: Puzzle Path Design created by Wiemker et al. (2015)



Following these indications, our activity was based on a sequential structure with the resolution of five tests contained in the respective envelopes; the students could not open an envelope if they had not solved the previous test beforehand. We used hidden objects and puzzles to simulate the traditional design of an ER.

Important aspects of designing an ER are a narrative that contextualizes the knowledge and skills needed to solve it (Subhash & Cudney, 2018).

We created a story around the test and set up the ER scenario in an empty classroom at the University of Cantabria. The students had to discover, through the tests, the basics to be able to practice sustainable mobility. The tests were designed for students between 10 and 13 years old and focused on five fundamental mobility topics: active mobility; the concept of car sharing for everyday trips and saving space in the city; the basics of the Mobility Pyramid; the difference between sustainable and non-sustainable means of transport; the organization and planning of the spaces in

a city. To solve the tests, the students were divided into heterogeneous groups of 5/6 members. Participants were given 50 minutes to complete the challenge and were initially introduced with a video explaining the scenario and the result they would have to achieve to complete the ER. After presenting the ER, they were given the rules to participate, the final objective was to block a backward counter with the code.

The experience involved 105 students from various schools in the city of Santander between 5th grade of primary and 1st of Obligatory Secondary Education (OSE), and they were given a questionnaire before and after to evaluate the change in knowledge obtained with our activity. The questionnaires are both divided into two parts: the initial questionnaire has 8 characterization questions and 14 questions related to mobility topics, the final questionnaire presents 9 satisfaction questions and the same 14 questions related to mobility topics. From the characterization part of the initial questionnaire proposed before the activity we can analyse different datareferring to: the place where they live; the number of family members; how many cars the family owns; if the children have a bicycle and the reason why they use it: whether it is to play or to go to places or both options. They were also asked whether they use public transport and how often: less than once a week or more.

The mobility topic questions were ranking questions, also known as order and ranking questions, where students were asked, for each topic, to compare three definitions with each other and to rank them according to their degree of knowledge from the most correct to the incorrect one. In this study we will only relate the results of the characterization questions to the results of the initial and final answers on the sustainable mobility topics. To determine whether learning actually took place, a pre- and post-test was applied. The pre-test was administered just before the students participated in the escape game, and the post-test was administered after the debriefing session. The results obtained from the test have subsequently been analyzed to identify the degree of learning using a multinomial logit model (Hensher et al., 2015).

4. Result

The sample was composed of 54% boys and 46% girls. Of the totality, 90% live in the city of Santander and 10% in the surrounding villages. Regarding family members, 45% belong to a 4-person family, 26% to a 3-person family, 18% to a 5-person family, 5% to a 6-person family, 2% to an 8-person family, 4% to other options. In the families 46% have a car, 26% have 2 cars, 21% do not have a car and 7% state that the family has more than two cars. The majority of children own a bicycle, with 68% reporting that they own a bicycle and the remaining 32% not owning a bicycle. Of the children who own a bicycle, 45% say that they use it for playing and 39% for going places, and 22% of them say that they use it both for playing and for going places. Most of them, 67%, also use public transport while 33% say they do not use it. As for the answers on sustainable mobility concepts obtained, table 1 shows how many were correct and how many were incorrect both in the final questionnaire and in the one carried out prior to the activity, considering that in each question the first two in the ranking are consider correct and the last one incorrect.

Table 1: Correct and incorrect answers to the initial and final questionnaire.

	Correct	Incorrect
Indicial Questionary	1131 (77,52%)	328 (22,48%)
Final Questionary	1167 (81,04%)	273 (18,96%)

The data shown show that there is an improvement of around 4% among the students who carry out the activity, although the previously acquired knowledge offers very positive initial results, since around 4 out of 5 individuals know the concepts to be acquired before carrying out the activity. This pattern suggests that in future research the questionnaire should be adapted to make the requirements to be assessed more complicated or to be more specific in the concepts to be included. For the exploitation of results on learning, a model has also been developed using a multinomial logit (MNL) approach, which allows the analysis of multiple categories of the dependent variable and several independent variables collected from the initial questionnaire carried out by the target (car ownership, number of bicycles or gender). In this model, the dependent variable is a categorical variable representing the choice made by an individual, and the independent variables are the attributes of the alternatives that influence the choice.

