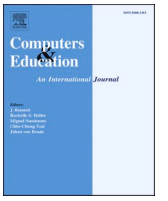
Computers & Education 200 (2023) 104798

Contents lists available at ScienceDirect

Computers & Education

journal homepage: www.elsevier.com/locate/compedu



Escape Addict: A digital escape room for the prevention of addictions and risky behaviors in schools

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ARTICLE INFO

Keywords:
Gamification
Digital educational escape room
Addiction
Risky behavior
Secondary education

ABSTRACT

Preventing addictive behaviors among teenagers is a crucial mission of public health organizations and public education institutions. However, it is chal-lenging to design effective and portable interventions for classroom settings. This research evaluates the effects of a novel classroom intervention called Escape Addict. Escape Addict is a digital escape room learning activity that aims to prevent, and raise awareness of, addictive and risky behav-iors. We conducted a controlled field experiment with 10 classes surveyed before (N = 202 pupils) and after (N = 199 pupils) the intervention, as well as 20 semi-structured interviews. Our results measured three weeks after the intervention show that Escape Addict significantly increased knowledge by 10%. Escape Addict also enabled pupils talk about addictions and risky be-haviors. The intervention had no major effect on risk perceptions and other behaviors. However, Escape Addict had heterogeneous effects. For instance, those pupils who enjoyed the intervention more, played fewer video games afterwards. Also, the effect on knowledge acquisition was stronger for pupils with higher educational achievement. Gender had limited effect. Our find-ings provide overall support that digital escape rooms represent interesting platforms to convey prevention messages in a compelling way.

1. Introduction

Adolescence is characterized by a relatively high level of risk-taking, sensation- and novelty-seeking, as well as by a strong need for experimenta-tion (Beck et al., 2014; Eaton et al., 2012). The path chosen during the rocky road through the teenage years can have long-term effects on people's health and well-being. For instance, (1) the vast majority of people using tobacco today began doing so when they were adolescents (Vallata et al., 2021), (2) alcohol consumption among adolescents is a major concern in many coun-tries (WHO, 2018), (3) particular patterns of video gaming are recognized as addictive behavior that may lead to psychological distress (WHO, 2021a) and (4) increased consumption of energy drinks may also become a public health risk, especially among young people (Chaudhry et al., 2022).

But adolescence is also a period of great opportunity (Patton et al., 2016; Sawyer et al., 2012). According to the World Health Organization (WHO) young people who adopt healthy habits early on, tend to maintain these over the long term and have a lower risk

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https://doi.org/10.1016/j.compedu.2023.104798
Received 7 February 2022; Received in revised form 24 March 2023; Accepted 4 April 2023
Available online 14 April 2023

of behavioral addiction, and a re-duced risk of non-communicable diseases in adulthood (WHO, 2021b). Ado-lescents are therefore a prime target for prevention and health promotion measures (Catalano et al., 2012).

With this in mind, preventing addictive behavior among teenagers is a crucial mission of public health organizations and public education institu-tions (Duncan et al., 2018). It is particularly important to develop evidence-based interventions in the community, online, or in the classroom for a vari-ety of addictions, such as smoking (De Santo et al., 2022; Duncan et al., 2018; Singh et al., 2020). However, interventions in school tend to disappear as a result of funding constraints (Duncan et al., 2018). This context pro-vides opportunities to design effective lightweight interventions using digital technology. Indeed, even though digital technology has become ubiquitous, the digital technologies that teenagers frequently interact with (e.g., social media) are rarely used as a vehicle for smoking prevention (Duncan et al., 2018). Among such potential interventions, activities relying on digital es-cape rooms have recently gained attention as promising collaborative and playful learning experiences for higher education (Vidergor, 2021). However, most of the research so far has focused on higher education in traditional fields such as computer science, engineering or medicine (Vidergor, 2021). It is not clear how such experiences can be designed to (a) support health promotion campaigns, and (b) target adolescents.

This paper seeks to address this gap by investigating the impacts of a novel digital escape room intervention in the particular context of the pre-vention of addictive and risky behaviors for teenagers. This paper contributes to the literature on digital escape rooms by demonstrating that its influence may extend beyond knowledge acquisition to some instances of behaviors. This paper also demonstrates that they may have heterogeneous effects de-pending on educational achievement and in some instances, gender. Additionally, this paper contributes to the general literature on human-computer interaction by showing that enjoyment plays a key role in gamified learning environment. Pupils who enjoy the experience to a larger extent also learn more and experience more positive behavior change subsequently. As a re-sult, we show that enjoyment of the experience contribute to the effectiveness of the learning environment and does not substitute it.

2. Related work

In recent years there has been a proliferation of the use of game elements and game design techniques in software that address real-life problems, from business to social impact challenges (Deterding et al., 2011). Research in human-computer interaction and game studies have often employed the term “gamification” to summarize a sizeable body of existing concepts. Gamifica-tion is defined as the use of game design elements in non-game contexts (Deterding et al., 2011). The experience may be game-like, but the purpose rests outside of the game and has validity and intention that are independent of the game’s experience. Gamified applications are systems that include game ele-ments but are not full proper games (Deterding et al., 2011; Fitz-Walter et al., 2014). In contrast, serious games, educational games or game-based learn-ing are defined as games that have the purpose to educate players, develop their skills or improve their knowledge (Ritterfeld et al., 2009). Early studies have demonstrated the valuable contributions of game-based approaches in education and training (Arnab et al., 2015; Malliarakis et al., 2021).

2.1. Educational escape rooms

Escape rooms can be described as games in which players, acting as a team, are trapped in a room and have to solve a series of enigmas to achieve a goal, usually to escape the room, within a limited amount of time (Beguin et al., 2019; Nicholson, 2018). Escape rooms are usually theme-based and involve a recreational role play driven by a narrative.

Escape rooms used in educational contexts are called educational escape rooms. Recreational escape rooms and educational escape rooms share many similarities as well as having some important distinctions. The most impor-tant distinction is that enigmas and solutions of educational escape rooms are designed for a specific target group and focus on well-defined learning objectives, whereas recreational escape rooms are for enjoyment purposes only. Furthermore, recreational escape rooms are typically held in one or more physical rooms with teams playing one after the other. In educational contexts, facilitators have generally more limited amount of time and re-sources to design, set up and support activities since classrooms are utilized for different courses, and all teams play at the same time. Educational escape rooms offer participants an engaging and entertaining learning environment, encouraging collaboration, cultivating soft skills, and their intellectual de-velopment (Kinio et al., 2019), while providing the facilitators a mobile and time-boxed learning experience.

Unsurprisingly, they have become an increasingly popular educational activity (Makri et al., 2021) and are integrated into many different edu-cational disciplines, such as healthcare (Hawkins et al., 2020; Morrell & Eukel, 2021; Roman et al., 2020), computer science (López-Pernas et al., 2019; Malliarakis et al., 2021), chemical engineering (de la Flor et al., 2020), pharmacy (Baker et al., 2020), physics (Vörös & Sárközi, 2017), mathemat-ics (Fuentes-Cabrera et al., 2020; Piñero Charlo, 2020) and biology (Alonso & Schroeder, 2020). Research results show that these interventions can have significant positive outcomes on academic performance through im-proved motivation, positive behaviors and engagement (Makri et al., 2021).

