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The Impact of a Digital Escape Room focused on HTML and Computer Networks on Vocational High School Students

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Abstract: Today, students live in a world surrounded by technology and traditional education methods are no longer very attractive to them. Applying the concept of a digital educational escape room to teaching can help increase students' interest in the subject. In an escape room, the players search for clues, complete tasks, and solve polymorphic puzzles, working together to escape the room within a certain time limit. This article presents the use of a digital escape room on third-year students in the field of computer network mechanics at a secondary vocational school. The aim of this study was to determine the effects of implementing an escape room focused on HTML and computer networks on third-year computer network mechanics students and to assess the students' levels of perception of the game. Although the experiment did not confirm an increase in students' cognitive abilities, the quantitative analysis confirms a significant increase in the motivation, engagement, and satisfaction of students in secondary vocational schools focusing on technical vocational subjects. Qualitative analysis provides a better understanding of these results and supports the conclusion that using a digital educational escape room is enjoyable for students, and leads to problem-solving skills and teamwork.

Keywords: educational escape rooms; active learning; puzzle; secondary vocational education; gamification; computer science

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1. Introduction

Escape rooms are a relatively new type of entertainment that provides an unforgettable experience. An escape room (ER) presents a story set in a specific category that players can choose according to their preferences. There are different types of plots, such as adventure, crime, or even horror. Escape rooms involve "voluntarily" locking a group of people in a room, resolving a series of puzzles, unlocking locks, and searching for hidden clues to escape the room. Using various scenarios and challenges, the escape room activity produces, an experience that is both motivating and educational for participants.

Traditional teaching methods, including teacher lectures, simple presentation of content on the board, PowerPoint presentations, or the simple use of textbooks, generally do not stimulate the current generation of students who desire active participation and are stimulated by success and belonging. In addition, today's students live in a world surrounded by technology that constantly causes great stimulation. Using the escape room method in teaching, where students have to overcome various challenges, becomes a very engaging activity and increases students' interest in the topic covered [1–3].

In an escape room, the player's job is usually to get out of the spaces in which they are trapped. Players in the room search for clues, complete tasks, solve polymorphic puzzles, and cooperate with each other, which will help them achieve an overarching goal within a certain time limit. Although escape rooms are adventurous activities, while playing, players must use multiple analytical skills, thinking skills, problem-solving,

cooperation, and communication skills, which takes the whole activity to a higher cognitive level [4–6].

While the classic escape room is purely recreational, the educational escape room (EER) is becoming an increasingly popular approach in educational courses that aim to involve students in their learning environment and stimulate their mutual cooperation and the growth of other skills. In the EER, the puzzles, riddles and solutions are designed for a specific target group of students and are related to well-defined individual learning objectives, which distinguish the EER from a classic escape room [7–9]. The EER is a motivational teaching method focused on the student.

An educational escape game can be defined as an instructional method that requires students to participate in collaborative playful activities; activities are explicitly developed to acquire domain knowledge or develop skills in order to achieve a specific objective by solving puzzles linked to clear learning goals in a limited time [10,11]. The goal may not only be to escape from rooms, which is difficult to do in school classrooms, but in the EER it can be physical boxes or safes which students have to break into using analog and digital materials; these are hybrid educational spaces that simulate the real atmosphere of an ER [12]. Educational escape rooms have a significant educational appeal to develop various skills by solving challenges or mysteries together [13–15].

Much of the literature on EERs describes escape rooms in various areas of education, such as pharmacy, chemistry, nursing, medicine, or information sciences [16–20].

In terms of the educational levels for which the EER proposals are intended, most of them focus on tertiary education, so there is still great potential for development, especially in the areas of secondary education, but also in primary education [21]. This is also reflected in publications focused on EERs, where there is a permanent rise in publications on EERs aimed mainly at universities and healthcare, but there are not enough publication resources on non-university education [22].

On the other hand, EERs appear to be an engaging way of ”gamifying” learning, including STEM learning, but a much more systematic approach and more evidence are needed [21]. The educational escape room is slowly finding application in the teaching of computer science and related technical subjects, which are part of STEM (science, technology, engineering, and mathematics) education.

However, the available computer science escape games are again primarily aimed at higher education. An example of such educational escape rooms can be EERs focused on topics such as cryptography [23], computer networks [24], or programming [25,26]. An EER aimed at teaching telecommunication engineering [27] is also interesting but is also aimed at university studies.

Although within the fields of education, educational escape rooms focused on information and communication technologies cover up to 14.7% of all fields [28], there are only a few publications dealing with escape rooms in high school computer science education.