The MNL model proposed assumes that the utility of each alternative is a linear function of its attributes and a random error term. The formulation of the utility functions for each alternative in this model is for each of the 2 options CC correct (the first two options correctly ranked) and IN incorrect (1) (2):

$$U(CC) = \beta_{ubicis} \cdot UBICIS + \beta_{sex} \cdot SEXO \quad (1)$$
$$U(IN) = in + \beta_{ncoche} \cdot NCOCHE + \beta_{bici} \cdot BICI \quad (2)$$

In modeling the final responses, the following formulation is adopted to represent the utility associated with the responses (3) (4):

$$(CC) = \beta_{ubicis} \cdot UBICIS + \beta_{choicei} \cdot CHOICEI \quad (3)$$
$$U(IN) = in \quad (4)$$

Where:
- UBICIS ∈(0,1): is the variable representing the use or non-use of bicycles for activities.
- UTPV ∈(0,1): represents occasional use of public transport for commuting.
- DOM ∈(0,1): takes the value 1 for city residents and 0 in towns.
- SEX ∈(0,1): takes the value 0 for men and 1 for women.
- IN: is the specific constant for incorrect answers.
- NCOCHE: takes the integer value of the number of vehicles.
- BICYCLE ∈(0,1): takes the value 1 if a bicycle is available and 0 otherwise
- CHOICE: represents whether they answered correctly to the first part of the survey.

The coefficients βbicis, βuptv and βsex βchoice can be estimated using maximum likelihood estimation. The estimated coefficients can be used to determine the effect of bicycle ownership and use, residence or gender on the probability of students choosing good or bad answers after solving the ER tests on sustainable mobility.

Table 2 and table 3 show the results of estimating the parameters of the presented models.

Table 2: Values of initial model coefficients.

	Parameter	Standard Error	z	Prob, z>Z*	95% Confidence Interval	
UBICIS	0,2858	0,0818	3,50	0,0005	0,1255	0,4461
UTPV	0,1915	0,0788	2,43	0,0151	0,0369	0,3460
SEX	0,2978	0,0706	4,22	0,0001	0,1595	0,4361
IN	-0,2284	0,0886	-2,57	0,0100	-0,4019	-0,0545
NCOCHE	0,15409	0,0554	2,78	0,0054	0,0455	0,2625
BICI	-0,1906	0,1019	-1,87	0,0613	-0,3903	0,0091

Table 2 shows the results of the initial questionnaire responses.

The coefficients of the model represent the marginal effect of each variable on the utility of choosing one alternative over the other two, holding the other variables in the model constant. The sign and magnitude of each coefficient indicate the direction and strength of the relationship between each variable and the outcome variable.

Starting with the significant coefficients, the UBICIS coefficient is positive and significant, indicating that cycling in everyday life has a positive impact on prior knowledge of the sustainable mobility issues raised.

Similarly, the coefficient of UTPV is positive and significant, indicating that, like cycling, children who use public transport frequently are more likely to be aware of the positive effects of sustainable mobility.

Finally, the coefficient for the SEX of the participants is positive and significant, indicating that being a girl increases the probability of answering the initial questionnaire correctly compared to the boys who took part in the study.

As for the factors affecting the probability of choosing incorrectly the answers to the initial questionnaire, the coefficient of NCOCHE is positive and significant, suggesting that an increase in the number of vehicles in the household increases the probability of incorrectly completing the questionnaire. Finally, the coefficient of BICI is not statistically significant at the 95% level, indicating that this variable may not have a significant effect, but its sign indicates validation of the initial assumption that owning bicycles reduces the probability of answering the questionnaire incorrectly.

Table 3: Values of final model coefficients

	Parameter	Standard Error	z	Prob, z>Z*	95% Confidence Interval	
UBICIS	0,1440	0,0747	1,93	0,0540	-0,0025	0,2904
CHOICEI	0,6842	0,0782	8,75	0,0000	0,5310	0,8375
IN	-0,1441	0,0483	-2,98	0,0029	-0,2388	-0,0494

As for the results of the model in table 3, the UBICIS coefficient represents the use of bicycles in everyday activities, and its value is positive and statistically significant at a significance level of 5%, suggesting that the more bicycles are used in activities, the greater the probability of responding adequately to the final questionnaire. However, its effect is not very large, as its coefficient is only slightly positive with respect to the other intervening variable.