2.2. Digital educational escape rooms

With the rise of digital technologies, the notion of the digital escape room also emerged. As suggested by Huang et al. (2020), a digital escape room can be considered as “an innovative teaching approach incorporating digital materials with reality”. For instance, digital artifacts such as video, QR codes, augmented reality can supplement physical escape rooms while bringing an additional technological dimension. Digitalization of educational escape rooms therefore contributes to reaching an even more cost-efficient,

portable and easy-to-use learning experience (Ang et al., 2020), potentially lowering actual funding, time and human resources barriers for school-based health promotion (Duncan et al., 2018). At the extreme of this digitalization trend, fully digital escape rooms make use of computerized applications to simulate a series of locks to be opened, puzzles to be solved and missions to be carried out (Kroski, 2020). It should be noted that the definition of a digital escape room does not exclude the use of physical artifacts (Huang et al., 2020). As such these digital escape rooms can be thought of as digitally enhanced escape rooms or blended escape rooms. This is also the approach we take in this paper.

Past research on escape rooms has mostly focused on physical escape rooms, digital escape rooms being a novel phenomenon still to be academi-cally explored (Makri et al., 2021). Furthermore, to our knowledge, research has not yet investigated how these light-weight, portable concepts could sup-port prevention programs for teenagers. These observations lead to the fol-lowing research question:

(RQ1) How effective are digital escape rooms at improving teenagers' knowledge and changing their perceptions and behaviors related to addiction and risky behaviors?

2.3. Effect of educational achievement

Previous research has shown that gameful interventions are more moti-vating for pupils with higher cognitive abilities (Vidergor, 2021). This might be an issue, since those people who are less scholarly inclined are associated with an increased risk of addictive behaviors such as drug abuse (Kendler et al., 2018). Nevertheless, the design of escape rooms may also incorporate digital technologies such as virtual reality, augmented reality or embedded screens (Buchner, 2023; Hanus et al., 2019; Mystakidis & Christopoulos, 2022). Such use of digital technologies, with which adolescents like to en-gage, could make them feel more connected to a health promotion interven-tion (Duncan et al., 2018). Digital escape rooms represent a novel educa-tional tool that may mentally transport pupils outside of the usual school setting and could benefit pupils who are less diligent at school. Overall, it remains unclear whether educational achievement conditions the impact of these interventions, leading to the following research question:

(RQ2) How does educational achievement influence the effectiveness of digital escape rooms aiming to prevent teenagers' addictive and risky behav-iors?

2.4. Effect of gender

Males enjoy and play video games more than females (Lucas & Sherry, 2004). Regarding serious games, the literature suggests less clear-cut results. Male pre-adolescents and adolescents seem more empowered and more en-gaged in the gameplay of serious games (D'Aprile et al., 2019), but this does not seem to apply to escape games, which attract both genders equally (López- Pernas et al., 2019). Neither does gender seem to condition the effect of digital escape rooms on gameful experience, collaboration and motivation of elementary school students (Vidergor, 2021). Previous work on gamification has identified several factors that should be considered when it comes to gen-der inclusion. For instance, identification with characters in the game seems to be an important process in explaining females' gaming motivations (Van Reijmersdal et al., 2013). But also, game elements such as badges seem to have a positive relation with perceived playfulness and are more enjoyable for females (Codish & Ravid, 2017). However, it is still unclear if these conclusions apply to various contexts and scenarios, leading us to our third research question:

(RQ3) How does gender influence the effectiveness of digital escape rooms aiming to prevent teenagers' addictive and risky behaviors?

2.5. Effect of enjoyment

When playing games, the player is in a playful state of mind (Moraes et al., 2022; Salen et al., 2004), also called playfulness (Hamari & Koivisto, 2015) which procures enjoyment. Enjoyment can be described as an out-come but also as a dimension of the game experience. In an effective serious game, enjoyment acts as a catalyst to encourage learning initiative (Fu et al., 2009). Previous research found that students were intrinsically motivated by educational digital escape rooms (Vidergor, 2021). Research also in-dicates that intrinsic motivation is directly linked to enjoyment, the pleasure of the game or the desire to improve skills (Lafrenière et al., 2012). As a result, the role of enjoyment as a potential facilitator of knowledge acquisition or of be-havior change in the pre-vention domain requires further exploration leading to our last research question.

(RQ4) How does enjoyment influence the effectiveness of digital escape rooms aiming to prevent teenagers' addictive and risky behaviors?

3. The escape addict learning experience

Escape Addict (EA) is a digital escape room learning experience that aims to raise awareness, provoke reflections and eventually lead to behavior change related to risky and addictive behaviors and their consequences.

EA is not restricted to one specific addictive behavior, but rather seeks to ad-dress the underlying mechanisms of addiction that can be very similar from one addiction to another. EA exposes pupils to the problems of tobacco, alcohol, cannabis, screen use (social networking, video games) and related consequences (e.g., bullying, addiction). This experiential prevention ap-proach confronts pupils with situations that they encounter or are likely to encounter in their daily lives, such as risk-taking opportunities, peer pressure

or problematic behaviors on social media.

EA was designed by Promotion santé Valais, a regional health promotion agency in Switzerland. It is a standalone intervention that can easily be deployed in a classroom and repeated across classrooms and schools. EA targets school pupils aged 12 to 15. It aims to reach the following learning outcomes: (a) raise awareness and elicit reflections in relation to addictive and risky behaviors, such as alcohol and tobacco consumption, or social media usage; (b) reduce or at least delay the start of any addictive and risky behavior; (c) connect at-risk pupils to available support. While achieving these educational goals, EA also aims to be fun, engaging, collaborative, portable and allowing active learning to foster depth.

3.1. The learning experience

An EA session lasts 1 h and an half (i.e., two school periods), in-cluding 15 min of instruction at the beginning and debrief at the end. The class is split up into self-selected groups of 4–6 pupils. Each group receives a digital tablet.

The game starts with a narrative audio recording setting the stage of the experience: the class is locked-down until pupils conduct a set of four investi-gations. Each investigation has its own scenario based around a teenager who has some issues related to risky or addictive behaviors and requires teams to perform certain tasks to correctly gives answers to quizzes (see Table 1 for an overview and Appendix A for a detailed presentation).

The experience provides different immersive interactions through the tablets (e.g. augmented reality, 360° camera). In addition to the tablets, the expe-rience makes use of several physical artifacts to provide a richer experience. For instance, the classroom is set up with a transportable 300 × 235 cm self-standing exhibition banner, illustrating a teenager's room (Fig. 1b), a safe sealed with a padlock (Fig. 1c), a digital clock with a countdown timer (Fig. 1c), and a ribbon figuratively sealing the classroom (Fig. 1d).

Each group of pupils has to follow the instructions on their tablet to solve the four investigations. The same investigations are provided to each group. As groups are solving investigations, they collect pieces of a physical puzzle that the whole class will have to assemble at the end of the game to unlock the room (Fig. 1a).

Finally, once all the teams have solved the four investigations, the class is brought together to solve the final puzzle. The resolution of the final puzzle provides access to the safe containing a pair of scissors which will be used to cut the ribbon that was locking the classroom. The session ends with a debrief led by the facilitator. The debrief aims to reinforce the key health messages following the game experience, but also to ask the pupils about their feelings, their learning and their future behaviors. For a more in-depth description of Escape Addict, see (Bezençon et al., 2022, chap. 28).