For example, high school EERs [29] focused on finding, debugging and fixing programming errors and used live-action escape room scenarios with five puzzles in the physical world; participants had one hour to resolve all the riddles and puzzles, open various locks and finish the game.

Another EER game in the field of informatics aimed at secondary school students is the game Room-X with computer science tasks that require general problem-solving strategies [30]; the objective of the game is to provide students with a motivating view of various topics in computer science within a limited time frame. For this reason, it offers puzzles from different areas of computer science, such as logic, encryption, and automata theory, which require computer-scientific and general problem-solving sub-strategies, such as representation and recognition of a model, reproducing algorithms, following a path, verification, and purposeful combination of results as well as continuous documentation. It is a physical escape game with digital and analog puzzles aimed at popularizing computer science.

Dochtsis et al. present the creation of EERs as a logic game, the objective of which is to familiarize users with the basics of logic gates and circuits as learning models applied in vocational education and training [31]. However, the article only mentions the design of EERs, but the application of EERs on students and the resulting conclusions have not yet been realized.

The experience of applying ERRs to students in a secondary vocational school with a focus on technical vocational subjects has not been published so far, and the aim of this study is to fill the gap in this area.

Advances in technology and their availability in schools enable the development of fully digital escape rooms; in addition, their cost-effectiveness, availability, and simplicity of use allow for their wide deployment in education [32–34]. Digital educational escape rooms (DEERs) can be classified as a form of gaming in digital, 2D/3D virtual environments, but also in the web environment [4,35].

In general, the educational benefits of EERs are varied, from the promotion of cognitive and affective learning outcomes to the development of problem-solving, teamwork, communication, and creative skills, as well as the promotion of career interests [10,12,21,28,36]. The degree to which a student enjoys the subject and the level of motivation can predict the future achievement of the student [37,38].

The aim of this study was to design, test and evaluate the effectiveness of a digital educational game of the escape room type on third-year students in the field of computer network mechanics in a secondary vocational school and to assess the level of perception of the game by students. To address this goal, the following research questions were formulated regarding the educational activity in the escape room:

(RQ1) To what extent are the learning objectives of the subject being taught reinforced using the escape room learning activity?

(RQ2) How do students perceive learning using a digital educational escape game in the context of secondary vocational schools?

(RQ3) What skills does the digital educational escape room develop in the education of secondary vocational school students?

In this study, an application experience in the classroom is presented; the collected data confirm that after applying DEERs to teaching, there is an increase in motivation, engagement, satisfaction, ability to solve problems and teamwork among students of secondary vocational schools focusing on technical vocational subjects.

The article is structured as follows. Section 2 describes the use of the DEER-based methodology, including how the DEER was constructed and the puzzles it consists of. Section 3 presents and discusses the results of escape room tests and analysis from a quantitative and qualitative point of view. In Section 4, there is a discussion of the results found. Finally, Section 5 concludes the article with conclusions and an outlook for future work.

2. Materials and Methods

2.1. Participants

The educational escape room was used at a secondary vocational school in the field of computer network mechanics. This study was carried out in the 2021/2022 school year at the Secondary Vocational School of Electrical Engineering in Trnava, Slovakia. The escape room was implemented in the third year of study in May 2022 for a group of 16 students. The vocational subjects of third-year students integrate the creation of web pages, graphic programs, computer hardware, diagnostics, and repair peripheral devices of PCs, as well as the assembly, diagnostics, and repairs of a local computer network. The field of computer network mechanics prepares graduates in the fields of information technology, computer networks, diagnostics, the maintenance and repair of computers and computer networks, network management, and communication technologies. A graduate in such a field of study can design, assemble, repair, set up, and maintain a local computer network. Students master the basics of programming and the basics of database systems.

They can work with the Windows operating system, Linux, with applications from the Microsoft Office suite, with graphic, video, and audio applications.

All data collected were anonymously analyzed in the group of 16 students, 15 boys and one girl, aged 17–18 years. The participants had not experienced a digital educational escape room; some of them had experienced a classic commercial escape room. No reward was given and each participant was randomly assigned to one of the pairs.

2.2. The Design of the Digital Escape Room

When playing, the escape room was run in the computer room as a native game for the MS Windows operating software. The escape room environment was developed using Gdevelop 5 software (https://gdevelop.io/, accessed on 1 September 2022). Gdevelop is a free, open-source, cross-platform game development software that is an easy-to-use, event-driven tool that requires no knowledge of programming languages to create games. However, a certain degree of algorithmization and the ability to think structurally are required from the game creator. The software can publish HTML5 games as well as native games for different platforms (Windows, Linux, Mac, Ios, Android), and exports can be done with one click. Its use to create educational environments can be found, for example, in [39,40].

