

01 **A night in the museum:** A museum exhibition that turns into an escape room by night

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ABSTRACT

Escape room games are a genre of physical games that has gained popularity in formal (schools and universities) and informal (museums) educational settings. In this paper we evaluate an innovative model of creating an escape room as part of an existing exhibition which in a way offers a refreshed curatorship of an existing exhibition.

The context is a small Natural History museum in Israel that commissioned the authors to create two escape games within the exhibition space. Each was built into the existing exhibition without affecting its function during the day. So the exhibition space functions as a museum by day and an escape room by night. The transformation was designed so that museum guides could easily with a few actions (such as opening hidden doors and engaging electromagnets) transform one into the other.

In this paper we focus on whether the model can attract new audiences, what educational experience this model offers visitors and dig into visitors' perceptions of the different game elements. Data were collected from visiting groups (108 players in 35 groups) and from gamemasters' observations (32 groups) using an online questionnaires.

Findings indicate that the model has indeed attracted new audiences to the museum and that this model affords an escape game experience not unlike ones reported in the literature. A deeper look into the different puzzles indicates that players enjoy hands-on puzzles that are also intellectually challenging. The puzzle that was most favoured was an experiment which includes both these attributes. A comparison of the visitor and gamemaster questionnaires seems to indicate that both perceive the gamemasters' levels of involvement differently, suggesting the importance of training the gamemasters.

KEYWORDS

Escape games, Museum education, Curation, Museum games, Visitor experience, Informal Learning

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1. Introduction

- 1 Escape room games are a genre of physical (aka as non-virtual or analogue) games that have gained huge popularity in recent years as a pastime experience. With their rise in popularity, escape games have made their way into more and more educational settings, both formal (s.a. schools and universities) and informal (s.a. museums). Within informal educational settings there are a number of accounts of escape games being used in museums for example as an educational activity in the museum classroom (Cambre, 2024) or in a specially designated room (Csopa Science Center, n.d.; Duff, 2019). In these accounts the escape game either occurs outside the existing exhibition space or only utilises part of the exhibition. In this paper we investigate an innovative model in which an entire existing exhibition becomes an escape game. We investigate two cases of escape games that were installed within an exhibition. In this model, the space functions as a 'regular' museum during the day. At night, with suitable adaptations the space becomes an escape game – Hence “A night in the museum”.
- 2 We take the point of view of a game as an alternative angle for curatorship. In essence, when a museum exhibition is constructed, it is constructed for a certain audience in a certain time and a certain Zeitgeist. After a decade, can a game be used to provide an alternative curatorship to an existing exhibition? To address this issue, we conducted an evaluative study of an escape game in a museum exhibition space and ask the following questions:
 - 1) Can an escape game embedded in a museum exhibition attract new audiences to the museum?
 - 2) What educational experience can an escape game embedded in a museum provide visitors?
 - 3) What are visitors' perceptions of the different game elements?

2. Literature review

2.1. Escape games

- 3 Escape room games are collaborative activities where players work together to solve a series of puzzles within a room to complete a mission and escape within a set time limit (Nicholson, 2015; Veldkamp et al., 2020). These games have their roots in various popular genres, including role-playing games like Dungeons & Dragons, digital games, treasure hunts, interactive theatre and TV adventure shows such as Survivor (Nicholson, 2015). Unlike many other games where players control an avatar or game piece,

escape room games are live action games in which players act as themselves, which enhances the immersive experience (Nicholson & Cable, 2021). This immersion is a key feature of escape room games (Veldkamp et al., 2020).

- 4 Escape room games are inherently social, as they are always played in groups. The social dynamics, including who you play with, significantly shape the overall experience. The games feature intellectually challenging puzzles that are designed to be difficult enough to be engaging but not so hard as to be frustrating, fostering a sense of fun and accomplishment (Vidergor, 2021). Additionally, elements of luck, such as finding hidden objects, add to the serendipitous and immersive nature of the game.
- 5 It is important to highlight that the characteristics described above pertain to so-called ‘recreational’ escape room games, which are physical, commercial entities available in numerous locations globally (Veldkamp et al., 2020). The genre has since evolved, resulting in various spin-offs that retain some original features while altering others. For instance, there are numerous digital escape games that can be played individually, such as the ‘Room’ series by Fireproof Games (n.d.). Additionally, there are board games inspired by the escape room concept, such as ‘Race to Escape’, and escape games designed for outdoor play (Peleg et al., 2024). Given the genre’s versatility and the fact that many games do not require a physical room, we will refer to these as *escape games* rather than *escape room games*.