4. Overview of empirical studies and methodology

To evaluate the effect of EA and answer our research questions, we used a mixed method design. Our first study is a field experiment that quanti-tatively measures the effects of EA on pupils' knowledge, perceptions and behaviors related to addiction and risky be-haviors, depending on gender, educational achievement and enjoyment. Our second study is qualitative and first seeks to understand pupils' learning and engagement with EA in more depth, triangulating some of the results obtained with the field experi-ment with qualitative data. The aim of this second study, which involves 20 qualitative interviews with pupils who experienced EA, was also to gain ad-ditional insights into the characteristics of EA that drive its effects. In terms of timing, the field experiment was conducted before the qualitative inter-views. The participants in the two studies were different. The two studies, with their respective methods and results are presented in separate sections: Section 5 for the field experiment and Section 6 for the qualitative study.

5. Study 1: field experiment

The field experiment aimed at evaluating the effect of EA on pupils' knowledge, risk perceptions and actual behaviors.[2] It also aimed to assess whether these potential effects interacted with gender, educational achieve-ment or enjoyment of the experience.

5.1. Participants

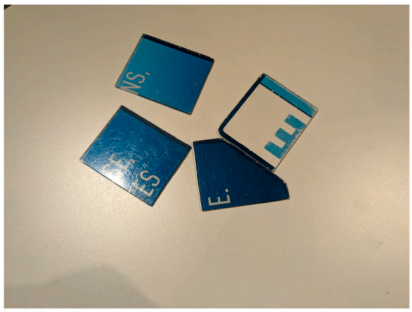
We selected four schools within a particular region of Switzerland to participate in the experiment – two schools in cities and two schools in suburbs. The four schools were randomly allocated to the control or treatment group, while ensuring the type of school was matched (i.e. one city school and one suburban school in each group). The allocation to the treatment or control groups was done by school rather than by class to minimize contamination effects. More specifically, the fact that control and treatment schools are geographically separated mitigates the possibility that the treatment affects post-test survey responses in the control group. Three classes from each city school and two classes from each suburban school were randomly selected to participate in the experiment and to receive the questionnaires. This led to five classes being allocated to the treatment group and five classes to the control group.[3] Overall, 202 pupils filled the pre-test survey and out to them 199 also filled the post-test survey.

[2] The evaluation of EA also measured for intentions, stereotypical perceptions and some other characteristics of the participants, which we do not discuss here to keep the focus on the most relevant measures.

[3] Classes belonging to the control group did the EA activity after the experiment was over.

Table 1
Summary of Escape Addict investigation scenarios.

	main character	topics covered	digital content	estimated duration
1	Adrien, 13, male	psychological dependencies such as video games addiction, sleep deprivation and energy drink consumption.	augmented reality, quiz	10–15 min.
2	Jordan, 12, male	alcohol and tobacco consumption, social networks cyber-bullying	360° video, videos, puzzle game, quiz	20–25 min.
3	Lyse, 13, female	alcohol and tobacco consumption, social networks and media manipulation	point and click, videos, photos, quiz	20–25 min.
4	Lisa, 12, female	co-addiction	audios, quiz	10–15 min.



(a) Puzzle pieces earned after each solved investigation.

(b) Transportable standing banner illustrating a teenager's room.

(c) Safe to unlock to exit the room and countdown timer with remaining time to complete the game.

(d) Ribbon figuratively sealing the classroom.

Fig. 1. Escape Addict physical setting.

5.2. Study design and procedures

The field study included a pre-test and a post-test survey administered respectively before and after the intervention. The treatment group did the EA activity between the pre-test and the post-test surveys, while the control group did not do the EA activity but nevertheless received the pre-test and post-test surveys at about the same time and interval. The study design is presented on (Fig. 2).

Staff in each school distributed the pre-test surveys (on paper) two weeks before the intervention, while the post-test surveys (also on paper) were dis-tributed three weeks after the intervention. Pupils were informed that their answers were confidential and anonymous (their name was never requested). Following previous research (Galanti et al., 2007; Wilson et al., 2010), we asked three

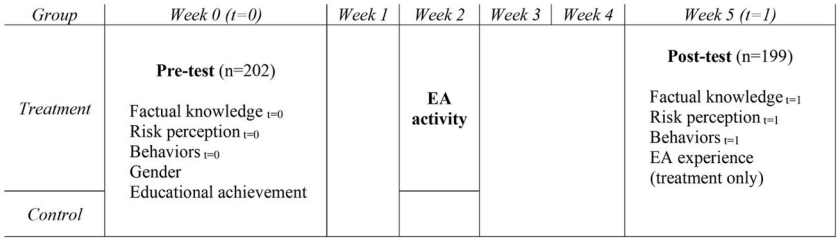


Fig. 2. Design of the field experiment.

personal questions to allow indirect identification and connect pre-test and post-test surveys: first name of their paternal grandmother, parents car brands, name of their favorite pet. This allowed us to connect 81.3% of the pre-test and post-test surveys. The other questionnaires could not be connected, either because the pupils were absent in the pre- or post-test or because the connection questions did not match. The final dataset excludes data on these identification questions. The questionnaire was pre-tested by three teenagers from the same age group but from a different region (i.e., not belonging to the population) as well as by a teacher for that age group, in order to make sure the questions were clear and understandable. Minor adjustments were made based on the comments. The head of the schools participating in the experiment as well as the head of regional edu-cation services approved the evaluation approach and the distribution of the surveys to the pupils.

5.3. Measures

The surveys measured: (1) factual knowledge, (2) risk perception, (3) be-haviors in the domain of addiction and risky behaviors (Fig. 2). Pre-test and post-test surveys were similar for both treatment and control group, ex-cept for extra (4) gender and (5) educational achievement questions which were asked only in the pre-test survey. For the post-test of the treatment group, (6) EA experience was also measured. Table B.8 in Appendix B lists the measures and scales.

5.3.1. Factual knowledge

Knowledge was measured with five specific multiple choice questions, cov-ering different domains considered in EA (shisha, to-bacco industry, social network, video games, alcohol). Answers were coded as correct if they cor-responded to the information pro-vided in EA or more conservative from a health promotion perspective. Our knowledge variable is then defined as the proportion of correct answers across all five questions.

5.3.2. Risk perception

We adapted existing measures (Knoll et al., 2015) to evaluate percep-tion of risk associated to specific behaviors. Seven questions measured risk perception in different domains (two questions about smoking, one ques-tion about cannabis consumption, one question about alcohol consumption, two questions about social networking and internet-related behaviors and one question about video gaming) with an 11-point answer format anchored from 1 - low risk to 11 - high risk. Our risk perception variable consists of the average of the seven items.

5.3.3. Behavior

Three types of behaviors addressed in EA were measured: (1) how much pupils talked about the topic of addictions, (2) the time spent playing video games, and (3) the privacy settings on social networks. The first behavior was measured with three yes-no questions asking whether pupils had talked about the topic of addictions (not about EA) with (a) friends, (b) parents, (c) teachers in the previous two weeks, that is, not directly after EA, but between one and three weeks after EA. Based on these questions, we created an index measuring the number of different types of interlocutors, going from 0 whenever they spoke to none of the cited interlocutors to 3 if they spoke to all of them. The time spent playing video games was measured by combining information on the number of days in which they played during a normal week and how many minutes they played on average during those days. The privacy settings on social networks were measured specifically by asking whether pupils activated privacy protection settings on social networks on which they were active.

5.3.4. EA experience

The post-test survey of the treatment group also included questions on their experience with EA. In particular, we measured how much pupils en-joyed the experience with EA (from 1 - did not enjoy at all, to 7 - enjoyed a lot), how realistic they found the situations they were confronted with (from 1 - not at all realistic, to 7 very realistic), how much they had the impression that they participated to the discussions within their teams (from 1 - not at all, to 7 - a lot), how much they thought they acquired new knowledge (from 1 - very little, to 7 - a lot), whether they spoke about EA specifically to their parents, friends or teachers (from 0 - none of them, to 3 - all of them), and the fraction of questions asked during the game they thought they understood (from 0 to 100 percent).