In addition to the final creation of the game in the development environment, it is necessary to first determine the requirements for the game, educational goals, to determine the general design of the game, design puzzles with regard to the educational goals and the overall duration of the game, design the story of the game, design and process the graphic elements of the game and the creation of the game levels themselves. Other requirements for games [41–43], which are used for education, are their compliance with the curriculum; games should have clear learning objectives such as progression or repetition; games should be interactive and include aspects that can be used for evaluation and feedback purposes, allowing students to monitor their own progress. From an educational perspective, educational escape rooms are related to the gamification methodology, since EERs are based on the design and structure of the game [36].

In the design of the educational escape room, a non-linear concept of the escape room was implemented. The non-linear escape room offers a higher number of tasks and puzzles that can be solved in any order. It is up to the players to choose their own order to solve the problems [44].

The story of the digital escape room consists of a terrorist threat, namely the placement of an explosive device by terrorists in a stadium full of people. The time limit to defuse the bomb is 30 min and there is no time to evacuate people from the stadium. In the game, it is necessary to successfully solve eight independent levels. After successfully solving each level, the student receives a key, and only after obtaining all eight keys can the bomb be deactivated. The first four tasks are focused on knowledge in the field of creating websites while the next four tasks are focused on knowledge in the field of computer networks (Figure 1). Help was available for each of the levels, which was supposed to prevent students from getting stuck on a puzzle for too long, which could cause students boredom or frustration .

The first level, *Differences*, consists of five sub-tasks and is aimed at assigning the correct HTML code to the relevant web element; the student must choose from two options and place them correctly. The second task, called *HTML*, is aimed at completing the HTML code from a set of HTML tags according to the displayed website template; the level is made difficult by the random disappearance and reappearance of some tags, even when the player moves them with the mouse. The third level, called *CSS*, is similar to the second level, but focuses on CSS properties. In the fourth level, *Pairs*, the player must match the correct HTML code with its resulting display on the rotating cards. The fifth level of the game, called *DNS names*, is focused on the correct placement of DNS names according to levels in the DNS hierarchy; the task is made more difficult by randomly appearing parrots that interfere with the solution and have to be pushed aside. The sixth

level of the game, called *Network topology*, tests the ability to correctly recognize an individual type of network topology and correctly place it in the maze. In the seventh level, *Abbreviations*, the player must correctly place the full name of the abbreviations in the boxes, one word at a time; words are constantly attracted by a magnet. In the eighth and last level, called *IP addresses*, it is necessary to find and choose the correct Ipv6 address and send it. Table 1 gives a more detailed description of the educational topics and the skills required of the student. After obtaining all eight keys, the student is redirected to the screen with congratulations and the student's final time is listed. If the student does not manage to solve the tasks within 30 min, the bomb explodes and the game ends unsuccessfully. Given that the goal of educational escape rooms is to provide an unforgettable learning experience, the experiential aspect of the game is vital to student motivation.

It Is possible to agree with the authors Vörös and Sárközi that the design and development of EERs for specific educational contexts is a time-consuming task [45]; and the development of DEERs requires from the game creators some knowledge and skills of the environment in which the DEER is developed, as well as a certain degree of algorithmization and programming skills. Furthermore, the designed educational escape room was tested by a Bachelor of Applied Informatics student who is a graduate of the targeted secondary vocational school and who volunteered to participate in the DEER. Finally, based on the experience gained from such tests and the feedback from the participant, some minor improvements were made to the escape room. The English HTML5 version of the digital educational escape room can be found at https://liluo.io/lh/escape-room—en- (accessed on 1 September 2022). The HTML5 version of the escape room has certain limitations compared to the native desktop versions, mainly in the possibility of pausing time while playing. For this reason, the native desktop version of the game was used in the experiment.

Figure 1. A screen with eight tasks in an educational escape room.

It should be noted that although the activity is called an escape room, the students were not, in fact, locked in a real room. This was the case of the so-called reverse escape room [25], where students try to help other people escape, respectively defuse an explosive device and thus ensure the safe exit of other people.

Although the classroom setting is different from a locked escape room, the whole situation involves a simplified version of those key elements that make up established escape games [34,46]. These are as follows: (i) an engaging story that replaces the lockdown and conveys the whole experience and that draws students into the event, (ii) an

enclosed space, in the case of the DEER, a virtual environment where all the components of the escape room are located, (iii) a series of puzzles to be solved, and (iv) a series of locks for students to open as part of the overall game, (v) receiving a reward after finding the correct solution, and (vi) solving DER tasks within a time limit, which creates some pressure and can stimulate the learning potential of students.