2.2. Escape games in informal education and museum

- 6 Building on to their popularity, the escape game genre has found its way into educational settings, with numerous accounts of their use in this context. In a systematic literature review on educational escape room games, Veldkamp and colleagues (2020) examined 39 academic papers. They discovered that most escape rooms were developed for formal education, predominantly focusing on medical or STEM education, with only three cases aimed at informal learning environments. Most educational escape games aimed to combine content knowledge goals with related skills.
- 7 Within informal settings such as museums, various models of escape game usage have been reported. Some museums incorporate escape room games in rooms outside their exhibition spaces to attract new audiences (Csopa Science Center, n.d.; Duff, 2018, 2019). These would be escape games that occur in a specially designed space (say an unused classroom/exhibition space) and would look very similar to recreational escape games. In other words, the whole space is designed with the intention of being an escape game.

- 8 A second model of escape games in museums is deploying a mobile escape game kit in the museum classroom. These would be temporary installations that are easily deployed and packed up to allow the classroom to be used for other purposes. An example for that is an escape game on chemistry is run by LATU in Uruguay (Cambre, 2024; Ministerio de Educación y Cultura, 2022) based on a previous escape room kit that was designed to run in school classrooms (Peleg et al., 2019).
- 9 A third model includes using digital tools to create an escape game experience. For example Antoniou and colleagues (2019) created a digital online escape game for visitors to get acquainted with the exhibition prior to visiting. Baas and colleagues (2019) created a VR escape game experience to allow sighted people to understand what visual impairment feels like.
- 10 A fourth model which we are investigating in this paper involves turning museum exhibitions into an escape game. In essence we are suggesting that the museum exhibition and the escape room share the same space. A similar approach was adopted by Back et al. (2019) who designed an exhibition which could be played as an escape game. Their evaluation showed that visitors saw the experience in a positive light, that there was evidence of learning through the experience and that designing an escape game as part of the exhibition meant that visitors spent more time in the exhibition than they normally would.

2.3. Research on escape games

- 11 Research in the field of educational escape games is still in its infancy, with many of the reported escape games in the literature being case studies that were “driven by educational practitioners who copied and adapted recreational ERs” (Veldkamp et al., 2020, p. 2). These case studies often lack theoretical and empirical rigor. However, recent efforts have been made to establish a research foundation for educational escape games. Veldkamp and colleagues (2021) used a mixed-methods approach, including online questionnaires, interviews, classroom observations, and student-made movie clips, to investigate teachers’ and students’ perceptions of an educational escape game. Both teachers and students noted the diversity of activities and the opportunities for developing teamwork and other skills. They also found escape rooms suitable for processing, rehearsing, and formative assessment of science knowledge and skills. Additionally, students reported feelings of autonomy and mastery during the game.
- 12 In an evaluation of an educational chemistry escape game, (Peleg et al., 2019) evaluated aspects of escape games that are normally used to characterize escape games in the lit-

erature including learning outcomes, teamwork and the concept of flow. Flow is a psychological state where an individual becomes completely absorbed and immersed in an activity (Csikszentmihalyi, 1988; Csikszentmihalyi & Hermanson, 2001). This state is characterized by high intrinsic motivation, making it an optimal environment for personal development and learning and can be monitored by asking for participants' perception of time flow.

- 13 To provide more theory-based design processes for educational escape games, Yachin and Barak (2024) applied situated learning theory to analyze the experiences of teachers and game design experts. They identified four components of situated learning: authentic situations, scientific content, collaborative learning, and self-reflection. These insights were used to develop a methodology for designing escape games.

3. Context

- 14 Man and the Living World, a small Natural History museum in Ramat Gan, Israel, has several exhibitions about zoology, ecology, genetics and palaeontology. It caters for around 30,000 visitors a year, most of whom consist of school groups visiting the museum during the day. These exhibitions, which have been on display for over a decade, successfully cater mainly for visiting elementary school groups. In an attempt to attract audiences that normally do not attend the museum, we (RP and YB) were commissioned by the museum to construct an escape game related to the museums' themes. After discussions with the museum management, curator and board, it was decided that the new escape game will not be in a classroom or a separate room, but rather it will be in the actual exhibition space, affording a fresh perspective of the exhibition.
- 15 The solution was to add a new layer of experience to the exhibitions in the museum by "converting" them into two escape rooms, one concentrating on the prehistoric man exhibition, and the other concentrating on the anatomy and dinosaur exhibits. In a way the escape game offers a new focused curatorship on the existing exhibition. This was done after carefully distilling the exhibitions educational goals into 'big scientific ideas' that can be conveyed in the exhibition. The operating model is such that after museum hours the exhibition quickly converts into the two escape rooms which required pre-booking of the games. After the last game the exhibitions are returned to the 'museum' state ready for the next day operation of the museum with minimal interference. This was done by designing puzzles that are based on the existing exhibitions, puzzles that blend in with the exhibitions or puzzles that quickly fold away.