The variable CHOICEI is a binary variable indicating whether children answered the pre-activity questionnaire correctly, and its coefficient is positive and highly significant at the 1% significance level, suggesting that those who answered correctly previously are more likely to choose the correct option now. Its coefficient is also relatively large, indicating that it has a significant effect on the choice, which allows us to state that participants increase or maintain their knowledge about sustainable mobility after the activity.

5. Conclusion

This article presents a face-to-face ER to increase knowledge and awareness of sustainable mobility. To assess which factors can influence the increase of knowledge, we used a questionnaire administered to 105 students before and after exposure to our ER containing questions related to mobility issues. When analyzing each question, we observed that most of the students answered correctly also before the activity. These results are similar to those obtained in their study on sustainability issues (Ceccarini & Prandi, 2022) with the conclusion that nowadays issues related to sustainable development are widespread. New generations are more informed about sustainability issues and in particular about sustainable mobility.

Overall, our results suggest that initial responses are influenced by a number of factors, such as the gender of participants, their place of residence, bicycle use or ownership, and most significantly by their regular use of public transport modes.

In summary, this model suggests that both the correct choice on a question at the beginning of the survey and the specific parameter of the incorrect part are important in determining the correct completion of the final questionnaire, while cycling in the activities also has a positive effect, but not as large.

Since no previous educational ER experiences in the field of sustainable mobility have been reported in the literature, our analysis of results constitutes a valuable source of information for anyone interested in creating educational escape rooms in this field.

This study can be considered as an initial part of a broader study since, through all the data collected, it is possible to provide further research scenarios. As for the next steps, we plan to continue analyzing the data obtained in this experience to be able to relate more variables to student learning in ER to further test and improve the effectiveness of the method.

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References

Andersson, A., Winslott Hiselius, L., & Adell, E. (2018). Promoting sustainable travel behaviour through the use of smartphone applications: A review and development of a conceptual model. *Travel Behaviour and Society*, *11*, 52–61. https://doi.org/10.1016/j.tbs.2017.12.008

Bassanelli, S., Vasta, N., Bucchiarone, A., & Marconi, A. (2022). Gamification for behavior change: A scientometric review. *Acta Psychologica*, *228*, 103657. https://doi.org/10.1016/j.actpsy.2022.103657

Brown, N., Darby, W., & Coronel, H. (2019). An Escape Room as a Simulation Teaching Strategy. *Clinical Simulation in Nursing*, *30*, 1–6. https://doi.org/10.1016/j.ecns.2019.02.002

Ceccarini, C., & Prandi, C. (2022). EscapeCampus: exploiting a Game-based Learning tool to increase the sustainability knowledge of students. *Conference on Information Technology for Social Good*, 390–396. https://doi.org/10.1145/3524458.3547123

Craig, C., Ngondo, P. S., Devlin, M., & Scharlach, J. (2020). Escaping the routine: Unlocking group intervention. *Communication Teacher*, *34*(1), 14–18. https://doi.org/10.1080/17404622.2019.1593475

Ferron, M., Loria, E., Marconi, A., & Massa, P. (2019). *Play&Go, an Urban Game Promoting Behaviour Change for Sustainable Mobility*.

Fotaris, P., & Mastoras, T. (2019). Escape Rooms for Learning: A Systematic Review. *Proceedings of the 12th European Conference on Game Based Learning*, 30. https://doi.org/10.34190/GBL.19.179

Fuentes-Cabrera, A., Parra-González, M. E., López-Belmonte, J., & Segura-Robles, A. (2020). *mathematics Learning Mathematics with Emerging Methodologies-The Escape Room as a Case Study*. https://doi.org/10.3390/math8091586

Guckian, J., Sridhar, A., & Meggitt, S. J. (2020). Exploring the perspectives of dermatology undergraduates with an escape room game. *Clinical and Experimental Dermatology*, *45*(2), 153–158. https://doi.org/10.1111/ced.14039

Hensher, D. A., Rose, J. M., & Greene, W. H. (2015). Applied Choice Analysis. In *Applied Choice Analysis*. Cambridge University Press. https://doi.org/10.1017/CBO9781316136232

