Digital Escape Games in Educational Programs for Financial Literacy

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Abstract: Escape from the Castle is a digital escape game created with the collaboration of the Museum of Saving in Turin (Italy), Neuroscience Lab Intesa Sanpaolo Innovation Center, and the GAME Science Research Center of IMT School for Advanced Studies Lucca. In the escape game, players must help Mica, the mascot of the Museum, to run away from the Ghost of the Baroness, from its Castle. To do that, every player has to solve four puzzles in four different rooms. Each room is correlated to a financial issue, such as saving strategies and planning. The game aims to increase the awareness that money represents a means for achieving a purpose (i.e., use value of money) and not an end, from a behavioural and neuroscientific point of view. So we built a study about the behaviour of teenagers. According to the literature, the cooperative approach proposes emotional and cognitive involvement as a tool to strengthen learning, increases awareness of self-efficacy and, when applied to money management, increases the self-perception of being able to make consumption choices. To better understand the mechanisms of cooperation, we built an experiment with 118 students from eleven to fourteen years old, that played the game during a visit to the Museum. We divided students into two groups: one in which students could collaborate with each other in solving the puzzles (treatment) and one in which they had to play individually (control), and we collected score and time of play (behavioural data). In each group, two students wore eye-trackers to record pupil dilation to collect neurophysiological data. Here we present mainly the behavioural results that show that the students who were allowed to collaborate obtained, on average, double the score compared to those who played individually. Furthermore, those who collaborated finished the game in less time than those who have not played as a group. Moreover, combining behavioural data with neurophysiological data, there are indications that high pupil dilation is correlated with high engagement in play, and this is often true in collaborating groups.

Keywords: escape games, museum studies, financial literacy, collaboration, learning, game-based learning

1. Introduction

Escape from the Castle is a digital escape game created with the collaboration of the Museum of Saving in Turin (Italy), Neuroscience Lab Intesa Sanpaolo Innovation Center, and the GAME Science Research Center of IMT School for Advanced Studies Lucca. The possibility to promote financial literacy using games has been extensively investigated (Paeßens & Winther 2021), also highlighting numerous attempts applying games (Richards et al. 2015) that try to bridge the financial literacy gap by using games and video games in teenagers and youngsters (Rasco et al. 2020).

Financial literacy could have a great boost through play or gamification, especially for lifelong learning. The game pushes towards autonomy, an increase in motivation, and improving support structures to ensure that lifelong learning and decision-making are managed effectively through an evolving system (Rasco et al. 2021).

Another aspect is what concerns the use of escape games. In recent years, escape games have also been investigated as tools for game-based learning (Fotaris & Mastoras 2019), with many examples of escape games for education (Veldkamp et al. 2020), including digital ones (Makri et al. 2021).

There are various fields in which educational escape games are used, including computer science at university level (Borrego et al. 2017), food education (Yachin & Barak 2019), just to give some examples, and more generally all STEAM disciplines (Karageorgiou et al. 2019), while there are just few examples of escape game used for economic arguments (Martina & Göksen 2020).

In the case of *Escape from the Castle*, we have not only designed a game, but also a research tool, as well as an interactive location inside the Museum of Saving in Turin, Italy. With *Escape from the Castle* we ran a neuroscientific and behavioural experiment about behaviours related to money saving and the role of collaboration in learning, in teenagers. According to the existing literature (Bandura, 1997), the cooperative approach proposes emotional and cognitive involvement as a tool to strengthen learning and favours the development of social skills in interactions between peers. For teenagers, these skills can help to build problem-solving abilities. A cooperative approach increases awareness of one's skills / abilities (self-efficacy) and, when applied to money management, can increase the self-perception of being able to make consumption choices effectively to be able to achieve one's own goals (about self-effectiveness, Tsang et al. 2012). In conditions of uncertainty, individuals with greater awareness of their abilities are more likely to reduce impulsive or impatient behaviours that, in general, make it more difficult to carry out personal projects related to savings and investment. In other words, a high level of financial self-efficacy favours intertemporal choices (between now and tomorrow) that are more reflected and, usually, more favourable in terms of economic output.