5.3.5. Educational achievement

In region Valais, four educational subjects (math, French, German and science) have a basic and an advanced level. In each class, pupils will take the basic or the advanced level of these subjects depending on their own level in each particular subject. Based on this, we coded educational achievement as ranging from 0 if the pupil is advanced in none of the subjects to 4 if the pupil is advanced in all subjects.

5.4. Analysis

The objective of the analysis is to identify the impact of EA on the pupils in the treatment group relative to the control. This requires two steps. First, we estimate how each outcome changes following the EA intervention by com-puting the difference between pre-test and post-test values among treated pupils. Second, we subtract the corresponding change observed among con-trol pupils. Intuitively, this approach of using double difference or difference in differences (Lechner et al., 2011) identifies the average treatment effect of the intervention (RQ1) by factoring out the trend observed among non-treated pupils. This is based on an assumption that, absent of treatment, treated pupils would have followed the same trend as those in the control group.

Statistical inference on these double differences is derived from a set of lin-ear regression models. We start by denoting measured outcomes by Y_{it}, where i is an index for pupils and t stands for survey waves (pre- and post-test). The outcomes we consider are: (i) knowledge (ii) risk perception (iii) discus-sions with interlocutors, (iv) activating private settings and (v) total gaming time. For each outcome, we then estimate the following baseline regression model:

$$Y_{it} = \alpha + \beta \cdot treated_i + \gamma \cdot time_t + \delta \cdot treated_i \times time_t + \varepsilon_{it} \quad (1)$$

where $treated_i$ is an indicator variable equal to one if i is in the treatment group, zero otherwise, $time_t$ is equal to one if t is after the EA intervention, zero otherwise, and ε_{it} is an error term. The term $treated_i \times time_t$ represents an interaction between the two indicator variables, so that it takes a value of one for treated unit in the post-test, zero otherwise.

The parameters α, β, γ and δ are estimated from the data using ordinary least squares regression. The parameter α measures the average outcome for the control group in the pre-test, β is the pre-test difference in the average outcome between treated and control groups and γ is the difference in average outcome between pre- and post-test for the control group. Of particular interest is the parameter δ, which is the double difference estimator and therefore quantifies the average treatment effect of the intervention.

We further expand Equation (1) to estimate how EA differentially affected alternative groups of pupils, as discussed in RQ2 to RQ4. Formally, we define a moderating variable X_i that potentially affected the size of the treatment effect, namely (i) educational achievements, (ii) gender or (iii) enjoyment of EA. This gives the following regression:

$$Y_{it} = \alpha + \beta \cdot treated_i + \gamma \cdot time_t + \delta \cdot treated_i \times time_t + \eta \cdot time_t \times treated_i \times (X_i - average(X)) + \theta \cdot X_i + \varepsilon_{it} \quad (2)$$

where the notation follows from above and η measures how the aver-age treatment effect changes as the moderating variable increases by one unit.[4] For example, if Y_{it} is our measure of knowledge and X_i is educational achievements, a positive and statistically significant estimate would indicate that EA leads to higher knowledge acquisition among students with high achievements (RQ2).

5.5. Results

This section reports the results from the field experiment. First, we pro-vide summary statistics on the sample and outcomes considered. Second, we report the results of Equation (1) focusing on the average treatment effects. Lastly, we report heterogeneous impacts across educational achievements, gender and EA enjoyment, based on Equation (2). Thus, the presentation of the results follows the flow of the research questions. Results related to RQ1, which invetigates the main effect of EA are presented in Section 5.5.2. Results related to RQ2, RQ3 and RQ4, which investigate the moderating effects of educational achievement, gender and enjoyment, are presented in Sections 5.5.3, 5.5.4, and 5.5.5 respectively.

5.5.1. Descriptive statistics

A total of 401 surveys were distributed: 202 in the pre-test and 199 in the post-test. We could not connect 39 questionnaires in the pre-test and 36 in the post-test, leaving 163 pupils with matched pre- and post-test records. Of those, we discarded eight questionnaires because some pupils were not present in the class during the EA activity or because they did not engage with the approach (not answering questions and writing jokes instead). This leads to a final sample of 155 pupils, including 80 in the control group and 75 in the treatment group.[5] Refer to Table 2 for the descriptive statistics.

Starting with the control group, our data suggests that pre- and post-test averages are very similar, with p-value from paired t-tests for differences be-ing below conventional levels. The only exception is time spent playing video games, which increases from 670.5 to 865.5 min per week, with the dif-ference being statistically significant (p-value $< .05$). More interestingly, the treatment group data suggest a statistically significant increase in knowledge, as the share of correct answers increases from 60 percent to 67 percent (p-

[4] Note that we subtract the average of the variable X_i when we construct the interaction term. This ensures that the main effect δ still quantifies the average treatment effect. This normalization does not affect the interpretation of the parameter η.

[5] Note that the sample size slightly varies across variables due to missing values for individual variables.

Table 2
Descriptive statistics for control and treatment groups.

	Control group			Treatment group		
	N	Mean pre-test	Mean post-test	N	Mean pre-test	Mean post-test
% female	80	0.49	0.49	75	0.51	0.51
Educational achievement (0–4)	70	1.96	1.96	72	2.28	2.28
Knowledge (% correct)	80	0.59	0.57	75	0.60	0.67
risk perception (1–11)	80	6.33	5.94	74	6.80	6.71
Addictions discussions (1–3)	80	0.37	0.37	74	0.36	0.46
Privacy settings (0–1)	78	0.79	0.73	69	0.72	0.71
Video games (min/week)	64	670.5	865.5	62	410.7	600.1
Enjoyment (1–7)	–	–	–	75	–	5.68
Realistic (1–7)	–	–	–	75	–	5.65
Participation (1–7)	–	–	–	75	–	5.77
Knowledge (1–7)	–	–	–	75	–	4.76
EA discussions (1–3)	–	–	–	75	–	0.64
Understanding (0–10)	–	–	–	75	–	7.96

Notes: This table reports summary statistics for the field experiment. See Table B8 for the list of measures and scales.

value < .01). Similarly, we observe a significant increase of addiction-related discussions with teachers, parents or peers (p-value < .05) and also an increase in the time spent playing video game (p-value < .05). By contrast, we do not find a statistically significant change in risk assessment.[6]

Regarding the EA experience, we can observe that pupils enjoyed the experience with EA, with a mean score of 5.68 on a maximum value of 7. Pupils also found the situations presented realistic (5.65 on 7). They also had the impression that they could participate actively to the discussions within their teams (5.77 on 7). The perceived knowledge acquired also seems interesting (4.76 on 7). Finally, pupils spoke about EA on average with 0.64 parties (among parents, friends or teachers), and understood the questions asked during the game well (7.96 on 10).

5.5.2. *Effects of EA on addiction prevention*

In Table 3, we aim to answer our first research question by reporting ordi-nary least squares (OLS) regression results quantifying the average treatment effect of EA on five alternative outcomes (Equation (1)). Specifically, Column 1 focuses on knowledge acquisition, Column 2 reports risk perception, and Columns 3 to 5 focus on behaviors, capturing respectively changes in the share of interlocutors, in the activation of privacy settings on social media, and in the time spent playing video games. Cluster-robust standard errors are reported in parenthesis.

