PROCEEDINGS OF SCIENCE

Escape Rooms as a tool for science outreach: the HEPscape! experience

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Escape rooms have gained significant popularity in recent years, offering a blend of puzzle-solving and treasure hunt-like challenges, making them an enjoyable activity for the participants and a team-building experience. More importantly, they provide a unique and engaging way to introduce new topics, which can be effectively leveraged for science outreach. In 2021, a team from INFN created HEPScape, an escape room focused on high-energy physics. Participants are immersed in a simulation of the Large Hadron Collider at CERN, stepping into a recreated experimental control room using projectors and lights creating an immersive room. By solving hidden clues, visitors learn about the role of particle accelerators and the nature of high-energy physics experiments through a fun activity. HEPScape is designed to be adaptable to different age groups, ensuring an adapted experience for all participants. The setup is portable, requiring 3 hours to assemble, making it ideal for science fairs and exhibitions. Its mobility allows it to be brought where needed. The simplicity of the materials and the flexibility of the game design also make it easy to replicate and translate into different languages. In this report we share feedback and insights gathered from events where HEPscape was showcased.

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1. Introduction

Escape rooms have seen a surge in popularity among teenagers and co-workers over the past decade. They offer an immersive experience where participants engage in a treasure-hunt-like activity. Typically, teams of 4-5 players work together to solve puzzles and riddles by deciphering hidden clues. The goal is to complete the challenge within a set timeframe and exit the room. The clues are designed in a sequential manner, meaning that solving one leads to the discovery of the next. To ensure players don't get stuck, a facilitator may provide guidance through external communication if needed.

The themes of escape rooms can vary widely, ranging from historical to scientific or investigative settings. This versatility makes them particularly suitable as innovative teaching environments. Furthermore, the dynamic nature of solving puzzles and receiving immediate feedback creates a rewarding experience, which is a key aspect of effective learning.

Modern education emphasizes the importance of the "4C" skills: communication, collaboration, critical thinking, and creativity. Escape rooms naturally foster these skills, as participants must work together to solve challenges. The collaborative environment encourages players to share ideas, draw on the strengths and expertise of the group, and approach problems from multiple perspectives. Thinking outside the box and experimenting with new strategies are key to successfully unlocking the room's mysteries.

Capitalizing on these elements, the escape room theme, immediate rewarding feed-back and compliance with modern education guidelines, escape rooms have recently been incorporated into scientific education and tested succesfully [1]. Libraries of escape room kits for teachers exist on the web for numerous school subjects.

Previous applications of escape rooms in the field of particle physics outreach include those organized during the 2019 CERN Open Days by A. Apollonio et al. [2], a prototype for a CERN high school student stage by D. Barney et al., and initiatives such as LabEscape by P. Kwiat at the University of Illinois at Urbana-Champaign [3]. These projects have successfully utilized the format of escape rooms to engage the public with the otherwise complex scientific concepts of particle physics.

In 2021, a group from INFN developed HEPscape, an immersive and interactive escape room designed to introduce visitors to high-energy physics [4]. The INFN team responded to a call for outreach proposals called "Physics Involving People". The escape room was initially launched at the European Researchers Night in Rome and later featured at the Genova Science Festival, along with numerous other events. The goal of HEPscape is to make topics such as particle accelerators and the building blocks of matter approachable, enjoyable, and inspiring. By presenting these subjects in a playful and engaging manner, the escape room fosters curiosity and demonstrates that science can be both fun and exciting.

The HEPscape kit is fully portable, allowing it to be easily transported and set up at various locations. Since its inception, three kits have been produced to cover a wide range of science exhibits and other events throughout Italy. To date, HEPscape has reached more than 8,000 visitors. In this paper, we present feedback from these experiences and share insights into how this innovative outreach tool has been received.

2. HEPscape: An Innovative Approach to High-Energy Physics Outreach

HEPscape simulates a visit to one of the Large Hadron Collider (LHC) experiments at CERN. Upon entering, visitors are handed safety helmets and are told that they are about to descend into the LHC underground facilities and must therefore wear the helmet. By solving various puzzles they manage to take an elevator and enter the LHC control room. However, things quickly go awry as an alarm sounds, signaling a breakdown. To restart the accelerator and help discover the Higgs boson, participants must learn about how particle accelerators work and understand the fundamental particles that make up the Universe.

HEPscape offers a fully immersive experience using projectors, lighting effects, and props to replicate a scientific environment. The setup can be installed indoors in a 6x6 m^2 room. The materials fit into a small van, and the installation takes approximately 3 hours. Outside the escape room, a desk with helmets and a curtain depicting the LHC tunnel welcomes participants.

Each session lasts around 40 minutes and requires three staff members: one guide who facilitates the game and explains the scientific content, and two assistants who manage the audiovisual elements and help the main guide. A typical group size is 25-30 visitors, which often includes entire school classes. For larger groups, participants are divided into smaller teams during the activity to ensure an engaging experience for everyone.

The HEPscape kit has been replicated in three cities (Rome, Padova, and Perugia) to accommodate the growing number of science fairs and events across Italy.

