Fighting Viruses Though Escape Room Design with Students

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Abstract: The first countermeasure against new waves of the pandemic is diffused science knowledge about what viruses are and how they harm our body. Can the design of a game offer suitable opportunities for relevant science learning about viruses? Moreover, can it contribute to the development of collaboration and communication soft skills, central both for academic success and in real life? This paper reports a case study of a mixed-class group of lower-secondary students in a Swiss Italian-speaking rural school that engaged in the design and development of an educational escape room on viruses during a project week. The paper illustrates how the activities were organized following the *Star Model* for the design of educational escape rooms, how roles were distributed among pupils and teachers, and what scaffolding was offered in order to blend content and game design, so to achieve a scientifically precise and at the same time fun game. The game design experience has been evaluated through (a) the pre-post assessment of teamwork and leadership self-efficacy; (b) the pre-post assessment of science knowledge about viruses; and (c) an interview with the teacher. The case study illustrated that, while self-efficacy variations are minimal but still positive, designing an educational escape room with pupils can be conducive to relevant subject-matter learning and team building.

Keywords: escape rooms, game design, secondary school, science learning, soft skills, project-based learning, game-based learning, Covid-19.

1. Introduction

The first countermeasure against new waves of the covid-19 pandemic, and of all virus pandemics, is diffused science knowledge about what viruses are and how they harm our body and our communities. This is indeed the basis both for understanding health policy decisions and for the effective application of individual measures such as face masks and social distancing. A memorable and engaging learning experience can be paramount in order to ensure deep learning of key science facts, and Game-Based Learning (GBL) provides a viable path for that (Li & Tsai, 2013; Sung & Hwang, 2013).

In this paper we try and move one step beyond game-based or gamified learning experiences to investigate the potential of game design for science learning. Can a game design process offer opportunities for relevant science learning about viruses? Moreover, can it contribute to the development of teamwork and leadership soft skills, central both for academic success and in real life?

After the introduction, section 2 reports the case study of a mixed-class group of lower-secondary students (age 13-15) in a Swiss Italian-speaking rural school that engaged in the design and development of an educational escape room on viruses during a project week. Section 3 describes the data collection methods and analyzes the pre-post surveys and the interview with the teacher. Finally, Section 4 discusses the limits and outlooks of this case studies and draws some conclusions for educators and researchers.

1.1 Learning with escape rooms

Appeared in the early 2010, escape rooms (ER) are a recent but growingly popular live entertainment format in many countries (Nicholson, 2016). The goal of the players, usually a team of 4-8 people, is to actually escape from a locked room by solving puzzles of different kinds within a set time. ERs let players enter a narrative circle that makes the escape meaningful and memorable – be it saving the Earth from a chemical disaster or capturing a gang of thieves. Born as an experiential game to be played in a physical setting, ERs often integrate digital elements, from active padlocks to augmented or virtual reality. Online escape rooms are also becoming increasingly popular.

ERs are raising the interest of the education community (Fotaris & Mastoras, 2019): a simple and rough search on Google Scholar with < "escape rooms" education > yielded no results for 2010, 17 for 2015, 440 for 2019 and 629 for 2020. Recent studies suggest that ERs can be beneficial for learning in many areas (Fotaris & Mastoras, 2019; Veldkamp et al., 2020) such as healthcare (Anderson et al., 2020), nursing (Adams et al., 2018), cybersecurity (Löffler et al., 2021), engineering (Ross & Bennett, 2020), science (Huang et al., 2020) and foreign languages (López, 2019). While most studies focus on higher education, interesting experiences were

reported also in compulsory schools (Ouariachi & Wim, 2020) and in teacher education (Neumann et al., 2020). However, after an initial wave of enthusiasm for this new GBL format, some scholars call for a more structured and methodologically sound approach to experimentation (Taraldsen et al., 2020).

Actually, learning with ERs can mean two different things. On one hand, as many team games, playing an ER fosters collaboration, communication, leadership and teamwork, and solving puzzles requires critical thinking and resilience – i.e., ERs can stimulate the development of soft-skills. On the other hand, Educational Escape Rooms (EER) can be intentionally designed for supporting learning specific subject-matter content (SchoolBreak, 2020). In the latter case both the narrative and the puzzles can integrate learning elements during the gameplay (Nicholson, 2018). EERs can be found off-the-shelf or be designed and shared by teachers.