Results in Column 1 confirm that the intervention increased the pro-portion of correct answers by around ten percentage points on average (p-value < .01), and had a positive impact on the variety of interlocutors with whom the themes of EA were discussed (around 0.1 points, with p-value < .1). The intervention is also associated with higher risk perception, higher prob-ability of activating privacy settings, and reducing gaming time, although these impacts are not statistically significant at conventional levels. Next, we discuss a set of OLS regressions documenting the role of alternative moderating variables (equation (2)), to answer research questions two to four. Results for educational achievements are reported in Table 4, gender is considered in Table 5, and the role of enjoyment in EA participation is in Table 6. Each ta-ble follows the same structure as above, including the five outcome variables, and reports cluster-robust standard errors in parenthesis.

5.5.3. *Effects of educational achievement*

Results for educational achievement (Table 4) suggest that the effect of the intervention on knowledge acquisition was stronger for pupils with higher educational achievement. Pupils with higher achievement tend to provide more correct answers to start with, and they also provide more additional correct answers after participating in EA (relative to pupils with lower educa-tional achievements). By contrast, at the lowest level of educational achieve-ment (level 0) EA does not significantly impact the knowledge of pupils. However, EA's positive influence on knowledge already becomes marginally significant at the next level (level 1) of educational achievement ($p = .08$) and significant afterwards ($p < .01$). This means that EA's positive im-pact becomes significant at relatively low levels of educational achievement. Educational achievement did not moderate the effect of EA on risk percep-tions (Column 2) or behaviors (Columns 3–5). The only effect of educational.

5.5.4. *Effects of gender*

Gender had limited impact on the effect of EA, as reported in Table 5. Only two behaviors are worth mentioning in relation to gender. First, females were less likely than males to change their privacy settings following their participation in EA, as suggested by the negative and statistically significant coefficient on the interaction term reported in Column 4. Second, Column 5 shows that girls play significantly less video games relative to males, although gender did not affect the influence of EA on gaming.

[6] We observe a large difference in gaming time between control and treatment (in both baseline and post-treatment). This is in part driven by the presence of some extreme gamers in the control group who play more than 7 h per day on average over the week.

Table 3
Average treatment effect of EA intervention.

Outcome:	Knowledge % correct	Perceived risk 1–11 scale	Addictions discussions 0–3. Diff. Interlocutors	Privacy setting activated = 1	Video games Minutes/ week
	(1)	(2)	(3)	(4)	(5)
Avg.treatment effect	0.098***	0.304	0.099*	0.050	−5.597
(δ)	(0.030)	(0.249)	(0.056)	(0.065)	(104.642)
Constant	0.588***	6.328***	0.367***	0.795***	670.469***
(α)	(0.019)	(0.166)	(0.040)	(0.046)	(105.152)
Treated (=1)	0.009	0.467*	−0.002	−0.070	−259.791**
(β)	(0.026)	(0.246)	(0.053)	(0.071)	(118.854)
Time (=1)	−0.019	−0.393*	0.000	−0.064*	195.000**
(γ)	(0.020)	(0.201)	(0.040)	(0.038)	(76.189)
N pupils	155	154	154	147	126
$_R2$	0.022	0.049	0.009	0.016	0.041

Notes: OLS regression coefficients reported. In Column 1 the outcome is proportion of correct answer. In Column 2 the outcome is perceived risk measured on a 1–11 scale. In Column 3 the outcome is the share of potential interlocutor. In Column 4 the outcome is an indicator variable equal to one if the privacy settings are activated. In Column 5 the outcome is the time spent playing video games in minutes per week. See Table B8 for the list of measures and scales. Robust standard errors clustered at the pupil level reported in parentheses. *, ** and *** denote statistical significance at 10%, 5% and 1% respectively.

Table 4
Effects of educational achievement on EA intervention impacts.

Outcome:	Knowledge % correct	Perceived risk 1–11 scale	Addictions discussions 0–3. Diff. Interlocutors	Privacy setting activated = 1	Video games Minutes/ week
	(1)	(2)	(3)	(4)	(5)
Avg.treatment effect	0.101***	0.280	0.097	0.027	−21.975
(δ)	(0.031)	(0.264)	(0.059)	(0.065)	(110.850)
× educational achievement	0.029**	0.052	0.024	−0.049	−8.880
(η)	(0.012)	(0.099)	(0.024)	(0.034)	(70.307)
Constant	0.563***	6.153***	0.388***	0.736***	792.734***
(α)	(0.027)	(0.217)	(0.054)	(0.068)	(179.264)
Treated (=1)	0.0003	0.384	−0.002	−0.083	−146.464
(β)	(0.027)	(0.258)	(0.055)	(0.073)	(116.007)
Time (=1)	−0.016	−0.385*	0.005	−0.044	214.636**
(γ)	(0.022)	(0.217)	(0.043)	(0.039)	(82.846)
Educational achievement	0.014*	0.121*	−0.011	0.031	−99.718**
(θ)	(0.007)	(0.068)	(0.016)	(0.022)	(47.645)
N pupils	142	142	142	136	116
$_R2$	0.123	0.064	0.020	0.018	0.078

Notes: OLS regression coefficients reported. In Column 1 the outcome is proportion of correct answer. In Column 2 the outcome is perceived risk measured on a 1–11 scale. In Column 3 the outcome is the share of potential interlocutor. In Column 4 the outcome is an indicator variable equal to one if the privacy settings are activated. In Column 5 the outcome is the time spent playing video games in minutes per week. See Table B8 for the list of measures and scales. Robust standard errors clustered at the pupil level reported in parentheses. *, ** and *** denote statistical significance at 10%, 5% and 1% respectively.achievement on behaviors was a main effect on gaming. Specifically, the higher the educational achievement, the less time pupils spend playing video games.

5.5.5. Effects of enjoyment

Lastly, results on the role of EA enjoyment shown in Table 6 suggest that the impact of the intervention on knowledge acquisition did not change as a function of self-reported enjoyment (Column 1). We find, however, that the treatment effect on risk perception is positively affected by enjoyment (Column 2, p-value $<.1$). That is, the more pupils enjoyed EA, the more they increased their perception of risk (i.e., they found the behaviors they were asked to evaluate more risky). We also find that enjoyment reported during the intervention is associated with a lower likelihood of activating privacy settings (Column 4), and a decrease in gaming time following the intervention (Column 5). Therefore, while we do not observe an effect of the intervention on gaming time (compared to the control group), gaming time declines for pupils who enjoyed EA to a larger extent. This effect is independent of the control group as enjoyment was only measured ex-post in the treatment group. Thus, the difference in pupils gaming profile between treatment and control does not play a role in the effect of enjoyment.

Table 5
Effects of gender on EA intervention impacts.