In this study we have run an experiment, through a neuroscientific approach, to understand if learning by solving problems with an escape game in a cooperative setting is better than in an individual setting, particularly in regard of financial literacy.

1.1 Design of the educational escape game

Escape from the Castle is a digital escape game developed by the research team that aims to increase financial self-efficacy in teenagers through collaboration between peers. In a more general sense, the game aims to increase the awareness that money represents a means for achieving a purpose (i.e., use value of money) and not an end, from a behavioural and neuroscientific point of view.

Escape from the Castle has a mediaeval setting, designed to engage participants with a series of puzzles and riddles that require the use of creative and logical thinking to solve them.

In the game, players have to help Mica, the Museum's mascot, to escape from the Ghost of the Baroness' Castle. To do that, each player has to solve four puzzles distributed in four different rooms of the castle. Each room is correlated to a financial issue, such as saving strategies and planning; for example the puzzle in the Library is correlated with savings planning.

The castle is divided into the following rooms: the lobby, the kitchen, the lounge area, and the library. Each room is associated with a different riddle correlated with different financial topics, such as saving strategies and planning. The lobby room contains a text comprehension connected with financial topics. Participants have to fill white spaces with the missing letters and understand the meaning of the text. In the kitchen, participants are presented with a recipe book and a series of ingredients; given the scarcity of resources, they have to choose the cheapest ingredients to cook one of the receipts written in the book. Participants receive a series of furniture used to renovate the room in the lounge area. The total cost of the furniture is too high, and players have to choose which elements to remove to be within the budget. Lastly, in the library, players have to put in the correct order a series of books. Each book contains a specific phase of saving planning.

Once logged in the game, players enter the lobby and have to solve the first riddle. After that, participants can decide, without a specific path, which of the other three rooms they want to enter. Once entered into the room, they can exit and re-enter as many times as they wish. In each room, once you have solved a puzzle, you get an object and victory points to add to the gaming score. Moreover, they have the possibility to ask up to two clues for each room, knowing that asking for a clue halves total points for that specific room. Also, succeeding to finish the game in 15 minutes grants extra points on top of the accumulated ones. Players are allowed to solve all the riddles in a maximum of 20 minutes.

The game was first designed between May and September 2020 and developed between October and December 2020. The game was playtested with teenagers of the same age as the target of the game, from 11 to 14 years old.

2. Research methods

The study was conducted at the Museum of Saving in Turin, Italy, an interactive museum that explores aspects and concepts related to the issues of saving, money and investment. Intervention materials were designed by the GAME Science Research Center partners, which comprises researchers and developers from the IMT School for Advanced Studies Lucca in collaboration with Neuroscience Lab Intesa Sanpaolo Innovation Center.

The project involved two secondary middle-schools and their students, aged between 11-14 years old. Each player was identified with an alpha-numeric code that guarantees the anonymity of the collected gaming data and makes it possible to connect them with data from the questionnaires. Six secondary classes from the middle-schools in Turin were recruited based on teacher interest. All participants were randomly allocated, within their classes, to one of the two experimental conditions. Students were accompanied to the museum by the teachers. Background questionnaires were administered in each school one month before the intervention in the museum, precisely in February 2021. The questionnaire was designed to cover different topics: ludic habits, propensity to collaborate in groups, and financial literacy. It also served the purpose to collect demographic and scholastic information, such as age, gender, and average mark.

The parents of students involved signed an informed consent form, with the specific consent for the possibility to link students' answers to their scores in the program. The study was reviewed and approved by the local IRB.

2.1 Experimental conditions

Figure 1: Materials used during the experimental sessions at the museum.