- 16 The games were designed with groups of adults or family groups in mind. Both escape games were piloted a number of times in an iterative process before the final version was commissioned and built into the exhibition. The general aims of both games were to:
1. Attract new audiences and expand public familiarity with the museum and its diverse content.
 2. Provide a valuable space for meaningful and challenging cultural experiences.
 3. Bring science closer to the public in an enjoyable and engaging manner.
 4. Create an innovative format that integrates the museum genre with the escape room genre, thus introducing elements of popular culture into the museum setting
 5. Develop a new edutainment format where the entire museum is transformed into a real escape room.
- 17 During each game run there was at least one ‘gamemaster’ in the control room who would oversee the running of the game. Gamemasters were specially trained museum guides who would monitor progress from a control room equipped with audio and video devices allowing monitoring of the players. There was also access to a control panel that linked to some of the puzzles allowing the gamemaster to operate some of the puzzles remotely. As with most escape room games, gamemasters were asked not to intervene unless asked a specific question by the players or if they saw that the players were stuck for too long on one puzzle.

The resulting escape games are described in detail below.

3.1 Return of Prehistoric Man

- 18 This game consisted of eleven puzzles around the “prehistoric man” exhibition which focuses on the evolution of humans from earlier species. In addition to the general aims above this game also aimed to highlight that in the past there were numerous species of humans existed, each with its own set of skills (such as y, mastering fire, taming animals).
- 19 The background story centres on a museum worker who secretly conducted scientific experiments within the museum:

Tens of thousands of years ago, two species of “man” lived on the earth at the same time: Homo sapiens and Neanderthals.

Despite the Neanderthals being very robust and having a developed brain similar to that of humans, they disappeared from the face of the earth.

The truth is that the researchers are not yet clear whether the Homo sapiens exterminated the Neanderthals, assimilated the Neanderthals into them, or the Neanderthals became

extinct independently of the Homo sapiens. It turns out that a part of the today's population has genes belonging to the Neanderthal species.

Methuselah Avni has been working at the museum for many years.

During these years he expressed great interest and researched the extinction of the Neanderthals, for some reason he decided that he had a higher than normal percentage of Neanderthal DNA. As such, he decided that his mission on earth is to avenge the defeat of his ancestors, and to take control of modern man, who is a descendant of the Homo-Sapiens. Methuselah is convinced from the fossils he found and from his own DNA, that he was able to isolate strands of Neanderthal DNA from his own DNA which he implanted into a virus that he would spread into the air. His plan is to release the virus into the world's air, thus increasing the Neanderthal DNA pool in the world. Methuselah Avni, who is not a great researcher, is not aware of the potentially devastating consequences of this move - the virus will not really succeed in implanting Neanderthal DNA in people, but it can cause terrible diseases such as various tumors. When you tried to find out what his plan was, he found out that you were following him and locked you here, in his secret laboratory hidden in the "Ancient Man" exhibit. You have an hour before he returns and succeeds in his mission. Will you be able to find the virus, before it spreads in the air of the world and harms everyone?

3.2 Great Bone Robbery

20 This game consisted of nine puzzles spread in four main spaces:

- Animals of Israel exhibition which includes dioramas of taxidermy of local fauna
- Movement, Skeleton, and Muscles exhibiting the skeleton of different life forms
- The auditorium as a neutral space with no exhibition
- Dinosaur Exhibition showing models of different pre-historic, extinct reptiles

In addition to the general aims above this game also aimed to highlight (1) that life on earth is constantly evolving, (2) that animals of shared ancestry exhibit homologous bone structures, and (3) the importance of fossils to scientific inquiry and why illegal trading of fossils is detrimental to human knowledge.

The background story centres on a museum worker who is illegally conducting trade of fossils on the black market:

Daniel, the museum's new day guard, suspected that one of the night guards was abusing his position at the museum and trading in fossils and dinosaur remains to earn a lot of money given to him by rich people.

These people tend to display these remains and brag about them to their friends - which takes the fossils out of the eyes of science and the public, and thus we will lose valuable information about the past of life on Earth.

Daniel suspects that the employee is on the verge of his biggest deal - he suspects that the employee imports bones from some country and assembles them into a complete skeleton

worth millions.

Yesterday Daniel told this to Dorit, the museum's curator. To Dorit's astonishment, Daniel did not show up for his next shift this morning. Dorit asks you to help her find evidence for Daniel's suspicions, which may also lead to the discovery of the reason for his inexplicable absence.

The night watchman found out that you were following him and under cover imprisoned you here. You didn't see his face, but you heard him tell someone on the phone that in an hour he would return to the museum and transfer you to that person. You have 60 minutes to break free, and on the way find out who that guard is and find evidence of trading dinosaur remains.



Figure 1. Photos of players in the escape games.