Outcome:	Knowledge % correct	Perceived risk 1–11 scale	Discussions 0–3. Diff. Interlocutors	Privacy setting activated = 1	Video games Minutes/week
	(1)	(2)	(3)	(4)	(5)
Avg.treatment effect	0.098***	0.303	0.099*	0.050	−5.087
(δ)	(0.030)	(0.249)	(0.056)	(0.064)	(103.912)
× female (=1)	0.056	0.124	0.008	−0.262**	22.377
(η)	(0.043)	(0.336)	(0.081)	(0.112)	(210.689)
Constant	0.580***	6.313***	0.334***	0.776***	931.350***
(α)	(0.023)	(0.188)	(0.044)	(0.057)	(155.421)
Treated (=1)	0.009	0.466*	−0.004	−0.071	−268.207**
(β)	(0.026)	(0.248)	(0.053)	(0.072)	(111.409)
Time (=1)	−0.019	−0.393*	0.000	−0.064*	195.000**
(γ)	(0.020)	(0.202)	(0.040)	(0.038)	(76.498)
Female (=1)	0.016	0.031	0.066	0.038	−521.763***
(θ)	(0.023)	(0.232)	(0.051)	(0.070)	(148.595)
N pupils	155	154	154	147	126
$_R2$	0.071	0.048	0.027	0.022	0.142

Notes: OLS regression coefficients reported. In Column 1 the outcome is proportion of correct answer. In Column 2 the outcome is perceived risk measured on a 1–11 scale. In Column 3 the outcome is the share of potential interlocutor. In Column 4 the outcome is an indicator variable equal to one if the privacy settings are activated. In Column 5 the outcome is the time spent playing video games in minutes per week. See Table B8 for the list of measures and scales. Robust standard errors clustered at the pupil level reported in parentheses. *, ** and *** denote statistical significance at 10%, 5% and 1% respectively.

Table 6
Effects of enjoyment on EA intervention impacts.

Outcome:	Knowledge % correct	Perceived risk 1–11 scale	Discussions 0–3. Diff. Interlocutors	Privacy setting activated = 1	Video games Minutes/week
	(1)	(2)	(3)	(4)	(5)
Avg.treatment effect	0.098***	0.299	0.099*	0.052	−17.361
(δ)	(0.030)	(0.247)	(0.056)	(0.066)	(103.902)
× enjoyment (1–7)	−0.007	0.214*	0.007	−0.089**	−175.338**
(η)	(0.017)	(0.116)	(0.039)	(0.039)	(85.597)
Constant	0.588***	6.328***	0.367***	0.795***	670.469***
(α)	(0.019)	(0.166)	(0.040)	(0.046)	(105.365)
Treated (=1)	0.009	0.467*	−0.002	−0.070	−259.791**
(β)	(0.026)	(0.246)	(0.053)	(0.071)	(119.095)
Time (=1)	−0.019	−0.393*	0.000	−0.064*	195.000**
(γ)	(0.020)	(0.201)	(0.040)	(0.038)	(76.343)
N pupils	155	154	154	147	126
$_R2$	0.058	0.053	0.016	0.016	0.054

Notes: OLS regression coefficients reported. In Column 1 the outcome is proportion of correct answer. In Column 2 the outcome is perceived risk measured on a 1–11 scale. In Column 3 the outcome is the share of potential interlocutor. In Column 4 the outcome is an indicator variable equal to one if the privacy settings are activated. In Column 5 the outcome is the time spent playing video games in minutes per week. See Table B8 for the list of measures and scales. Robust standard errors clustered at the pupil level reported in parentheses. *, ** and *** denote statistical significance at 10%, 5% and 1% respectively.

6. Study 2: qualitative interviews

The aim of the qualitative interviews were (1) to gain additional insights on pupils' learning and engagement with EA, that is, to better understand the type of knowledge acquired and the behaviors performed; (2) to better understand the characteristics of the escape room that drives its potential effectiveness, (3) to provide recommendations to improve the intervention and related concepts. The first two objectives relate to our research ques-tions and the willingness to understand EA's effects, whereas the last one is prescriptive.

6.1. Methods

We conducted 20 semi-structured interviews with pupils who participated in the EA activity. The interviews were inspired by the phenomenological approach, as we were interested in understanding pupils' lived and shared experience of Escape Addict (Creswell, 2007). We let pupils describe their experience of the escape room. The interviews occurred in the semester following the field experiment, with different pupils. Participants were drawn from two classes in two different schools. The pupils' parents were informed of the interviews several weeks before their child's participation in EA and were given the option to withdraw their child

from the interview (one was withdrawn). The interviews were conducted on the school premises during one full day per class. They occurred five days after the pupils had been exposed to EA for the first class and 10 days after the second class. We randomly selected 9 pupils from one class and 12 from the other (in total, 10 boys, 10 girls and 1 absentee). Pupils were called during their normal lessons to the interview room. Given our access constraints, our interviews lasted between 20 and 40 min. Table 7 presents the list of interviewees by gender, educational achievement and interview length. The interview guide evolved after the first day of interviews. Appendix C presents the final version.

During the interviews, pupils were informed of the objectives of the study, the confidentiality of their response, and the option of not answering certain questions or of abandoning the interview at any time (which no one did). In addition to the parents' consent, the head of education services also consented to the interviews. The interviews were recorded with pupils' permission.

6.2. Data analysis

We started the process of analyzing data as soon as we began collecting it (Belk et al., 2013). For instance, the first iteration of analyses based on the first round of interviews led us to add and modify questions in the interview guide for the second round. We followed Thomas (2006)'s approach to analyse qualitative evaluation data via a general inductive approach. The general inductive approach involves condensing the raw data into a brief summary format, establishing connections between the research objectives and those summaries, and finally, developing a framework or model about the underlying structure of the experiences or processes apparent in the raw data.

More precisely, following this approach, we transcribed the audio files to text files, using the same format for every interview. The names of the pupils and any identifying information were deleted from the analysis files. Names were replaced with numbers. We then read the interview transcripts several times until we became familiar with the content and could see patterns from which we derived major themes. The identification of those themes was also influenced by the objectives of the evaluation (Thomas, 2006). In particular, the four themes that emerged as the result of this process were the pupils' ex-perience with EA, their recollection of EA puzzles, their knowledge of health messages and the capacity of EA to trigger reflections, discussions and other behaviors. These four themes represent the most salient aspects of the learn-ing experience. We also identified lower-level categories, which were created by coding different text segments of the transcripts. This phase involves the reduction of data into meaningful segments and labeling the segments (Creswell, 2007). In doing so, we move from "identifying patterns in the data to attempting to find meaning in the patterns" (Belk et al., 2013, p. 147). These lower-level categories were developed iteratively as the data analysis and interpretation unfolded. As a result, overall, the focus of the findings was influenced by our evaluation objectives but their content emerged from the analysis of the data, not from a priori expectations (Thomas, 2006).

6.3. Results

The results are structured along four themes: experience with EA, recol-lection of EA puzzles, knowledge of health messages and capacity to trigger reflections, discussions and other behaviors. Results are illustrated with rep-resentative quotes from pupils which have been translated from French to English (the number refers to the interview number in Table 7).

Table 7
List of interviewees by gender, educational achievement and interview length.

interview	class	educational achievement (0:basic, 1:advanced)						interview length (min.)
		gender	math	French	German	science	total	
[1]	1	M	1	0	0	1	2	26
[2]	1	M	1	1	1	1	4	21
[3]	1	M	1	1	1	1	4	30
[4]	1	M	0	0	0	0	0	20
[5]	1	F	0	1	1	1	3	31
[6]	1	M	0	0	0	0	0	27
[7]	1	F	1	1	1	1	4	26
[8]	1	F	1	1	1	1	4	29
[9]	1	F	1	1	1	1	4	26
[10]	2	M	1	1	1	1	4	26
[11]	2	F	1	1	1	1	4	24
[12]	2	F	0	0	0	0	0	20
[13]	2	M	1	1	0	1	3	31
[14]	2	F	1	1	1	1	4	25
[15]	2	F	0	1	1	1	3	39
[16]	2	M	1	1	0	0	2	28
[17]	2	M	1	1	1	1	4	29
[18]	2	M	0	0	0	1	1	28
[19]	2	F	1	1	1	1	4	26
[20]	2	F	0	1	1	1	3	26

6.3.1. Experience with escape addict

Overall, the qualitative interviews largely confirm that pupils enjoyed participating in EA. The escape room format was appreciated. Pupils par-ticularly enjoyed the technological and multimedia features. One said "I found it very interesting and original to use a tablet, I didn't expect that", then "I liked it when we had to go to the billboard and look for objects, I appreciated the music in the game" [7].