1.2 Learning through game design

The case study reported in this paper does not focus on learning through *playing* ERs or EERs, but on learning through *designing* an EER. This is indeed *not* an instance of GBL: designing and developing an EER can be better framed as an instance of Project-Based or Design-Based Learning, which also includes a Peer-teaching perspective.

Interestingly, while there are papers that discuss methods and approaches for ER design *for* students (they are presented in the next section), very few studies report the design of an ER *with* students (Karageorgiou et al., 2020). To our knowledge, no studies exist on the design of an EER with students for other students in secondary education. The main assumption upon which the experimentation reported here was based, was that designing an escape room could also provide deep and effective learning opportunities and combine a design-based approach to content learning and soft-skills development.

2. A case study in educational escape room design

Every year a rural secondary school in a mountain region in the Italian-speaking part of Switzerland organizes a *special week*. Teachers propose special 1-day or more-day workshops, not necessarily related to their subject, for which they can have guests. Students are then presented the week's program, and they can individually register for the workshops they prefer, creating mixed-class groups.

The case study reported in this section took place in October 2020 as a 5-day workshop in the special week, and was animated by a Science teacher, an English teacher and one of the authors. The participants were 16 secondary school students in the age range 13-15, 11 girls and 6 boys. Some of them already studied viruses (the pre-defined topic of the EER), and half of them already had played one or more escape rooms, either commercial or at home.

2.1 Design model and constraints

The design process of an ER has been analyzed in (Karageorgiou et al., 2020). Some authors propose to have it follow existing design models such as the Experience Pyramid model (Heikkinen & Shumeyko, 2016), or in any case to follow a reiterative and reflective approach (Eukel & Morrell, 2021; Whitton, 2018). In our special week workshop, we followed the *Star Model* (Botturi & Babazadeh, 2020), which blends inspiration from the EscapED model (Clarke et al., 2017) and from classic game design texts.

According to the Star Model (see Figure 1), EER design originates from the thoughtful and non-streamlined interaction of:

- 5 game elements, namely *learning, game-flow, puzzles, narrative* and *equipment*.
- 4 context elements, namely *players, constraints, debriefing* and *evaluation*.
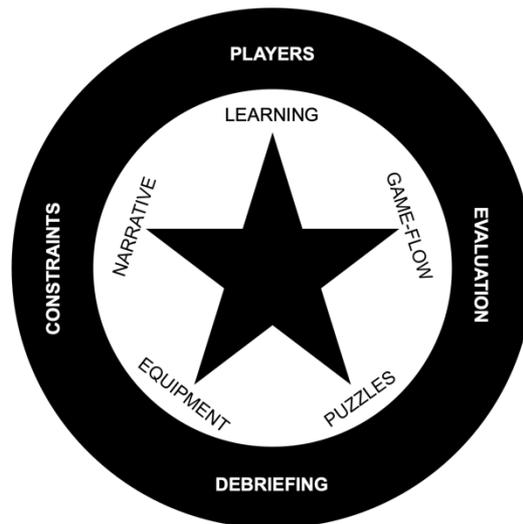
Figure 1: The Star Model (from Botturi and Babazadeh 2020)

During the workshop, some elements were pre-defined, and therefore were taken into account as constraints, in particular:

1. The learning topic of the EER was *viruses*: this was set by the coordinating science teacher, in response to questions that some of the participants raised during regular classes.
2. The space for the escape room was the village city hall, which the municipal authorities made available, just beside the schoolhouse. This was a large room, with a theatre stage, an upstairs inner balcony and a small bar/kitchen on the side.
3. In order to allow more players to play the room, the duration of the gameplay must be below 40 minutes, so that a whole session (including introduction and short debriefing) could remain within 1 hour.

Moreover:

4. The players of the EER were expected to be fellow students, so that the target group was 12-15 years.
5. The equipment available was one set of boxes and padlocks from BreakoutEdu.com and all what could be found at home (no further expenses were allowed).
6. The room should be ready for playing by Friday at noon, so that the whole design and development process should remain within 4,5 days (from Monday to Friday morning).

2.2 Design process and team organization

The 5-day workshop schedule included playing and analyzing two EERs from the SchoolBreak project (www.school-break.eu) on the first day. The analysis was conducted so to let the elements of the Star Model emerge. On the second day the group visited a local escape room company: they played one commercial escape room and interviewed the owners and game designers, focusing both on vocational and design-related elements. These two days were important to build up the team and also to have them share examples of ERs and EERs to find inspiration.