Note: The photos show how the game puzzles were integrated into the museum exhibition. (a) Sharpening

of branch puzzle. The sculpture on the right is *homo habilis* who possessed an ability to use basic tools such as sharpening sticks using stones. The contraption on the left was added as part of the *Return of Prehistoric Man* game. To represent basic tool making the players need to sharpen a stick and use it to open the contraption which houses a *homo habilis* skull. (b) The bottom of the cabinet is the 'lab' that was installed in the *Return of Prehistoric Man* game. To deactivate the 'lab' the participants need to key in a code. The 'lab' was installed in an existing cabinet, the top of which houses museum artefacts. (c) The Bat Skeleton puzzle part of the *Great Bone Robbery* game. Participants need to use the skeletons in the diorama to solve the puzzle. (d) Participants doing the Amber experiment in the museum's auditorium as part of the *Great Bone Robbery* game.

4. Methodology

To answer the research questions we collected questionnaire data from both visitors and gamemasters (staff running the escape game).

4.1. Participant questionnaire

- 21 We constructed an online questionnaire that consisted of 18 items. The first five items aimed to unveil the demographics of the visitors and focused on participants background (age, how they heard of the escape game, who they came with, etc.). Ten items related to the experience and learning (8 likert-type, 2 open) and were adapted from an earlier study on a educational escape game (Peleg et al., 2019). In that study students' qualitative comments after playing the escape game were converted to questionnaire items. In order to, discover which puzzles were favoured and for what reason, two items relating to the favourite puzzle were added. Finally, participants were given the chance to provide general feedback ("Is there anything you want to tell us").
- 22 The questionnaire was administered at the end of the game. As the groups approached the last puzzle of the game, the gamemaster would wait for them at the exit. The gamemaster would then ask each group if they would be willing to participate in an anonymous online questionnaire. If they agreed they were given a tablet with the questionnaire on it or a link to the questionnaire according to their preference. Since the escape game is experienced as a group, participants were encouraged to fill in the questionnaire as a group and the unit of analysis is thus as a group. Conversations between participants whilst filling the questionnaire were encouraged. Also, groups were encouraged to fill in the questionnaire on site (rather than after leaving the museum) for the same reason and to reduce drop out.

4.2. Gamemaster questionnaire

- 23 To enrich our data, we tapped into the experience of the gamemasters (as they are present in and monitor all games). We created an online questionnaire and asked the gam-

emasters to fill out the questionnaire at the end of each run of the escape game (if time allowed - this was not always possible, for example if two groups played one after another). The questionnaire had two purposes. The first was to validate the findings from the participant questionnaire. The second was to provide gamemasters an opportunity to log any issues that occurred in the escape game.

- 24 This online questionnaire consisted of 19 items and was developed for the purposes of this study. It was based on our experience of running escape games as gamemasters. We also added questions that would give the gamemasters' perspective on the visitors' experience. Ten items related to basic characteristics of the activity and the group (date, number of participants, etc.). Six items related to the gamemasters' assessment of the activity including their involvement in helping the group (what puzzles did you provide most help with? How would you rate your level of involvement?) and assessment of the groupwork (How did you feel the group worked as a team?). The last three items gave the gamemaster an opportunity to suggest improvements to the game and report any faults.
- 25 For both questionnaires, closed items were analysed using descriptive statistics. Open items were first coded and the coded data was then analysed using descriptive statistics. The sample consisted of 108 participants who played in 35 groups as detailed in Table 1. Of the 35 groups, 27 (77%) were families or groups of families and 8 were group of friends (23%). The gamemasters filled in 32 questionnaire (in a few cases due to time constraints they were unable to fill in a questionnaire).

Game	Number of groups who filled in the questionnaire	Total number of people in these groups	Number of gamemasters' responses
Return of Prehistoric Man	12	37	11
Great Bone Robbery	23	71	21
Both games	35	108	32

Table 1. Details of sample.

5 Findings

The findings will be addressed in the order of the three questions.

5.1. Can an escape game embedded in a museum exhibition attract new audiences to the museum?

- 26 This question can be answered by looking at who played the escape game and to what extent these players saw the connection between the game and the exhibition.
- 27 About half the groups (51%) visited the museum prior to the game whilst the rest did not (49%) (Figure 2a). Most groups (89%) have played at least one escape game before with 40% having played more than 5 escape games before. Only 4 groups (11%) claimed they have never played an escape game before. This suggests that the escape game activity attracted people with experience in the genre, half of whom have not been to the museum before.