Furthermore, the proposed DEER also tries to stick to the DEER rules of focusing on a specific subject type, skill set, or grade level and not trying to cover too much because the activities are designed to be completed in one sitting [46].

Table 1. Description of the DEER educational topics and the necessary student skills.

	Educational Topic	**Gaming Task**
Puzzle 1	HTML code for selected visual objects	— find the differences in which the objects differ — assign the correct HTML code to the object
Puzzle 2	HTML code for the website	— correctly identify missing HTML tags — correctly place the tags to match the website template
Puzzle 3	CSS properties for a web page	— correctly identify missing CSS properties — correctly place CSS properties to match the template of the web page
Puzzle 4	HTML code for tables	— find the right pair, i.e., correctly assign the image of the table to the HTML code of the table
Puzzle 5	DNS names	— understand the DNS hierarchy — understand which domains belong to which level — correctly place the domains in the boxes
Puzzle 6	Topology of computer networks	— understand what kind of network topology it is — correctly place the topology image in the box
Puzzle 7	Network protocol abbreviations	— understand what each abbreviation means (more difficult if English is not the mother tongue) — correctly place the full name of abbreviations in the boxes, one word at a time
Puzzle 8	Ipv6 addresses	— find hidden IP addresses — identify the correct Ipv6 address — place it on the screen

An EER designed in this way allows students to learn from their own mistakes. The student sees that when the solution is not correct, the room reacts to the incorrect solution; every time the student's solution to the puzzle is not correct, the student can start solving the puzzle again. This is an activity that allows the student to go back and redo the task and thus learn the correct terminology/procedures even in the case of a mistake.

2.3. Research Instruments

The main goal of this study was to evaluate how students perceive learning using a digital educational escape room. In addition to experiential learning, the effectiveness of learning in the digital educational escape room was also measured as a side effect. The effectiveness of the education was measured based on the performance of the pre-test by the students just before the DEER and also by the performance of the post-test after the end of the DEER. Both the pre-test and the post-test contained a total of 26 questions, 14 questions from the HTML area, and 12 questions from computer networks, constructed so that both tests were at the same knowledge level and required the same knowledge identical to the terminology/procedures that the students encountered in the escape room. During the tests, the students chose one correct answer from the listed options; the correct answers were learned only after the end of the entire experiment. For each correct answer, the student received one point; for an incorrect answer, zero points. The student's result

was the sum of all points obtained. It should be emphasized that, based on the observation, during the escape room, the students fully concentrated on solving the puzzles and trying to succeed in the ER and did not talk about the pre-test among themselves at all, so the results of the post-test were not affected in this way.

An example of a multiple choice question from the pre-test and post-test focusing on HTML code: *What is the meaning of the* alt *attribute of the* <img> *tag?* (i) text description of the image, (ii) path to image. And an example of a question focused on computer networks: *How many levels are there in the domain name "kai.fpv.ucm.sk"?* (i) 3 (ii) 4 (iii) 12.

Students were divided into pairs, with each pair solving the escape room together on one computer; therefore, there were eight teams in total. It should be noted that the pairing was intentional; teams consisting only of pairs to solve the ER experienced change in terms of leadership, where leadership roles often changed [47]; for teams that had three or more players, leadership roles tended to persist for the duration of the escape room; similar pairing formation for ER can also be found in many cases [25,48–51]. When students are in pairs, especially for tasks focused on HTML or CSS coding, it is possible to use the advantages of pair programming. In pair programming, two programmers work together on the same computer using one keyboard and one mouse. Pair programming as a collaborative practice is directly related to computational thinking, which is a central skill in computer science; computational thinking practices include problem decomposition, the creation of computational artefacts, testing and debugging, iterative improvement, collaboration, and creativity [52]. During the game, the participants were directly observed, which provided several insights into the game and the testing process.

Each participating student completed an individual pre-test, post-test, and survey using a questionnaire. The questionnaire consisted of 14 questions aimed at measuring student satisfaction with the activity and was distributed to students electronically through the Google Forms platform immediately after completing the escape room activity. Students showed their level of agreement or disagreement with the statements listed on a five-point Likert rating scale, where 1 = strongly disagree and 5 = strongly agree. A similar measure of student motivation through a questionnaire associated with EERs can be found in the work of other authors [4,53–55].

At the end of the experiment, a group interview (focus group) was conducted as a qualitative method with all 16 students who participated in the digital educational escape room. Open-ended questions and informal discussions during the group interview were secondary data collection mechanisms. Data collection from the group interview was done using audio recording during the group discussion; two recording devices were used to ensure optimal audio access.