The six classes participating in the experiment visited the Museum during three days of May, namely the 4th, the 5th, and the 6th. Each class arrived at the museum at a different time, and the visit lasted 2 hours. Once arrived, each class was divided into three groups of eight, which participated separately at three experimental sessions, each lasting 40 minutes. When called for the experimental session, students of each group were randomly divided into two experimental conditions: the individual (control group) and the cooperative (treatment group) condition. The two groups were physically and acoustically separated in two different rooms in the Museum. The two rooms were cautiously set to have a similar level of brightness. In the control group, students were seated far apart from each other, and they were not allowed to communicate between them. On the contrary, in the treatment condition, students were seated in front of each other and were allowed to communicate without any limitation. These rules were part of the experimental instructions that were read aloud by the experimenters in each of the two conditions' rooms. Participants could ask clarification questions before starting playing to ensure complete comprehension. In both settings, each student received an iPad with the escape game application already opened and ready to start the game. Two students in each condition were randomly selected to receive an eye-tracker to record pupil dilation data. Experimenters supervised for the entire time the two groups, without intervening but available in case of technical problems.

In the meanwhile, for each class, the remaining two groups of eight visited the museum, until they were called by the experimenters to start their session. Students of the same class belonging to different groups were unable to interact during the visit to avoid pollution of the experimental sessions by any kind of anticipation.

The ad-hoc design of the videogame allowed us to collect experimental data on its use, i.e. score and time. Both scores and times were available as a total for the whole game, and as partial values attached to each riddle. Overall, during the experimentation at the Museum, we thus collected behavioural data from the videogame, as score and time of play, and neurophysiological data through the eye-trackers.

2.2 The gamified retention phase

After the experimentation at the museum, students were again allowed to play the escape game online by accessing a dedicated reserved area on the Museum's website. They received instructions on how to play the online version at the end of the experimental session at the museum. The online game was playable at any time without limits during a four weeks period that ended at the beginning of June 2021. These four weeks represent a retention phase, where students could reinforce their learning through repetition by voluntarily engaging in further sessions of the game. The online version of the game was slightly different from the one played at the museum. It contained the same environments but riddles inside each room were different to stimulate thinking abilities and thus keeping the game challenging. Each riddle was designed in up to three different versions. When starting a new game, for each room, one out of the three possible riddles were randomly selected by the software. Our experimental design for the retention phase consists in having two different approaches between the two schools to investigate the effect of gamification on young students' engagement and learning. In one of the two schools, students were informed that when playing during the retention phase, the leaderboard would have been updated weekly with the points accumulated in the online games, thus potentially changing the ranking. Moreover, they were informed that, at the end of the four weeks, the final ranking would have determined a podium with the winner, second and third place, and that qualifying at these positions would have granted a special recognition by a symbolic prize. On the opposite, students from the other school were given no prize and no ranking information at the end of the gaming period. Their leaderboard was thus not updated weekly and the only ranking they were able to check was that obtained during the experimentation at the museum. This experimental setting allowed us to investigate and test the role of incentive schemes provided by gamified systems when voluntarily playing an educational game.

3. Results

A total of 118 students are enrolled in the project. The average age of the sample is 12.4 (SD 0.92) and 45% are females. Summary statistics by treatment and control groups show that the two groups are well balanced in both age (Z=-0.625, p-value=0.532) and gender (Fisher's exact test, p =.467) composition. Moreover, as shown in Table 1, no statistically significant differences are found between groups regarding average marks received at the end of the last scholar year, previous escape game experience and how much they play video games, suggesting that random assignment to the treatment group produced balanced samples.

Table 1: Average difference of control and treatment groups in the background questionnaire

Variable	Control	Treatment	Min	Max	T-C Diff. *p*-value
Age	12.40 (0.92)	12.48 (0.88)	11	14	0.532
Female	0.45 (0.50)	.52 (0.50)	0	1	0.467
Av. Mark	7.21 (0.97)	7.16 (0.97)	5	9	0.946
Escape Games	2.21 (1.33)	1.86 (0.95)	1	5	0.297

Variable	Control	Treatment	Min	Max	T-C Diff. *p*-value
Video Games	3.21 (1.48)	2.80 (1.24)	1	5	0.139

Note: Age is the students' age. Female is equal to 1 if female, 0 otherwise. *Av. Mark* is the average mark students obtained at the end of the past scholar year. *Escape Games* is a 1-5 Likert scale from "*Never*" to "*A lot*" on how much students play escape games. *Video Games* is a 1-5 Likert scale from "*Never*" to "*A lot*" on how much students play video games.