The actual design and development of the EER took therefore place on days 3, 4 and 5 (only morning), with the following schedule:

- Day 3 (full day): setting the stage
  - 1-hour lecture about viruses, to identify the key contents to be set as learning goals
  - Identification and discussion of constraints (see above) and visit to the location
  - Brainstorming and first ideas for the narrative and the puzzles
  - Team organization (see below)
- Day 4 (full day): game design
  - Definition of the game-flow and combination with narrative and puzzles
  - Production of the audio introduction
  - Production of the video outro
  - Test of all puzzles at least once in paper-based form and once with actual materials
  - Collection of all props

- o Outlining the debriefing on paper
- Day 5 (morning): fine-tuning and testing
  - o Fine-tuning of puzzle materials, especially checking if they were understandable
  - o Room set-up
  - o Definition of live-action roles (briefing, hints and in-game support, debriefing, sounds, light management, room reboot, etc.)
  - o 2 rounds of testing with volunteer fellow students

After the first brainstorming and ideas collection phase on day 3, the participants were organized in three groups with distinct but interlinked responsibilities.

1. One group focused on the narrative, the briefing and the debriefing. This group was in charge of writing the background story and to produce the media elements required to convey it. They were also in charge of the debriefing.
2. The second group was in charge of designing the puzzles, so to make them clearly understandable and solid enough to be used multiple times.
3. The third group was in charge of the room set-up, including both the layout and finding all non-functional props, i.e., theme-related ones and red herrings.

Every half-day all teams met and updated the game-flow chart that was drawn on the board and served as a coordination map for the whole group.

2.3 The virus escape room

> *"Hello? Hello? Please help me, we are all in great danger! I am Doctor Moritz, and a few years ago I discovered this virus that turns humans into zombies. But I also found a vaccine, which is hidden in my lab. You have to find it before the zombies break in. You have only 30 minutes! If you need help, shout "help" and I'll get to you - but I'll do it only 3 times… they are coming! good luck!" [groanings of zombies chasing Dr. Moritz]*

This was the audio file that played over a fake phone call that the players received on a real phone after they were locked in the dark in the hall of the city assembly room, now transformed in Dr. Moritz's lab. After the phone call ended, they discovered the only unlocked door and entered the small bar/kitchen. While zombies were beating on the closed windows and groaning, they had to solve the first puzzle and shout the keyword "antibody". When that word was pronounced aloud, a mysterious character, with the face covered by a gas mask, opened a passage to the main lab room: a huge half-lit space with four tables and a lot of strange equipment. The timer started, counting down 30 minutes, and the players had to open several boxes to find Dr. Moritz's vaccine. The EER game flow is illustrated in Figure 2.
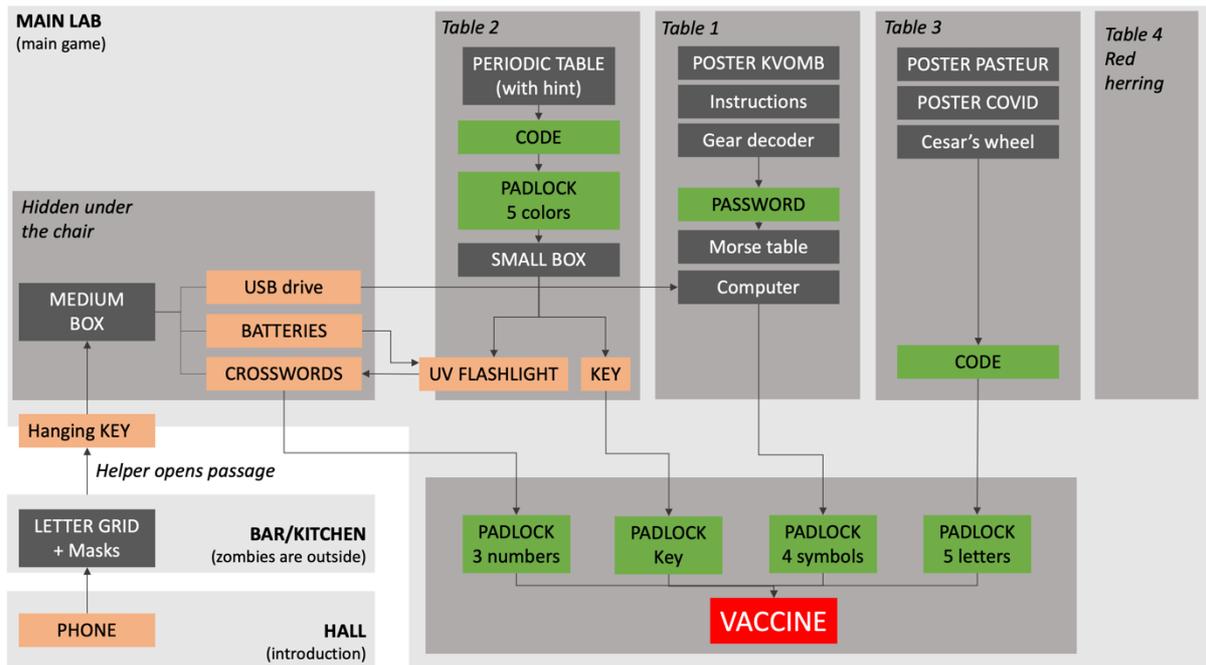
Figure 2: The Virus EER game-flow map