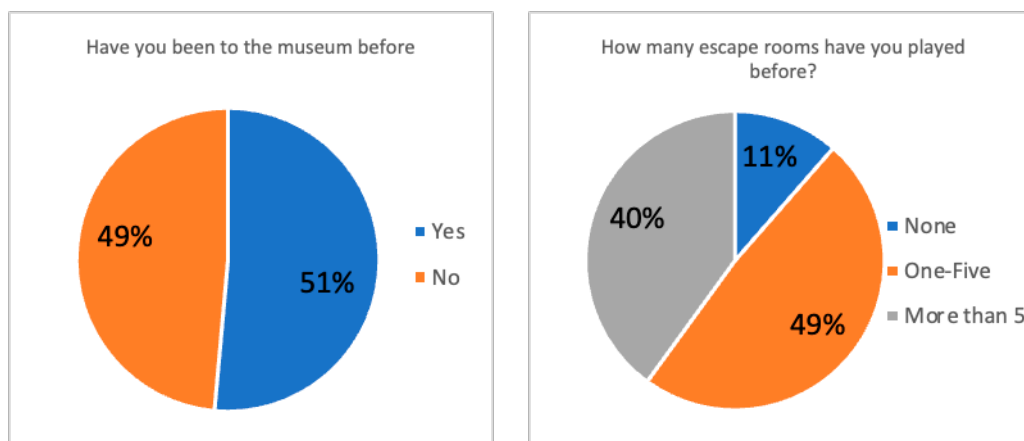


Figure 2. Showing percentage of groups who have visited the museum before and how many escape games they played before playing this one.

5.2. What educational experience can an escape game embedded in a museum provide visitors?

- 28 Visitors' views on their experience were collected in a number of Likert-type items asking for the extent of agreement with specific statements (Figure 3). These items were formulated so that 1 was agreement to a limited extent and 5 to a great extent. In the analysis we will therefore consider 3 as neither agreeing nor disagreeing with the statement. Answers under 3 will be considered as disagreement and above 3 as agreement.
- 29 Most visiting groups claimed that they were so engulfed that they did not feel time

passing, suggesting they were in a state of flow (94%, Figure 3, item f). Most groups agreed with the statement that they have learnt something new in the room (66%, Figure 3, item c). Most groups felt that the teamwork in their group was good (83%, Figure 3, item e) as was also observed by the gamemasters (Table 2, items b and c).

Interestingly whilst most groups felt that the gamemasters were too involved in their game (83%, Figure 3, item g), when asking the gamemasters the same question, they felt they did not get very involved in the game (Table 2, item a).

When asked about the connection between the museum and the game most participants felt that the escape game puzzles were linked well with the scientific content of the museum exhibitions (see Figure 4). This was slightly higher for the ‘Prehistoric Man’ than it was for the ‘Bone Robbery’ probably because the former used more props from the exhibition as part of the puzzle.