The data collection in the classroom (class observations and a group interview) was carried out by one researcher; however, the questionnaire was designed by all three authors. Coding was conducted by the main author with subsequent checks by the co-authors. Data analysis included three levels of coding according to Strauss and Corbin [56]: open coding, axial coding, and selective coding. In the stage of open coding, the data were sorted to be compared and to create categories. During the axial coding, the categories were contrasted to find descriptive relations between them. During the selective coding, core categories were selected.

2.4. Data Analysis

The statistical analysis in the text was performed using IBM SPSS (Statistical Package for the Social Sciences) version 28 software and MS Excel.

For the means obtained from the pre-test and post-test, a two-sample t-test was used to show whether or not there are statistically significant differences between the students' scores in the pre-test and post-test.

Data obtained through a questionnaire about the perception of the digital escape room by students were analyzed using a quantitative research approach. Mean values (M) and standard deviation (SD) were calculated from the Likert scale for each question.

Univariate analysis was also taken into account, that is, the percentage range of individual points.

According to the communicative methodological approach [57], the analysis of information obtained from the group interview with students was used to supplement and compare the information obtained from the analysis of the questionnaire. The group interview was audio recorded and transcribed.

Data from direct observation and audio recordings of the group interview were analyzed using a qualitative data analysis approach. The team collected observational notes, grouped and interpreted the observations, and prioritized the findings based on this.

The results obtained by the different data collection methods were compared and discussed among the three researchers.

2.5. Experimental Procedure

Studies traditionally use the space at the end of the school year to repeat the material covered for the entire year of study, to strengthen the acquired knowledge and skills in the last month of study. The EER experiment was carried out in this time frame with the aim of strengthening knowledge, motivating students, and evoking emotions that will lead to better retention of knowledge. The goal of the digital educational escape room was to motivate and engage the most important concepts in the field of HTML and computer networks, which the students covered in the third year of study.

The study was carried out during regular school hours, during hours intended for repetition of material from the entire year of study. A pre-test and post-test design was used to investigate the change in students' cognitive abilities before and after completing the digital escape room focused on HTML and computer networks. In both the pre-test and the post-test, students were asked questions similar to the issues they covered during the year in class. First, a pre-test was conducted using the Google Forms tool. Subsequently, the students were divided into pairs, and the students performed a digital escape room. Before starting the game, the students were informed about the rules, the time limit, the story of the game, and the objectives of the escape room. After completing the DEER, the students completed the post-test, again using Google Forms.

A questionnaire survey and a group interview were used among students to investigate changes in motivation, satisfaction, engagement, and teamwork. These activities followed immediately after the students took the post-test. After collecting all data, researchers analyzed the collected data to examine the effect of the DEER on the cognitive, behavioral, and affective abilities of vocational high school students focused on technical professional topics.

The overall course of the experiment with the DEER consisted of six phases: a game briefing, a pre-test, a DEER activity, a post-test, a student survey, and a group interview (Table 2). A similar scheme to test an EER in teaching was used in the research of the authors Abdul Rahim et al. [58] and Kuo et al. [59]. During the entire experiment, the classroom teacher and one researcher were present in the classroom.

Table 2. Procedure of the digital escape room experiment.

Session	Purpose	Time
Game briefing	The teacher introduced the rules of the digital escape room and divided the students into pairs.	10 min
A pre-test	Each student independently completed a 26-question pre-test using Google Forms.	15 min
Digital escape rooms	Students participated in a digital escape room in pairs.	30 min
A post-test	Each student independently completed a 26-question post-test using Google Forms.	15 min

A student survey	Survey using a questionnaire consisting of 14 questions aimed at measuring student satisfaction with the activity through the Google Forms platform.	10 min
Group interview	Finally, the researcher conducted a group interview with the 16 students who participated in the digital educational escape room.	20 min

3. Results

This section presents results based on data collected from students using a questionnaire and using pre- and post-tests, as well as feedback recorded after participants completed the escape room. For this reason, the section is divided into quantitative and qualitative results.

3.1. Quantitative Results

Students were required to take a pre-test before the escape room activity and a post-test after it to analyze whether there was an increase in knowledge. The results for the number of points obtained by the students in the pre-test were: M = 16.50, MD = 16.00, SD = 2.53; and in the post-test were: M = 16.31, MD = 16.50, SD = 2.87. Data from the pre-test and post-test scores follow a normal distribution as verified by the Shapiro–Wilk test of normality distribution. Based on the two-sample t-test performed, it can be concluded that no statistically significant differences ($t = 0.194$; $p = 0.849$) were found between the change in students' knowledge after completing the DEER. The differences between the means of −0.19 and the medians of 0.5 indicate the same cognitive abilities before and after completing the escape room.