The puzzles included physical puzzles (e.g., discovering a key hanging from the ceiling with a severed hand), codebreaking (e.g., a morse code message; or decoding a picture using the periodic table as cypher), crosswords, and other types. All puzzles had to do with vaccines and viruses. For example, a crossword asked to find keywords like "vaccine" or "antibodies" from their definition; a code-breaking puzzle required to find the decoding key from reading a poster presenting Pasteur's life and achievements.

During the testing phase on the morning of day 5, the escape room was played by two groups of teachers. Some hints were made more visible as time seemed too short. During the afternoon of day 5, 3 groups of fellow students played the escape room – all of them getting close to win, but never making it (Figure 3).

Figure 3: A group of players during the game

The plan was then to open the escape room again in the following weekend to invite other students and parents to play it. Unfortunately, due to Covid restrictions being tightened in those days, this was not possible.

3. Assessing science learning and soft skills self-efficacy
The escape room project was definitely energetic and satisfactory for the participants – but was it worth from a learning point of view? The game design experience was evaluated blending quantitative and qualitative data. A pre-post survey investigated (a) changes in self-efficacy in teamwork and leadership and (b) science

knowledge about viruses. Pre-intervention data were collected first thing in the morning of day 1, while post-intervention data were collected at the end of the final debriefing in the afternoon of the last day. A blind code allowed matching anonymous data across the two data collections. All the participants filled in both surveys (N=16). An interview with the teacher, along with open comments collected during the post survey, provide complementary qualitative data.

The reduced number of participants and the very local nature of the experience do not allow any statistical elaboration, but only the use of simple descriptive statistics in order to illustrate the case study and get more definite insights.
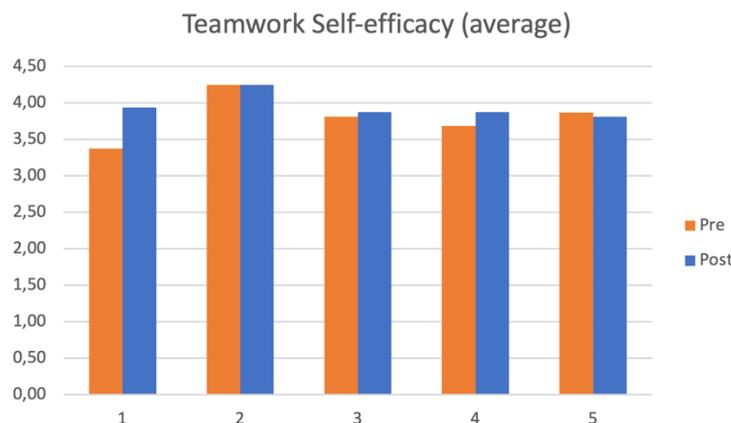
3.1 Teamwork and leadership self-efficacy

Self-efficacy, i.e., how well one thinks s/he can tackle a definite set of issues, is a relevant part of science learning and has impact on future careers (Chemers et al., 2011). We focused on teamwork and leadership self-efficacy, i.e., two competence domains which are intensively stimulated both in project-based learning and in playing escape rooms, and which are also central in many school curricula, including the Swiss one for secondary education. The pre-post survey used the Leadership/Teamwork Self-Efficacy Scale (LTSES; Cheemers et al., 2011), which was already validated and used in other studies (Deemer et al., 2020). The instrument includes 5 items for each dimension (teamwork and leadership; see Table 1), for a total of 10 items to be assessed on a 5-point Likert scale.