Pupils also appreciated getting away from a more prescriptive (or even moralizing) prevention model and move towards a more playful model: "I thought it was well done, because it was not centered on something like it's bad to smoke and drink" [18]. Another one said that "it was not boring because we did not have to listen to the theories of someone" [11]. The teamwork helped to move away from the traditional model. For instance, someone noted: "It was interesting and funny. In addition, I could do it with my friends. It boosted us to succeed" [9].

Three pupils out of 20 mentioned that they disengaged towards the end (even if they spoke positively about EA during the interview) [1, 4, 5]. One person would have preferred doing the activity alone or that an expert talks about the topic instead, in particular because in team, "it raises embarrassing questions" [4]. The other two were in teams of six pupils, which may explain a certain disengagement towards the end (usually, teams were composed of four or five participants). Beyond these exceptions, doing the activity as a team was a valued feature.

Overall, EA was much appreciated, in particular for its playfulness, its technological features, its originality and the teamwork that it relied on.

6.3.2. The role of character gender and digital features on recollection

In the second day of the interviews, we asked pupils about the investiga-tion that they found the most memorable. No one mentioned the investiga-tion on video games (Investigation 1), four pupils mentioned the investigation that discussed harassment (Investigation 2), five mentioned the investigation on ethylic coma (Investigation 3), one mentioned the investigation on the alcoholic parents (Investigation 4) and one did not answer. Investigations 2 and 3 are the longest investigations (about 20–25 min each vs 10–15 min for Investigations 1 and 4). It is unsurprising that these two are more memorable. More interestingly, five out of six girls mentioned the in-vestigations in which the main character was a girl (investigation 3 and 4) and three out of four boys mentioned the in-vestigations in which the main character was a boy (investigation 2). Even though the sample is too small to be conclusive, this observation could hint that the gender of the character is important for the memorability of the investigation.

Another observation is that when pupils are asked to talk about the in-vestigations, they first and foremost talk about the scenarios and the digital features and less about the prevention messages.

Overall, these preliminary findings point to the importance of specific design features, including who the main character is (gender and potentially other characteristics on which the intervention wants to be inclusive) and how the health messages are embedded in the scenario and the digital features.

6.3.3. Knowledge of health messages

The very large majority of interviewees think they have learned something useful. The field experiment also showed that their knowledge significantly improved. However, when the pupils are probed about the type of knowledge they gained, it mostly stays at a general level (e.g. "if you drink alcohol, you can do dumb things and ruin your life" [2]). Nevertheless, slightly less than half of the interviewees do mention at least one specific message such as "When there is an addiction, we should talk about it to someone. Also, there are phone numbers we can call when there is an emergency, such as the 144" [19].

Moreover, pupils with higher educational achievement seem more able to remember specific messages. About three-quarters of pupils with high achievement in all four disciplines managed to formulate specific messages learned through EA. Only one quarter were able to do it for the others. This is consistent with our field experiments which showed that the impact of EA on knowledge acquisition was stronger for pupils with higher (vs lower) educational achievement.

6.3.4. Capacity to trigger discussions, reflections and behaviors

A minority of interviewees mentioned explicitly that EA made them re-flect ("It really made me reflect on substances" [4], "The stories make you think. It is shocking that 12–13 year old kids already do things like that" [9]). Some of them also mentioned that they would act differently, faced with a given situation: "If I have a buddy who is drunk, I will maybe better know what to do" [3]. Even if only a minority of pupils mention those reflections or implementation intentions, it is possible that EA had a similar effect on other pupils even if they are not necessarily able to explicit it during the interviews.

About three-quarters of the interviewees spoke about EA with their friends and even more with their parents, which echoes the descriptive results of the field study. However, the content of the discussion remains relatively shallow. With their parents, the discussion typically consisted of a brief description of EA, of its appreciation by the pupil and of some elements of gamifica-tion (solve puzzles, collect points, reward, etc.). Those who spoke about it with their friends also shared their opinion about the intervention, compared their scores or certain answers. The underlying health message has been less discussed. Two or three pupils discussed it with their parents.

It is interesting to note that although the content of the discussion re-mained shallow, the discussions may have occurred because of the playful and innovative features of EA. A traditional expert-based in-class prevention intervention would probably not have led a majority of pupils to talk about the intervention with their friends and parents several days after.

Several pupils had already had discussions with their parents in relation to addiction. Some parents seem very concerned about the topic. How-ever, others seem unaware of how to approach addictions (and screen time most specifically): "I told my parents that we

had that thing on EA. My mother was happy because I play a lot with video games" [3]. For those parents in particular, EA and serious games more generally could potentially help trigger discussions between parents and children or compensate for the powerlessness of parents or even disengagement. When asked whether their parents try to trigger a discussion on addictions, a pupil answered: "Yeah, but it is not like a serious topic. It's more for fun. I'm a teenager, so they think I do unhealthy stuff, which is not true, so they laugh at me thinking I do stuff." Then: "I told them that it [EA] was cool, that I learned things. They said it was a bit useless. Anyway, my parents are a bit closed-minded, I can't really talk about that kind of topic with them" [20].

Overall, EA triggered a lot of discussion, albeit relatively shallow.

7. Discussion

Through a mixed-method approach, this research is the first to show the effect of a school-based digital escape room in the domain of addic-tive and risky behaviors prevention. In current studies, most digital educa-tional escape rooms' audience targets are participants in higher education (pre-graduate, undergraduate, graduate, and post-graduate), with only few studies targeting primary or secondary education (Makri et al., 2021). Our findings confirm the effectiveness of digital escape rooms for educational pur-poses for secondary education pupils in the particular context of addiction prevention. They also show that digital escape rooms could help pupils talk about the topics of addictive and risky behaviors. It is a promising result, since addiction is not the primary interest of pupils in the studied age group. Overall, although EA did not affect all outcomes we measured, the signifi-cant effects on knowledge acquisition and discussion generation are powerful, given that the intervention lasted only 90 min and the outcomes were measured long after the intervention (three weeks). Nevertheless, we cannot compare pupils' learning in this study with those that may have been ac-quired by a traditional intervention (e.g. an expert talking about addiction prevention in class), as we compared our intervention to a control group with-out intervention. Overall, previous studies have demonstrated mixed effects of school-based health interventions on different adolescent health behav-iors (Sharma et al., 2018). Therefore, although further research is needed to formally compare different types of intervention (rather than one intervention vs no intervention), the findings in the current study appear encouraging.

There is however a caveat with digital escape rooms. Pupils may prefer to engage with interventions built with technologies and media that they like (Duncan et al., 2018), but pupils with higher (vs lower) educational achievement acquired more knowledge with EA. This result is unfortunate but aligned with previous findings, which identified that escape rooms are more motivating for pupils with higher cognitive abilities (Vidergor, 2021). However, even if EA's influence on knowledge acquisition was not signifi-cant at the lowest level of educational achievement, it became marginally significant or significant at all the other levels. Thus, EA is not only benefi-cial to elite students and remains an interesting intervention for pupils with relatively low levels of education.