Figure 2 shows the average score obtained by participants (left chart) and the average time, in minutes, spent to complete the game (right chart). Looking at the average score obtained by participants in the control group, it is around 25 points, against the 43 points obtained, on average, in the treatment group. The Mann-Whitney test rejects the null-hypothesis that the difference in the average score between control and treatment groups is equal (Z= -4.710, p <.001). On average, the treatment group obtains around the double score reached by the control group. Looking, instead, at the average time each participant takes to complete the game, we find that, on average, participants finished the game in around 19.4 minutes in the control group while, in the treatment group, they were able to finish it 1 minute earlier, around 18.5 minutes. However, this difference in time is not statistically significant (Z= 0.758, p=.448).

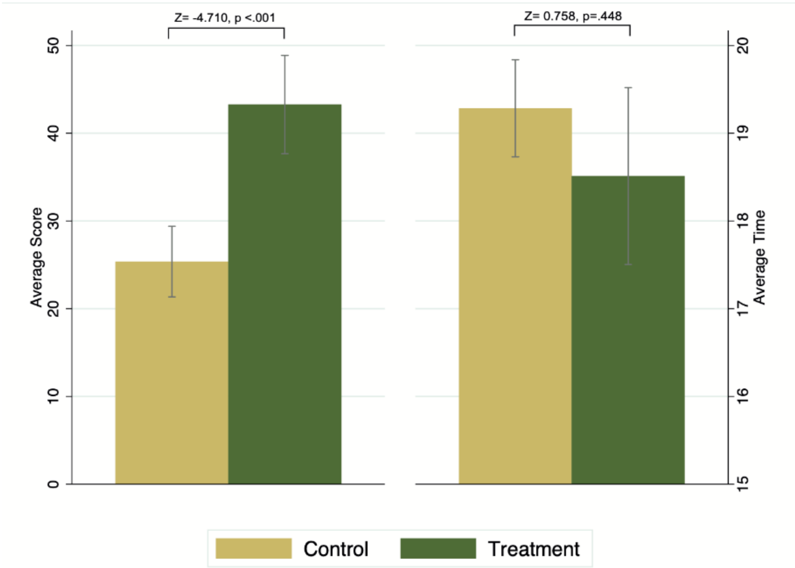

Figure 2: Average score obtained by players (left chart) and average time in minutes for completing the game (right chart) in the control and treatment groups

It might be interesting to understand if the effect on the final score is given by a specific score reached in one or more riddles of the game or if the score obtained in some riddles, depending on the difficulty, were not so different. Figure 3 shows the average score obtained in each room divided by treatment groups. As shown in the figure, no difference is found in the lounge area riddle (Z= -1.051, p=.403). On the other hand, statistically significant differences are found in the lobby (Z= -3.225, p<.001), in the kitchen (Z= -4.783, p<.001) and in the library (Z= -3.539, p<.001). These findings suggest that, depending on the difficulty of the riddles, cooperation sometimes works better than individual activities, other times same results can be achieved also without cooperation.

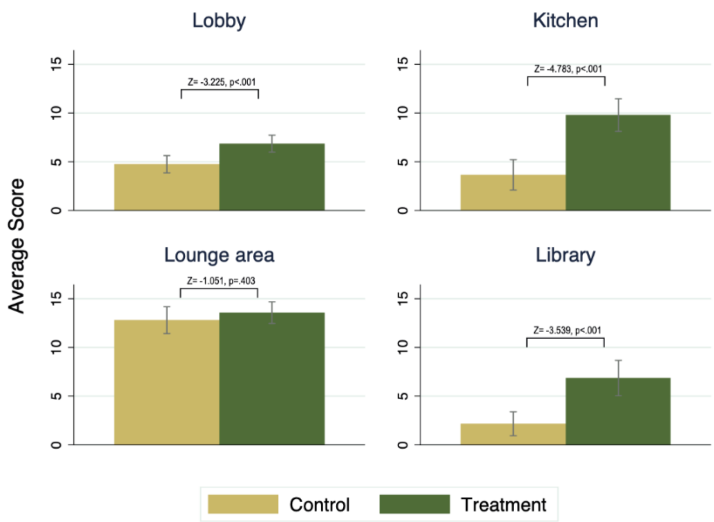

Figure 3: Average score obtained by players in the control and treatment groups by rooms

Finally, only 40% of the participants in the treatment group were able to conclude the escape game within the limited time, meaning that completing the entire game was not so easy. On the other hand, looking at the percentage of students in the control group who escaped from the castle, only 15% of them reached the end.