The students' perception of the escape room was surveyed immediately after the activity using 14 statements using a 5-point scale (1, strongly disagree; 5, strongly agree) and the respondents could indicate to what extent they agree or disagree with each statement (Table 3).

Table 3. Perception scale of escape room activity ($N = 16$).

Item	Mean	SD	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Q1. Time was running too fast during the game	1.69	0.95	56.25%	25.00%	12.50%	6.25%	0.00%
Q2. I felt a sense of accomplishment when I passed the level	3.81	1.22	6.25%	6.25%	25.00%	25.00%	37.50%
Q3. I was satisfied with the game	4.44	0.73	0.00%	0.00%	12.50%	31.25%	56.25%
Q4. When I was playing, I was not aware of my surroundings	3.06	1.18	12.50%	12.50%	43.75%	18.75%	12.50%
Q5. I wanted to complete the entire game	4.44	1.09	0.00%	12.50%	6.25%	6.25%	75.00%
Q6. The game was an interesting way to review the topic of HTML and computer networks	4.31	0.87	0.00%	0.00%	25.00%	18.75%	56.25%
Q7. I would recommend this activity to other students at school	4.75	0.68	0.00%	0.00%	12.50%	0.00%	87.50%
Q8. The game was an interesting way to learn new information from HTML and networks	3.63	0.96	0.00%	6.25%	50.00%	18.75%	25.00%
Q9. The game encouraged me to think about the curriculum in a new way	3.63	1.36	12.50%	0.00%	37.50%	12.50%	37.50%
Q10. I also learned something from my classmate in the escape room	3.19	1.56	18.75%	18.75%	18.75%	12.50%	31.25%

Q11. Learning through play is better than a regular class	4.50	0.97	0.00%	6.25%	12.50%	6.25%	75.00%
Q12. It was difficult for me to concentrate on the content because I felt stressed	1.19	0.54	87.50%	6.25%	6.25%	0.00%	0.00%
Q13. The tasks I had to solve in the levels (maze, pairs, search, etc.) distracted me from concentrating on the content about HTML, networks	1.63	0.72	50.00%	37.50%	12.50%	0.00%	0.00%
Q14. In general, I like to play games (e.g., video games, social network games, board games,...)	4.31	1.40	12.50%	0.00%	6.25%	6.25%	75.00%

1, strongly disagree; 2, disagree; 3, neutral; 4, agree; 5, strongly agree.

In general, the results showed the satisfaction of the students with the use of escape rooms in the teaching process for secondary vocational schools in the field of computer network mechanics. Such satisfactory results add to the findings from other sectors and levels of education that educational escape rooms are an excellent way to promote motivation in teaching and provide experiential learning for students. The results indicate a strong influence of the escape room on the perception of students, indicating the potential benefit of this activity beyond the novelty factor itself.

As can be seen in Table 3, the student evaluations of the escape room focused on HTML and on computer networks were very satisfactory to the students, especially in the items: Q3 *I was satisfied with the game* with 87% satisfaction; Q5 *I wanted to complete the entire game* with 81% positive answers; Q6 *The game was an interesting way to review the topic of HTML and computer networks* with more than 75% positive responses; Q7 *I would recommend this activity to other students at school* with 88% strong agree; for the majority of students, 81%, teaching through the DEER is more fun and motivating than regular lessons; Q11 *Learning through play is better than a regular class*; up to 94% of students disagreed with the difficulty of concentrating; Q12 *It was difficult for me to concentrate on the content because I felt stressed*; and up to 88% did not perceive solving puzzles as something that distracted them from learning; Q13 *The tasks I had to solve in the levels distracted me from concentrating on the content about HTML, networks*.

Taking into account the results obtained, it can be concluded that the students perceive the implemented digital educational escape room as a highly engaging and entertaining educational activity. The engagement, immersion, and fun in learning give students more opportunities to develop their skills and apply their knowledge.

The individual results of the questionnaire are analyzed in more detail below in combination with the results of the group interview.

3.2. Qualitative Results

In addition to the open participant direct observation of students during the escape room activity, the qualitative method of the group interview (focus group) was also used for data collection.

After completing the questionnaire (Table 3), a group interview was held with the participants in the educational game. The focus group consisted of the 16 respondents who participated in the escape room game. The group interview method was used as an additional method to obtain more specific and personal answers from the respondents, since only hard data (numbers, percentages, etc.) are obtained from the questionnaire. Regarding the individual questions in the questionnaire, the findings stated by the respondents during the group interview are presented in more detail. This procedure allowed one to achieve a higher quality of the data obtained. Student quotes and analysis provide evidence of their perceptions of the escape room activity.