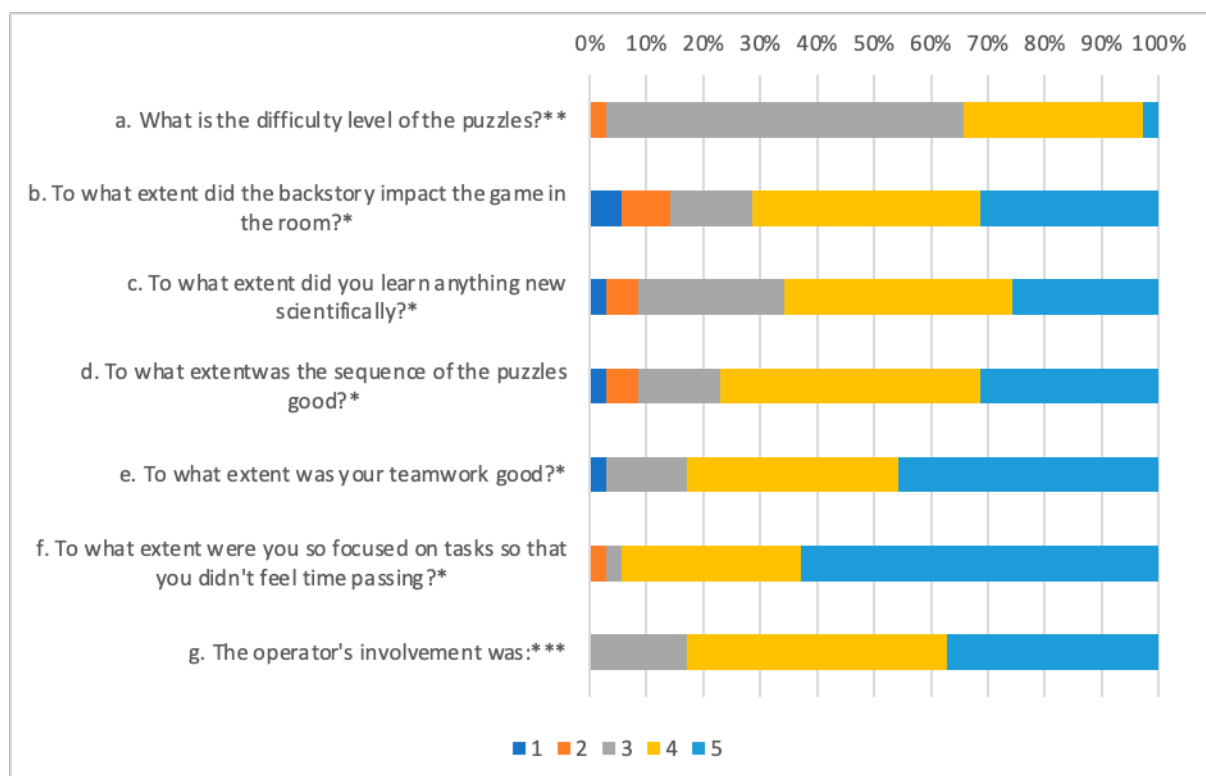


Figure 3. Summary of responses to Likert-type items relating to visitor's perceptions of the puzzles for both rooms. Responses are from all 35 groups.

Note: All items were likert-type questions. In all items 1 represents the most negative response and 5 the most positive response. Specifically:

- * 1 = to a limited extent 5 = to a great extent
- ** 1 = very easy 5 = very hard
- *** 1 = too limited 5 = too much

Because in these items there was little difference between the two rooms, we consolidated the data of both rooms into one chart.

Item a ^a . To what extent did you get involved in the game? (Likert-type item)				
Percentage of responses in each level of agreement (1 – not at all; 5 – to a great extent)				
1	2	3	4	5
3%	56%	13%	19%	9%
Item b ^b . Who was most active in the game? (Open response)				
Adults	Children	Both equally active		
9%	16%	75%		
Item c ^c . In your judgement how good was the teamwork? (Open responses)				
Good	Reasonable	Only some puzzles		
53%	9%	13%		

Table 2. Responses to three relevant items in the gamemasters' questionnaires (n=32).

Note: The results of three questionnaire items are shown. There were 32 responses, each representing the gamemaster's assessment of one group playing one game.

- ^a Likert-type item. Gamemasters choose their agreement with the statement with 1 being full disagreement and 5 being full agreement.
- ^b Open item. Data was analysed using content analysis.
- ^c Open item. Data was analysed using content analysis. Percentages do not add up to 100% since some responses were left blank.

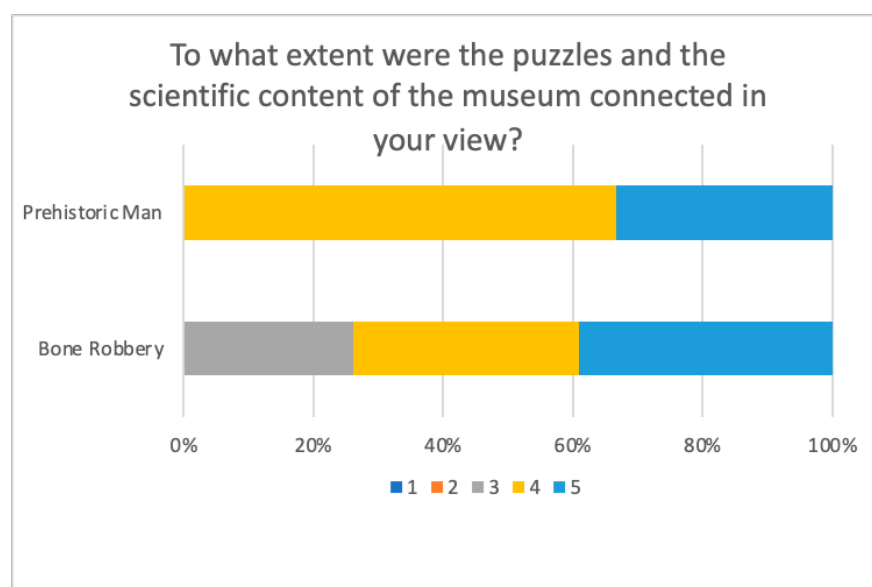


Figure 4. Visitors' perceptions about the link between the puzzles and the museum exhibits

Note: This was a likert-type question asking to what extent participants felt the puzzles and the scientific content were connected. 1 = to a small extent, 5 = to a very large extent. There were no responses of 1 or 2.

5.3. What are visitors' perceptions of the different game elements?

- 30 Overall the majority of groups felt that the sequence of the puzzles was good (77%, Figure 3, item d). Most visiting groups (63%) considered the puzzles as neither easy nor difficult with around a third (34%) considering the puzzles difficult (Figure 3, item a). Regarding the backstory (provided under 'Context' above) the majority of groups agreed the backstory impacted the game in the room to some (40%, Figure 3, item b) or to a great extent (31%).
- 31 Figure 5 summarises what the favourite puzzles were for the visiting groups. To make sense of the data we further categorised the puzzles into one of four categories according to the strategy needed to solve the puzzle (see Table 3). Naturally there is an overlap between these categories (for example a hands-on puzzle might require some thinking), in categorising the puzzles we chose the main mode required to solve the puzzle.