Table 1. LTSES items (5-point Likert scale)

Dimension	#	Statement
Teamwork	1	I know how to cooperate effectively as a member of a team
	2	I find it easy to follow instructions or take orders from others
	3	I have high confidence in my ability to function as part of a team
	4	I can provide strong support for other team members of any team I am on
	5	I know how to be a good team member
Leadership	1	I know a lot about what it takes to be a good leader
	2	I know what it takes to help a team accomplish its task.
	3	I am confident of my ability to influence a team I lead
	4	I know how to encourage good team performance.
	5	I am able to allow other team members to contribute to the task when leading a team

The data indicate a slight average increase on both dimensions, namely 0,16 for collaboration (pre=3,79; post=3,95) and 0,14 on leadership (pre=3,40; post=3,54). The increase is consistent across all items (Figures 4 and 5, where the 5 statements for each dimension are displayed on the horizontal axis).

Figure 4. Pre-post average results for the 5 items on Teamwork Self-efficacy
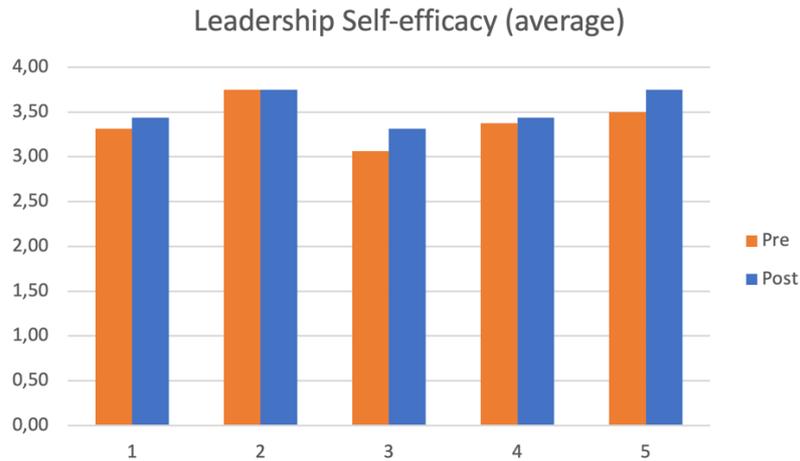
Figure 5. Pre/post average results for the 5 items on Leadership Self-efficacy

Variance on the average scores for each dimension is rather high. This suggests that individual responses might be very different from the class response. Actually, the analysis of individual cases reveals both participants with a very high increase of teamwork self-efficacy (+0,80) and with a very high decrease (-0,80); the same happens for the leadership items, with an even more pronounced gap (from +1,60 to -0,80).

While the numbers are too little to draw any conclusion, it might be interesting to notice that 7 of the 8 participants who had a decrease in one or both self-efficacy indicators never played escape rooms before the workshop. However, the two other participants who never played escape rooms before had the highest increases in the same indicators.

From the teacher's point of view, the participants "strengthened their communication and collaboration skills, as they had to work as a team to accomplish the design and development of the escape room in a very short time." She also noticed that on day 1 the group was split in two subgroups, as students were from two villages, but "after playing the escape rooms on day 2, they blended in more and more. Everyone was able to find his or her role in the team, nobody was left out and all actively participated in the challenge."

Being more aware of each individual participant's story, the teacher was also able to identify some special moments. For example, she tells the following story:

> *"Only one participant was from grade 7, so younger than all the others. She was quite shy and somewhat scared by the older teammates. While one of the groups was playing the virus escape room, she took up the microphone and interacted as a game master with the players. I found it very nice to see her flourish socially over the week. She was also appreciated by the older participants."*
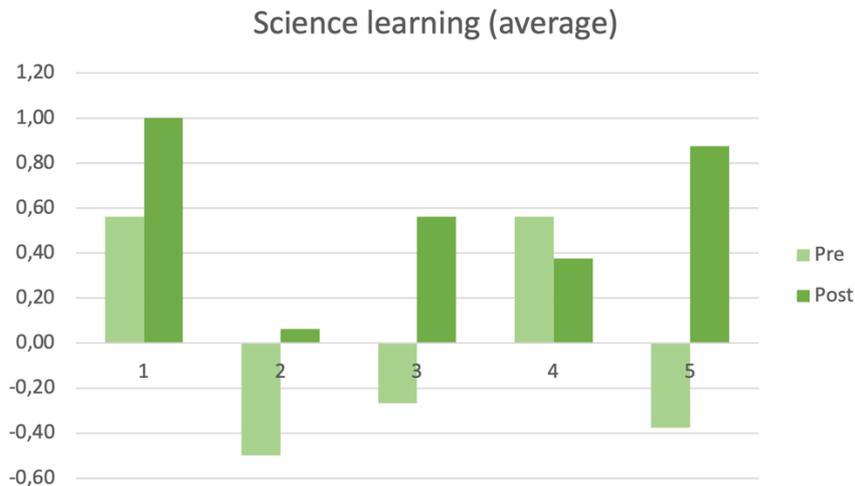
3.2 Science learning