1. *Time was running too fast during the game*: In general, the students disagreed with this statement (M 1.68, SD 0.95), which is a result closer to the *disagree* value from below. During the group interview, students suggested "reducing the time to 20 min if there are only eight tasks." Some suggested that, much more than reducing the time, they would welcome an increase in the number of tasks to at least 16, which resulted from their interest in the game. They also expressed the view that they did not feel any time stress at all and would not have had a problem with it at all if the time were tighter: "The game was good, maybe for the time we had, more tasks would have been better."

Even from direct observation, it was clear that the students managed to finish all levels of the game in sufficient time and the time limit of 30 min was more than enough. The average finish time in the group was 16:25 min, the shortest time 11:36 and the longest 20:33 min.

2. *I felt a sense of accomplishment when I passed the level*: In general, the students agreed with this statement (M 3.81, SD 1.22), which is a result closer to the *agree* value below. In the discussion, they discussed which level was the most interesting/funniest for them. The *IP addresses* level appeared to them as "the worst and most boring", although they evaluated it as "it took the longest to find where the addresses were hidden"; on the contrary, they evaluated the *Abbreviations* level as the most interesting; "it was good". They felt that they solved the *Network topology* level the fastest; "there was also a hint on the picture and that's why it was easy". They evaluated level *DNS names* as more complex "to think about" and "once I found the system, it's ok." Students admitted in a group interview that they did not solve all tasks strictly professionally; they even typed in some of them; an example is the *Pairs* level, where students stated that they used a combination of guessing and solving when solving.

Although in the group interview the students claimed that the *HTML* and *CSS* levels were easy ("when someone has already done it, it's not difficult"), direct observation showed that one pair had significant problems with these tasks and a certain degree of frustration was visible in them; the encouragement to finish had to come from the teacher. The mentioned fact occurred only with this pair and only with the *HTML* and *CSS* levels.

3. *I was satisfied with the game*: In general, students agreed with this statement (M 4.44, SD 0.73), which is a result closer to the *agree* value from above. The students rated the game as good in a group interview. They commented on it, saying "Perfectly processed. I praise the creator." "The game was fun. I would definitely accept learning this way." In the discussion, they themselves also gave suggestions on how to make the game even more attractive. "If there were still sounds, if bombs ticked and we could have headphones." Or "I would add that, for example, with more than 4 mistakes, the bomb would explode or something like that".

Direct observation confirmed the high participation of the students in the DEER and the enjoyment of the participants during the activity.

4. *When I was playing, I was not aware of my surroundings*: The responses to this statement were close to the mean value of the rating scale (M 3.06, SD 1.18). On the other hand, it was obvious from direct observation that the pairs concentrated only on their computer and did not follow the events around them in the other groups until they finished the game. In addition, neither pair required the help of the teacher while playing.

5. *I wanted to complete the entire game*: In general, the students wanted to finish the game to the end (M 4.44, SD 1.09), which is a result closer to the *agree* value from above. In the discussion, they agreed; they would try to finish the game even if they missed the time limit. Even if they left a level of the game before finishing it, which according to them was the case primarily with the *DNS name* level, they returned and wanted to finish this level as well.

6. *The game was an interesting way to review the topic of HTML and computer networks*: In general, the students were quite convinced that the activity allowed them to repeat the discussed topics in an interesting way (M 4.31, SD 0.87), which is a result closer to the *agree* value from above. In a group interview, the students stated: "we repeated it well", or "it

wasn't boring, it was definitely a pleasant repetition of HTML and networks." Finally, there was an opinion that "if it's like this at graduation, I'll be happy."

7. *I would recommend this activity to other students at school*: In general, the students *strongly agreed* with this statement (M 4.75, SD 0.68), which is a result closer to the value of strongly agree from below. In the discussion, they confirmed this strong recommendation: "yes, let them try it," and "everyone should try it."

8. *The game was an interesting way to learn new information from HTML and networks*: The responses to this statement were close to the value of *agree* from below (M 3.63, SD 0.96). On the other hand, in the group interview, the statements were more toward the fact that the game only contained things they already knew and that "we just repeated them." Although there was also the statement: "Definitely more lessons like this, the student learns best through tests like this and practice."

9. *The game encouraged me to think about the curriculum in a new way*: The answers to this statement were close to the value of agree from below (M 3.63, SD 1.36). As in the previous question, the discussion was more about repetition than about a new way of learning.