Overall, gender had little influence on the effect of EA, which is a posi-tive indication that the design of the learning experience does not unwittingly disadvantage one gender over another. The only outcome that differed ac-cording to gender was privacy setting behavior. The limited effect of gender may also be attributed to how EA balanced the use of genders in represent-ing the main characters of the puzzles. Our qualitative interviews indeed show that females and males are more struck by puzzles in which a female (male respectively) is the main character. This extends previous research on identification with game characters, showing that gender identification leads not only to more motivational strength (Van Reijmersdal et al., 2013), but also to more recall of the puzzle. This is also in line with previous research showing that people respond more positively to stimuli that are congruent with their identity (Reed II et al., 2012), such as when the stimulus features a person with whom the person identifies (Madadi et al., 2021; Takano & Taka, 2022; Whittler & Spira, 2002). Digital escape room designers, and prevention specialists in general, should carefully think about the characters they feature on the stimuli, not only in terms of gender, but more broadly in terms of characteristics on which the project should be inclusive (e.g. cultural communities, etc.).

Finally, our results show that enjoyment plays a significant role in driving EA's effectiveness. EA promoters feared that the playfulness of the concept would shift pupils' focus from the prevention messages to the gameplay. How-ever, our results show that EA's effectiveness was stronger on some outcomes for people who enjoyed EA's experience to a larger (vs lesser) extent. In par-ticular, pupils who enjoyed the experience played less video games after EA's exposure and marginally increased their perception of risk related to addic-tive behaviors.

Overall, digitalization of educational escape rooms can contribute to reach-ing a cost-effective, portable, reusable and easy-to-use learning experience. The main budget lines of developing and maintaining Escape Addict are the following. The software costs for the development of EA amounts to USD 120,000. The initial purchase of the materials (tablets, billboard, etc.) was USD 16,500. Maintenance costs (software and material) came to USD 17,000 per year. In terms of human resource, every EA session needs a facilitator for a 90-min period. Compared to a traditional model where an expert talks about addiction prevention in class, the initial investment for EA may seem high, but it is spread over 160 classes per year and could be licensed out to other prevention organizations. As a result, over time, EA is a little more expensive than traditional interventions, but is still within the same order of magnitude. Compared to traditional escape rooms, however, EA is more portable, more convenient and cheaper. Indeed, the animation can be made in-class (vs moving the class to a dedicated location, which is costly to create and rent).

Overall, this paper extends the literature on digital escape rooms (see (Vidergor, 2021)) by showing that they can be successfully designed for applications outside of traditional domains such as medicine, engineering or computer sci-ence to the domain of addiction prevention. It also shows the positive effect of digital escape rooms on a public of adolescent participants. Finally, it shows that digital escape rooms can not only affect knowledge acquisition, but can also be applied to motivate some behavior change.

7.1. Implications and recommendations for practitioners

Overall, digital escape rooms seem promising as school-based interven-tions. EA made pupils talk about the intervention and to some extent about the prevention messages. It also improved knowledge acquisition and changed some behaviors. However, our evaluation also shows that EA could be im-proved. In what follows, we discuss how to increase the effectiveness of future digital escape rooms, based on the findings of our research.

Overall, pupils had a fairly superficial memory of the prevention messages. A way to increase pupils recollection of the key messages is to make those messages inseparable from the investigation and the technological features. Indeed, when a message is well-integrated into a stimulus, knowledge about the message increases (Akpinar & Berger, 2017). For instance, the health message related to the video 360° where pupils had to identify dangerous ads was well embedded, and pupils remembered it more.

Also, EA addressed a large array of topics, with many underlying mes-sages. An overly ambitious and diverse prevention inter-vention (substances, video games, behaviors online, etc.) in only 90 min may make it more difficult for pupils to leave with a clear set of takeaways. Future digital es-cape rooms (and prevention programs more generally) may limit the number of messages and make messages easier to take home. This may be par-ticularly relevant given our findings in relation to educational achievement. Our research shows that pupils with lower educational achievement gain less knowledge than others through EA and seems less able to retain specific and more complex messages. Future digital escape rooms may be designed with this finding in mind. In this respect, they may for instance include different levels of complexity in their prevention messages or include different game levels within the escape room. This may better attend to the heterogeneous needs of a diverse classroom. Another recommendation particularly suitable for pupils with lower educational achievement is to rely less on knowledge acquisition and more on the pupils' behaviors to modify their environment. For instance, rather than asking pupils to remember phone numbers (even if only three figures), it may be better to ask pupils to directly enter the num-bers in their mobile phones (for those who have one) or distribute a sticker or list with important phone numbers.

Finally, to increase the extent and depth of the discussions that digital escape rooms trigger, the interventions could be com-plemented, for instance by developing content for parents or pursuing the game outside the classroom. A last point to mention is that EA was motivating not only for pupils, but also for teachers, schools and facilitators. The digital escape room format made it easier for prevention specialists to convince schools and teachers to welcome it into their classrooms.

7.2. Limitations and future research

This research is not without its limits. Using a field experiment to ro-bustly evaluate the effectiveness of a school-based digital escape room is dif-ficult, resulting in limited sample sizes. Therefore, detecting effects is more difficult and the likelihood of false-positive or negative is increased. How-ever, the qualitative and quantitative parts show overall convergence, which increases the confidence in our results.

Also, field experiments are subject to field incidents. One of the schools in the control condition could not be surveyed at the same time as the other schools, which makes external effects less adequately controlled. We could, however, keep the same interval between the two measurements. Results are similar with and without this school, which tempers this problem. In addi-tion, we evaluated the effects of EA without being able to disentangle which features of EA were causing the effects. For instance, which technical features within the puzzles were specifically inducing a positive learning experience? Is the conscious aim of preventing many types of addictive and risky behav-iors in one escape room degrading learning? We can only speculate about the answers to such questions. Future research could compare alternative designs of digital escape rooms to provide more solid answers. Another limit of our study is that we compared our intervention to a control group with-out intervention. Future research could investigate how digital escape rooms compare to other prevention models, such as expert presentation. In our research, we can only assert that the digital escape room had an effect, but not that this effect was superior to that of any other prevention model.

More broadly, future research could explore how to design digital es-cape rooms that are free from educational achievement bias. Like other formats (Arbabisarjou et al., 2016), digital escape rooms seem to be more beneficial for teenagers with higher educational achievement. Future research could address this issue by investigating alternative delivery models that are appealing to and effective with all teenagers (or even more effective with teenagers with lower educational achievement, since they may start with a lower knowledge base, as our research shows).

Finally, our research points to the need to smoothly integrate the preven-tion messages in the puzzles and in the technology, so that remembering the technology or the puzzle becomes inseparable from remembering the mes-sage. Future research could explore how to optimally embed the messages in order to maximize impact.

Credit author statement

Valéry Bezençon: Conceptualization, Methodology, Data curation, Writing- Reviewing and Editing, Supervision, Project administration **Alessio De Santo**: Writing – original draft, Writing- Reviewing and Editing, Investigation, Resources, Visualization **Adrian Holzer**: Writing- Reviewing and Editing, Validation **Bruno Lanz**: Writing-Reviewing and Editing, Formal analysis, Method-ology, Data curation.

Data availability

The data that has been used is confidential.

Acknowledgment

The authors would like to thank Promotion santé Valais for the access they provided to Escape Addict and for the use of the evaluation data. The authors would also like to thank Mansour Omeira for his contribution in the design phase, in particular on the survey questionnaires. The evaluation of Escape Addict on which this article is based was funded by Promotion santé Valais.

Appendix A-C. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.compedu.2023.104798.

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