The design of the escape room was an opportunity to learn science, namely about viruses. This was also measured via the pre-post survey through five items prepared in advance with the teacher. They were true/false items and were scored with 1 for a correct answer, -1 for a wrong answer and 0 for "I do not know". The items are shown in Table 2. The knowledge addressed by the five items was included in the initial 1-hour lesson about viruses, which provided the content base for the game development.

Table 2. Science learning items (true/false)

#	Statement
1	A virus is a living being
2	There are viruses that are useful to humans ("good viruses")
3	A virus can multiply by itself
4	Humans can modify viruses
5	Antibiotics kill viruses

The average class score on the five items increased dramatically, as shown in Figure 6, rocketing from 0 on day 1 (with half of the class below 0) to 2,88 on day 5 (with everyone above 0). The number of "I do not know" answers dropped from 17 to 3. Of course, this is the result of a knowledge test right after the learning activities – but this is comparable to how standard tests are usually taken. It is interesting to notice that while there was a strong increase for all items, this was not the case for item 4, which had a slight decrease. Indeed, the topic (how humans can modify viruses, for example to create vaccines) was not included in the escape room puzzles. As the teacher puts it "the participants had an opportunity to learn more about animal cells and grasped the difference between a virus and eukaryote cell, and between an antidote and a vaccine".

Figure 6. Pre/post average results for science learning items

4. Discussion and conclusions

Motivation and engagement were the first visible features of the escape room design workshop: all participants worked very hard, skipping pauses and arriving always on time, and were committed to present their schoolmates a fun and playable escape room. In the final survey, 15 of the 16 participants would recommend their peers to register for the same workshop the following year. The comments they wrote included expressions such as "fun", "engaging", and "I learned new things".

The data collected to illustrate the case study suggest that the escape room design project had a rather limited, but still positive impact on the development of teamwork and leadership self-efficacy. One path that might be explored and that our data seem to suggest is that this might have a correlation with previous escape room experiences. On the other hand, the data indicate a definitely positive impact on subject matter learning, namely science.

Designing and developing and escape room is different from just playing an escape room: it takes more time and requires extended collaboration. It is about engaging peers and becoming an author, which is a completely different agency perspective from being a player. While playing an escape room can allow to *observe* teamwork and leadership, a game design week offers an opportunity to work on it. Also, in ER playing sessions, learning starts in the game, but requires a debriefing in order to be acquired (Botturi & Babazadeh, 2020); during an ER design project the participants are asked to acquire new knowledge, make sense of it and apply it within the design cycle itself. We therefore believe that playing and designing (educational) escape rooms are two different and complementary ways of capitalizing on the affordances of this game format in education.

The experience reported in this paper is very limited and specific. It is about one group of 16 people from different classes (i.e., it is not a regular school class) in a rural school; it could be expected that the same workshop would yield different results in a different context or with a group of a different site. Also, it was a 1-week intensive workshop with relatively limited reflection time; a different schedule, possibly more extended over time, might lead to different outcomes. Finally, the topic was science, namely viruses: how much did this impact on the motivation and learning outcomes of the workshop?

The experience reported in this paper is illustrative of the opportunities that escape room design might offer to teaching and learning. While useful to describe and understand the case study, the data collected do not support any generalization, nor we claim that such an approach might be universally beneficial.

Nonetheless, our results seem to be aligned with those from the other studies referenced throughout the paper, suggesting that EERs and EER design are worth the interest they receive from the educational community. More studies are required in order to explore the conditions, constraints and factors that make such an approach effective. We suggest that such studies should consider both content and soft skills learning; they should also try and clearly identify the different instructional designs (learning goals, time available, schedule, integration into the class activities, etc.) in which EERs are being designed or played. Comparing different cases, possibly in different school systems and cultures, in a wide or even longitudinal study, would probably yield very interesting results.

Playing and designing EERs takes time, both for the class and for the teacher: we know it is fun and motivating, but is it worth in term or learning? Is it efficient with respect to other approaches? Does it work after the "first time" effect has vanished? We believe that investigating such questions might lead to stronger awareness not only in relation to EERs but of GBL in general.

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