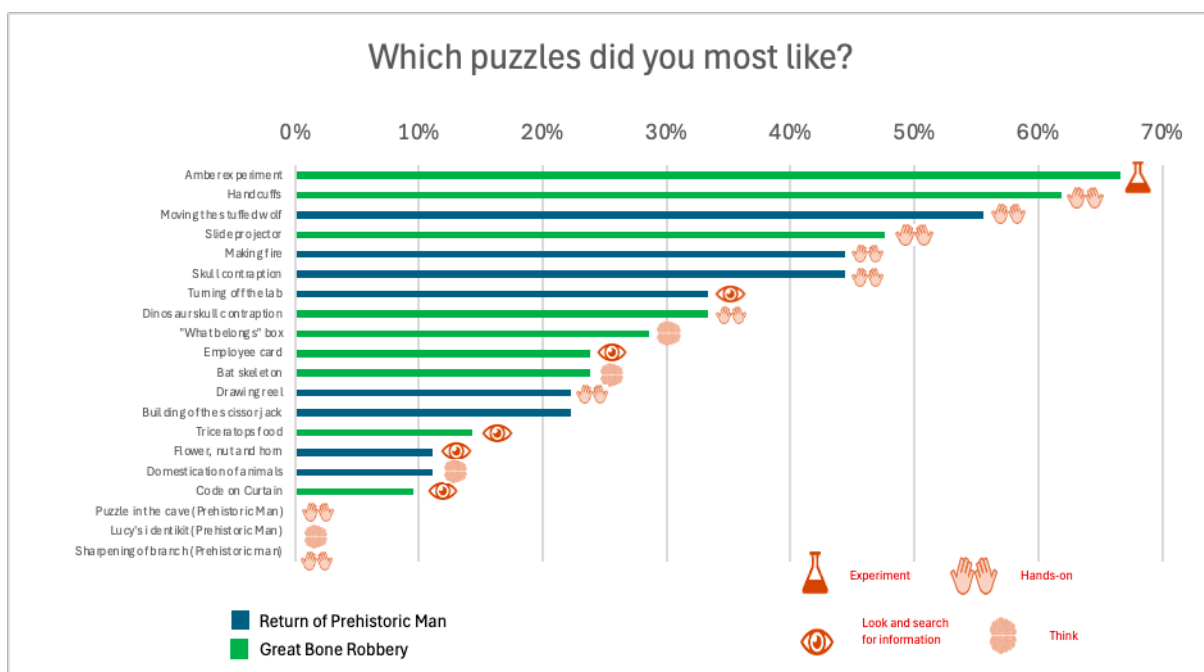


Figure 5. Responses to the question which puzzle the groups most liked.

Note: The bars present the percentage of groups that mentioned that puzzle as one they liked. So for example for the Amber Experiment, 14 groups of the 21 who played the Great Bone Robbery game mentioned this group, hence the calculated bar shown above is 67%. We put the puzzles from both rooms into the chart for easy comparison, each one was calculated as a percentage of the groups that played that specific room (n=21 for the Great Bone Robbery and n=9 for the Return of Prehistoric Man).

Category of puzzle	Description	Example
Hands-on	Puzzles that require physical work to solve.	Building of Scissor Jack – players need to find a box with lots of wooden parts, they need to assemble these to build a jack that can help them reach for a key.
Looking and searching for information	Puzzles that mainly require searching for objects or information.	Employee card – players need to find the right employee card of the villain (see description of the Great Bone Robbery game above). The card contains a code needed to open the next puzzle.
Thinking	Puzzles that mainly require players to think and solve a puzzle using logic.	Bat Skeleton – Players find diagrams relating to the skeleton of a bat and a human. They need to find homologous bones which gives them a code.
Experiment	Puzzles that require conducting a small scientific experiment.	Amber experiment – Players find a bag of real and fake amber. They follow a ‘recipe’ to run a small experiment in which they put the stones in brine. This allows them to determine which amber is real and which is fake. The real amber stones are fed into a box that opens a door.

Table 3. Categorisation of the puzzles with a description and an example.

- 32 The most popular puzzle (67% of responses) was the amber experiment (Figure 5). The next 5 popular puzzles were all hands-on puzzles. This is not to say that hands-on puzzles were automatically ranked highly, but rather that it seems to be a favourable condition. Also in figure 5, it can be seen that the puzzles of the Great Bone Robbery seem to be more popular than those of the Return of Prehistoric. Figure 6 shows participants’ responses to why they chose the puzzle they did in Figure 5. The highest ranking response (69%) was that they were intellectually challenging. All other responses were spread around the other options (between 40 and 50%).