3.1 The retention phase results

Based on the data collected during the retention phase, only 20 students out of 118 played the escape game during the four weeks after the visit to the museum. Among these 20 students, 18 belong to the incentivized setting (treatment group) and only 2 are from the school without incentives (control group). The total number of sessions of the game played by the treatment group is 154 against the 3 sessions played by the students in the control group, suggesting that the role of incentive schemes provided by gamified systems worked properly.

At this point, one might wonder whether playing the game more times increases the final score obtained by students, which is in line with the results found by Erhel & Jamet (2013). In their experiment, they show that giving feedback after each game, participants performed better on comprehension, underlining the role of feedback on triggering deep cognitive processes that contribute to better learning (Sweller et al., 1998).

Figure 4 shows the average score obtained by students on the sessions played online. Given that most of the 20 students played at least 2 games, but only few played more than 3 times, we averaged the final score of the games after the 2 in only one score (third column of the chart). The Kruskall-Wallis test rejects the hypothesis that the average score in the sessions played during the retention phase are equally distributed ($X2= 9.323$, $p=0.009$). Looking at the difference between the first and the second session played, the Mann-Whitney test confirms that the average score significantly increases by around 20 points ($Z=-2.647$, $p=.007$). This suggests the efficacy of the learning-by-doing approach and an increase in the knowledge about the game and the financial aspects presented in the game.

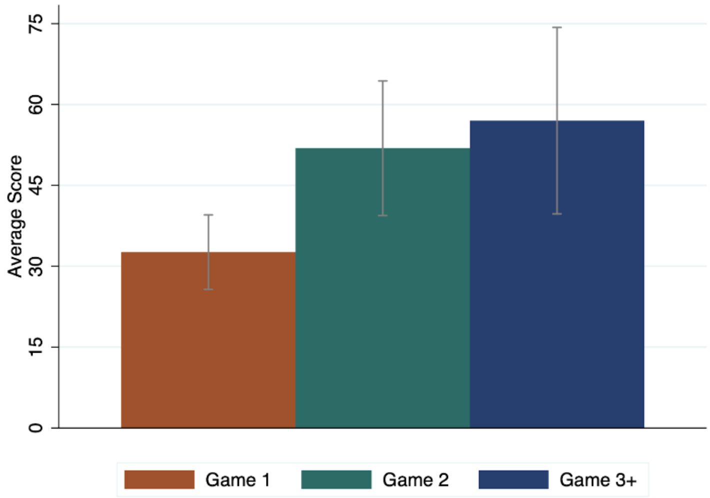

Figure 4: Average score obtained by players during the retention phase in the first (Game 1), second (Game 2), and following (Game 3+) sessions of the game played

4. Discussion

The data collected indicate that collaboration increases the performance in the game, both in terms of the score and in terms of the resolution time of Escape from the Castle; indeed groups that collaborate finished the game with higher scores on average and faster than those who play alone.

Results confirm the important role of collaboration in the process of using a game, in problem solving, and also in the learning process. These was also underlined by other studies (for example Troussas et al., 2020; Hämäläinen et al., 2006; Zhang, Q., & Yu, Z., 2021), which highlighted how effective construction of game tools is essential for developing collaborative learning (Hämäläinen et al. 2008). Precisely in the case of Escape from the Castle, the data reveal how the tool works better with a collaborative approach to the game, rather than playing alone, at least during the first game session and within a museum environment, i.e. when the possibility of repetition is very limited. The second phase of experimentation, concerning gamification, has highlighted instead that repeating the game several times (even with randomized and never the same puzzles), allowed individuals, playing alone, in achieving excellent results.