The kit is versatile enough to be installed both indoors and outdoors in a gazebo. For indoor installations, it is often helpful to survey the space in advance, especially if the room needs to be darkened or equipped with projection screens. The setup includes three self-supporting screens arranged in a U-shape for projecting the interactive content, alongside laser projectors, LED lights, and various props that enhance the immersive experience. The main projector is a laser projector that is installed at the bottom of the central screen. The other two projectors are placed next to the lateral screens, and project on the opposite screen. The projectors are controlled by a computer using a video-wall and HDMI cables. Six LED lights illuminate the room creating the ambience, and guiding the attention of the visitors to the various clues while the game unfolds. A tablet controls the LED lights via bluetooth. The computer and tablet are controlled by the operators. The room is decorated with many posters and books, monitors and keyboards. The clues are hidden in the room: in the posters and books, or in the videos. The solution of each puzzle is usually a numeric code which unlocks a safe.

The puzzles are adaptable for different age groups: kids (6-8 years), juniors (9-12 years), and adults (13+). Smaller groups and older participants often play independently, with the guide focusing primarily on explaining the scientific aspects, while for younger groups the guide has a more active role.

During the game, each participant receives a badge with a QR code providing additional information about particle physics and accelerators.

Between two shifts the games are reset and prepared for the next group. It takes about 10 minutes to reset the room, or to change between different age group setups.

The staff who runs the escape room is often made of physics students, graduates, doctoral candidates, and young researchers. Thanks to this activity, they learn to speak in public about the

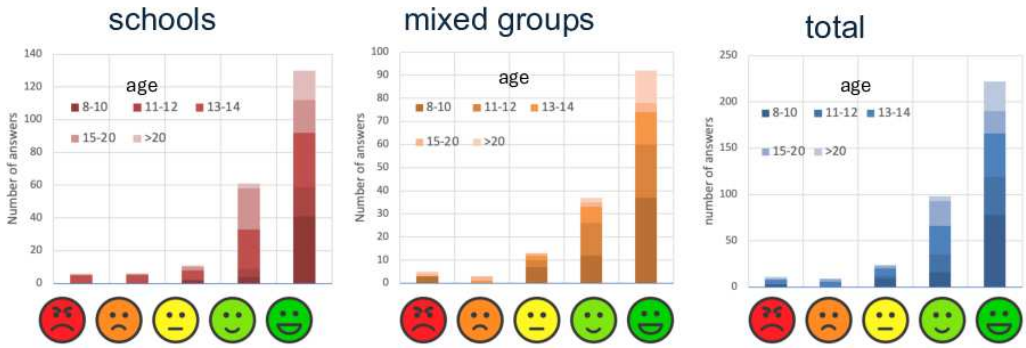

Figure 1: Satisfaction test results collected during the Torino book fair in 2024 for school group (left), mixed groups (middle) and total visitors (right). The satisfaction is indicated on a scale of 1 to 5 (very unsatisfied, unsatisfied, neutral, quite satisfied, very satisfied) for the different age groups as indicated in the legend.

science they work on, using simple terms, understandable by the general public, and to communicate their passion.

At the exit of HEPscape there is an Instagram photoboot and a satisfaction test. We ask the visitors to fill a questionaire, indicating the age group and their appreciation of the activity in a scale of 1 to 5 using the very unsatisfied, unsatisfied, neutral, quite satisfied, and very satisfied emojis. Furthermore there is a free text field where the visitors can write a comment. We regularly read the comments and analyze the satisfaction tests. Figure 1 shows the satisfaction survey taken at the Torino book fair in May 2024. The fair took place over 5 days. On the week-days many schools had reserved the activity, while on the week-ends the activity accepted 50% reservations and 50% walk-ins. School kids from 8 years old were accepted for the activity at this fair. During the week-ends the visitors were mostly families with kids, students and general public. For the schools, the escape room setup was tuned to the age of the visitors, while for the mixed groups the activity was often run in the junior setup (tuned for 9-12 years old). The survey results has an average score of 4.4. The messages in the free text clearly show that the young visitors (up to the age of 12) absolutely love the activity. Some of the survey messages filled by high school students indicate however that they prefer to be more autonomous in the game. Therefore an effort has been done to improve the videos and the story-telling to reduce the guide assistance.

Figure 2 shows the types of events and the number of events where HEPscape was presented. These are mostly science fairs and outreach events, or public engagement activities in contemporary with large HEP conferences. The left plot shows the number of visitors per day at each event. Typically we can host an average of 150-200 visitors per day, with peaks of 300 visitors at the European Researchers Night. In total more than 8000 visitors have participated in the activity.