Ho, A. M. (2018). Unlocking Ideas: Using Escape Room Puzzles in a Cryptography Classroom. *PRIMUS*, *28*(9), 835–847. https://doi.org/10.1080/10511970.2018.1453568

Huang, S.-Y., Kuo, Y.-H., & Chen, H.-C. (2020). Applying digital escape rooms infused with science teaching in elementary school: Learning performance, learning motivation, and problem-solving ability. *Thinking Skills and Creativity*, *37*, 100681. https://doi.org/10.1016/j.tsc.2020.100681

Jambhekar, K., Pahls, R. P., & Deloney, L. A. (2020). Benefits of an Escape Room as a Novel Educational Activity for Radiology Residents. *Academic Radiology*, *27*(2), 276–283. https://doi.org/10.1016/j.acra.2019.04.021

Kinio, A. E., Dufresne, L., Brandys, T., & Jetty, P. (2019). Break out of the Classroom: The Use of Escape Rooms as an Alternative Teaching Strategy in Surgical Education. *Journal of Surgical Education*, *76*(1), 134–139. https://doi.org/10.1016/j.jsurg.2018.06.030

Larson, K. (2020). Serious Games and Gamification in the Corporate Training Environment: a Literature Review. *TechTrends*, *64*(2), 319–328. https://doi.org/10.1007/s11528-019-00446-7

Nicholson, S. (2015). *Peeking behind the locked door: A survey of escape room facilities*. Http://Scottnicholson.Com/Pubs/Erfacwhite.Pdf

Ouariachi, T., & Wim, E. J. L. (2020). Escape rooms as tools for climate change education: an exploration of initiatives. *Environmental Education Research*, *26*(8), 1193–1206. https://doi.org/10.1080/13504622.2020.1753659

Poslad, S., Ma, A., Wang, Z., & Mei, H. (2015). Using a Smart City IoT to Incentivise and Target Shifts in Mobility Behaviour—Is It a Piece of Pie? *Sensors (Basel)*, *15*(6), 13069–13096. https://doi.org/10.3390/S150613069

Sanchez, E., & Plumettaz-Sieber, M. (2019). *Teaching and Learning with Escape Games from Debriefing to*

Institutionalization of Knowledge (pp. 242–253). https://doi.org/10.1007/978-3-030-11548-7_23

Sipone, S., Abella-García, V., Rojo, M., & Dell'olio, L. (2021). Using ClassCraft to Improve Primary School Students' Knowledge and Interest in Sustainable Mobility. *Sustainability 2021, Vol. 13, Page 9939*, *13*(17), 9939. https://doi.org/10.3390/SU13179939

Subhash, S., & Cudney, E. A. (2018). Gamified learning in higher education: A systematic review of the literature. *Computers in Human Behavior*, *87*, 192–206. https://doi.org/10.1016/j.chb.2018.05.028

Wang, W., Gan, H., Wang, X., Lu, H., & Huang, Y. (2022). Initiatives and challenges in using gamification in transportation: a systematic mapping. *European Transport Research Review*, *14*(1), 41. https://doi.org/10.1186/s12544-022-00567-w

Wells, S., Kotkanen, H., Schlafli, M., Gabrielli, S., Masthoff, J., Jylhä, A., & Forbes, P. (2014). Towards an Applied Gamification Model for Tracking, Managing, & Encouraging Sustainable Travel Behaviours. *ICST Transactions on Ambient Systems*, *1*(4), e2. https://doi.org/10.4108/amsys.1.4.e2

Wiemker, M., Elumir, E., & Clare, A. (2015). *Escape Room Games: "Can you transform an unpleasant situation into a pleasant one?"* http://scottnicholson.com/pubs/erfacwhite.pdf

Wynn, C. T., & Okie, W. (2017). Problem-Based Learning and the Training of Secondary Social Studies Teachers: A Case Study of Candidate Perceptions during their Field Experience. *International Journal for the Scholarship of Teaching and Learning*, *11*(2). https://doi.org/10.20429/ijsotl.2017.110216

Zoi Karageorgiou, E. M. and P. F. (2019). Escape Room Design as a Game-Based Learning Process for STEAM Education. *Proceedings of the 12th European Conference on Game Based Learning*, 46. https://doi.org/10.34190/GBL.19.190