Numerous ideas can be made to explain why collaborative groups had higher scores. The exchange of ideas and therefore the conversation is one of the factors that could make the most difference and this would seem to be confirmed by observing the game groups. Escape from the Castle is comparable in many aspects and within our experimentation to an interactive museum location. It is therefore clear that it follows the same directives, especially with regard to informal learning, as well highlighted in the literature (Hein, 2002; Falk & Dierking, 2016) with numerous examples of projects (Solima, 2018; Rowe et al., 2017; Cesário et al., 2017). In the case of informal learning, conversations between participants usually allow information to be rebounded and a common solution to be reached together, which is not possible alone. The resolution of the puzzles is also closely linked to financial content; therefore, it is presumed that learning is better in the collaborating subjects, both for a greater exchange of information and for a better gaming experience. The escape game was chosen precisely to evaluate this aspect: understanding how to solve puzzles (and therefore the content, closely linked to the puzzles) is a difficult solo test.

Secondly, the gamification experiment. Even if the students who participated were not many, the game sessions were numerous, especially in the school with incentives. This underlines how important it is to think carefully about all the elements of gamification in order to help a learning process (Sailer & Homner, 2020). The interesting element is that with each new game session the score increased on average and the resolution time decreased on average, this also considering that the puzzles were randomized at each new game session. This seems to indicate that with each subsequent game there was a better understanding of the game and therefore indirectly a learning of the contents of the game.

Finally, the neurophysiological data collected with the use of eye-trackers is very interesting, but extremely difficult to analyze. Preliminary results seem to indicate that those with greater pupil dilation also achieved higher scores. Additionally, there appears to be a significant difference between pupil dilation in the first half of the play session and in the second half. These data could indicate a greater involvement in collaborative groups compared to solitary players, who failing to solve the puzzles independently, gradually deconcentrated, losing motivation and engagement. Unfortunately, the neurophysiological data are not easy to read. The real difficulty was collecting clean data in an experimental setting, the museum, which was very difficult to standardize. Furthermore, the short time available did not help to collect clear data right away. Precisely for this reason it was decided to continue the experimentation and try to go deeper using EEG (Electroencephalography) to better understand what happens during the game session, using a laboratory setting that is much easier to standardize.

5. Conclusion

Escape from the Castle is now a multimedia exhibit in the Museum of Saving in Turin, as well as an app that can be downloaded from the iOS and Android stores. This game is an example of how careful design can allow you to create a useful tool in a museum to build engagement with visitors and at the same time a useful tool for scientific research related to learning and behaviour. If on the one hand the multimedia exhibit is finished, on the other hand, scientific research will not be closed yet. The project plans to collect behavioural data on cooperation trying to further expand and diversify the sample, following the example of other virtuous projects (Bilancini et al. 2021), involving schools other than the initial ones. Unfortunately, Covid-19 has made it very difficult to collect data within a museum, but the end of the health emergency can help research, easing the imposed limitations and allowing the sample to be enlarged. For this reason, the experimentation will continue by repeating a data collection in some schools near Lucca, Italy. The power of collaboration, which Escape from the Castle promotes, needs to be further investigated in order to have bigger and more solid samples and to analyze the issue even more in detail. Many aspects of the game can be interesting ideas to reflect on; for example, careful game design can help improve collaborative skills (Brandt & Messeter, 2004) or push to learning and training about skills related to problem solving and collaboration (Sánchez & Olivares, 2011). Language, conversation during play and how it is addressed seem to be determining factors in encouraging learning through play (van der Meij et al. 2011). The same thing happens in a very similar way in museums with regards to learning related to exhibits (an example of conversation for learning in Haden, 2010), underlining how there is a strong parallelism about informal learning between games and museum locations.

Another fundamental aspect to be explored is that relating to the increasing engagement as a conduct for learning. In particular, finding a quantitative signal that can indicate from both a behavioural and neuroscientific point of view when and how a subject is more focused on an educational activity then will allow to build a series of design elements capable of pushing learning more effectively.

Precisely to this, it is also important to continue experimentation on the neuroscientific side. Unfortunately, Covid-19 has strongly limited this part of the research and therefore a neuroscientific experimentation will also be carried out on young adults with other neuroscientific investigation tools such as EEG to go into more and more detail.

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