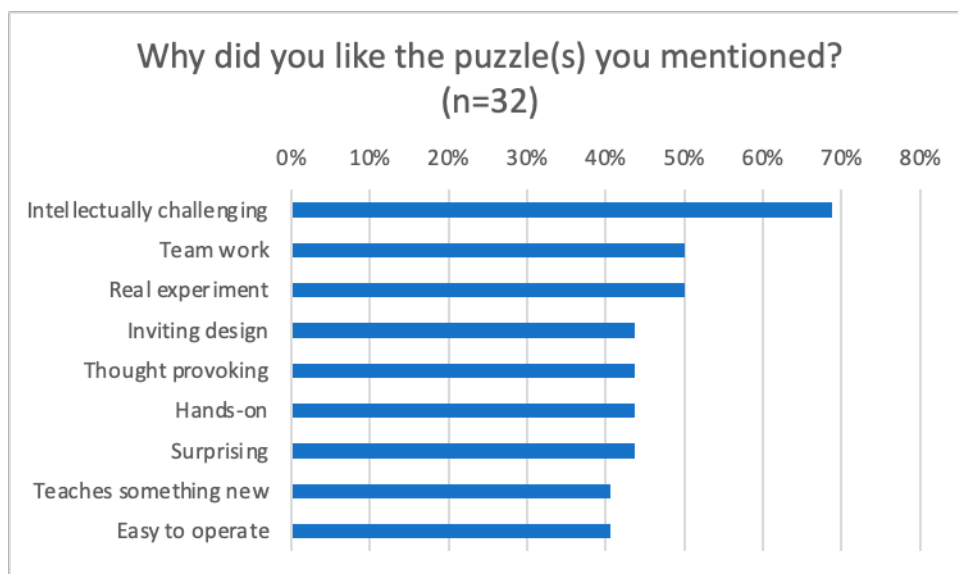


Figure 6. Responses to why participants chose the puzzles they liked (why they chose their response shown in figure 5).

Note: Here we merged the responses from both rooms since this is not game specific. Some groups did not answer this question, hence the total number of responses was 32. The percentage shown is groups that chose that specific answer. Groups could choose more than one response from the closed list.

6. Discussion

- 33 This study aimed to investigate a model of embedding an escape game into an existing museum exhibition. We wanted to know whether this model can attract new visitors, what players experience is and what we can learn about puzzle design from this evaluative study.
- 34 From the visitor data it seems that this model indeed was successful in attracting visitors who have played an escape game before, suggesting that they were compelled to visit the museum thanks to the new game activity. Looking at the picture of the visitor experience it seems to have successfully installed aspects of successful escape games including good teamwork (Nicholson, 2015; Veldkamp et al., 2021) and instating a state of flow (Peleg et al., 2019). Suppositions made in the literature also appeared in our findings with participants appreciating the intellectual challenge of the puzzles (Veldkamp et al., 2021; Vidergor, 2021) and the importance of a backstory (Fotaris & Mastoras, 2018).
- 35 The findings hint at some directions for successful puzzle design. The puzzles that were most popular had an element of hands-on experience. However, this does not

mean that automatically all hands-on puzzles are favoured, there were a number of hands-on puzzles that did not feature as favoured. Crossing this with the main reason of why participants chose their favourite puzzle, namely that they were intellectually challenging, suggests that the most successful puzzles would be hands-on AND intellectually challenging. This might be the case with the most favoured puzzle – the amber experiment. Here participants need to conduct a scientific experiment which practically combines both hands-on and an intellectual experience.

- 36 An interesting finding emerged when comparing the evaluation of the two rooms. The puzzles of the Great Bone Robbery were liked more, yet the puzzles in Return of Prehistoric Man were seen as more connected with the science content of the museum. Indeed, in Return of Prehistoric Man we made more efforts to convert the actual exhibits into escape game, thus limiting our freedom in creating the puzzles. In the Great Bone Robbery more of the puzzles were ‘stand-alone’ or required the exhibits just for information, leaving us more freedom with the puzzle design.
- 37 Another interesting point arises when comparing the data from the two questionnaires. Whilst the participants felt that they were being assisted too much, the gamemasters felt they were not assisting enough. It is sometimes difficult as a gamemaster to know when to assist and more importantly when not to assist. This could be addressed when training gamemasters.
- 38 The evaluative study had a number of limitations. Our sample was limited in size. Also, due to the nature of the activity it was sometimes difficult to have participants commit to filling in the questionnaire. Most of the data collected was self-reported, with the exception of the data from the gamemaster questionnaires. As discussed in the paragraph above, comparing different data sources yields interesting findings and future research should consider other ways of collecting data such as the analysis of video recordings.

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