3. Diversity and Inclusion

Since its launch, HEPscape has strived to broaden its reach and engage more diverse audiences. Special efforts have been made to bring the activity to different regions across Italy, particularly to smaller cities without access to major scientific institutions. HEPscape has also been adapted for the hearing-impaired community with the help of sign language interpreters during a dedicated

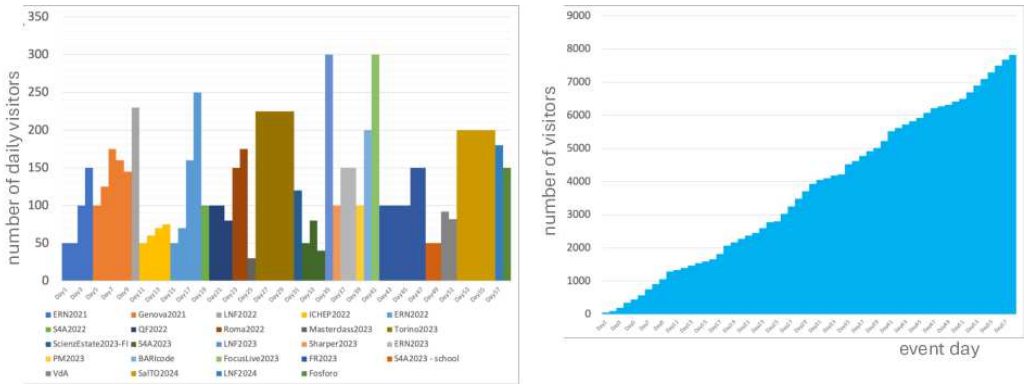

Figure 2: Left: number of daily visitors in the various events where HEPscape was presented; Right: cumulative number of visitors.

event in Rome. Furthermore, work is ongoing to translate the videos and materials into multiple languages, facilitated by the SmartHEP project. A team in Finland has already replicated the HEPscape experience in their own outreach efforts.

We are currently working on forming a network of interested institutions to share ideas, expand the reach of the escape room, and share ideas on new games.

4. Future Developments for escape rooms in outreach

As the success of escape rooms continues to grow, several developments based on new technologies may be exploited in HEPscape or other outreach escape rooms to expand the audience or enhance the experience:

- Web-Based Escape Room: this consists in the creation of an online version of the escape room. This would allow users from around the world to participate in a virtual escape room focused on high-energy physics. The web-based platform would enable broader access, particularly for schools or individuals in remote locations, unable to attend in-person events. With interactive puzzles and educational content, an online escape room version could mirror the hands-on experience while utilizing multimedia tools to deepen the engagement. An example of a web-based escape room is available here [5].

- School Kits: developing a portable kit that can be used directly in schools could provide teachers with all the materials necessary to run a simplified escape room in their classrooms, as described by the teachers in [1] and also as developed here [6]. By incorporating a flexible format that adapts to different age groups and curricula, this initiative could help bring high-energy physics to students directly in their classrooms.

- 3D Virtual Escape Room: technological novelties allow for a more immersive experience: from 3D visors to motion sensors cameras. A fully immersive 3D virtual escape room could offer an unparalleled educational experience. Utilizing virtual reality (VR) technology the participants could explore an even more realistic simulation of the LHC and its experiments.

Integrating virtual reality into the game could create a highly engaging environment where players interact with one another and the scientific setting in an immersive manner.

These future possibilities will expand the accessibility and impact of escape rooms in outreach, allowing more people to explore the wonders of science in innovative and engaging ways.

5. Conclusions

The HEPscape escape room has proven to be an innovative and highly effective tool for engaging the public with complex scientific concepts in the field of high-energy physics. By combining interactive puzzles, immersive environments, and a dynamic learning experience, HEPscape successfully introduces the subject of particle accelerators and the study of fundamental particles, making these topics accessible and enjoyable for visitors of all ages.

The feedback from the more than 8,000 visitors who have participated so far has been positive, with strong indications that the format fosters curiosity and excitement about science. The adaptable nature of the games, along with the portability of the escape room kit, has allowed us to reach diverse audiences across Italy: science festivals, schools, public outreach events. Future plans include presentations in smaller cities and other italian regions.

Through initiatives aimed at inclusivity and diversity, HEPscape continues to broaden its impact. Efforts to involve hearing-impaired audiences and the ongoing work to translate the content into multiple languages are part of our commitment to making high energy physics scientific themes accessible to all.

Looking ahead, possible future developments in the field of escape rooms for outreach may include web-based versions, school kits, and virtual reality experiences.

In summary, HEPscape is not only a fun and educational activity but also a powerful outreach tool that has already contributed significantly to public science education. With ongoing improvements and expansions, it has the potential to inspire future generations of scientists and foster a deeper understanding and appreciation of the fundamental science that shapes our world.

References

[1] A. Veldkamp, M. Knippels, W. van Joolingen, *Beyond the Early Adopters: Escape Rooms in Science Education*, Front. Educ., 11 March 2021 Sec. STEM Education Volume 6 - 2021, https://doi.org/10.3389/feduc.2021.622860

[2] https://opendays.cern/site/point-4-lhc/activities/escape-room-operate-lhc

[3] https://labescape.org/

[4] https://web.infn.it/hepscape/en/

[5] https://www.rsc.org/news-events/community/2022/feb/escape-the-lab/

[6] https://guardup.com/phantom-physics-quest/