10. *I also learned something from my classmate in the escape room*: Respondents' answers to that statement are almost balanced for each option, and therefore the overall result for this statement was close to the mean value of the rating scale (M 3.19, SD 1.56). The group interview revealed that the students were happy to solve the game in pairs. For them, it meant more fun, more experience, and faster completion of tasks: "it was great," "it was better in a group," "it's good when you complement each other," "if I played it alone it would be slower, at least by 5 min."

This fact is also confirmed by direct observation when the students worked together from the very beginning of the game and tried to find a solution to the task together (Figure 2). An example is a pair who objected before the start of the game that they did not want to play the game in pairs and that they would like to solve it individually. However, as soon as the game was launched, they collaborated intensively on solving it and were even the first to solve the game.

Figure 2. Students in pairs while playing a digital educational escape room.

11. *Learning through play is better than a regular class*: In general, the students strongly agreed with this statement (M 4.50, SD 0.97), which is a result closer to the value of *strongly agree* from below. In the group interview, students strongly confirmed the feeling that the teaching method was more interesting than regular classes; even that they have an experience from the game and that they will remember it; "that something happened here." One student expressed the opinion that "it depends on what kind of teacher we are with, it matters a lot, but yes, it was more interesting." A discussion developed regarding whether they play similar games in class: "no such games," "we did other than micro:bit, but not like this," and "not at school." Likewise, students expressed the opinion that they would like more such games in class; even "yes, make it more challenging," which was based on the feeling that the activity was short. In addition, students expressed the opinion that they would not mind being graded at the end of the activity "if it would do it justice, according to the playing time," and another student added that "Tested and graded this way, it would be more interesting and fun than the usual way."

12. *It was difficult for me to concentrate on the content because I felt stressed*: In general, the students strongly disagreed with this statement (M 1.19, SD 0.54), which is a result closer to the *strongly disagree* value from above. In the discussion, they expressed the view that they did not feel any stress, that it was fun for them, and that "it was nice." Furthermore, everyone expressed satisfaction with the control of the game, and they always knew what to do during the game. They approached the use of help for each of the levels only rarely: "only once," "when it disappeared, I didn't know why it was disappearing, so I took help," and "at the IP address, it said it was on the right. "

13. *The tasks I had to solve in the levels (maze, pairs, search, etc.) distracted me from concentrating on the content about HTML, networks*: In general, the students disagreed with this statement (M 1.63, SD 0.95), which is a result closer to the *disagree* value from below. During the group interview, they expressed the feeling that if there weren't these tasks to make the level more difficult, it would not be as fun and "it would be too easy"; "there needs to be twice as many"; "let there be more and bigger ones." They also expressed the opinion that it is more interesting when each level is different: "definitely each different, it's better"; "we had to think for a while about what to do"; and "even more difficult, not to allow repeating some activities." On the note that if the levels were similar, as was the case for the *HTML* and *CSS* levels, it would be easier to solve the task after all, the students answered that "We don't want easy, we want difficult."

14. *In general, I like to play games (e.g., video games, social network games, board games...)*: The answers to this statement were close to the value of *agree* from above (M 4.31, SD 1.40). In the group interview, the students mentioned different types and kinds of games, even with specific names.

Finally, a fact from direct observation is also interesting; after the end of all the activities connected with the escape room testing in class, the students rewarded the whole experiment with a long spontaneous applause, which is not common in the teaching process.

4. Discussion

By introducing the concept of escape games into the third year of a secondary vocational school in the field of computer network mechanics, the objective was to determine the educational potential of ER in a secondary vocational school and the perceived experience of the students. Based on the three categories of research questions mentioned in the introduction to this study, the following is a discussion of the results obtained from the experiment carried out. The main reason for carrying out this study is the fact that the use of escape rooms in secondary vocational schools focused on technical vocational subjects has not been documented anywhere, although ER is used in other fields, especially medical fields [22]. Studies dealing with the use of escape rooms in secondary vocational schools in fields close to computer science are absent in the professional literature.

According to the students, the DEER was pleasant, helped them review the content of the subject, and they could enjoy working in pairs. Likewise, students' desire to apply more games of this type within secondary vocational education in other educational subjects indicates that a teaching strategy based on ER is suitable for student motivation. Similar conclusions to these findings can also be found in previous studies such as [25].

In terms of entertainment, the digital educational escape room implemented was a success, as up to 87% of the participants said they were satisfied with the game. This outcome was further supported by qualitative data obtained from group interviews and direct observations, which demonstrated the high involvement and enjoyment of the participants during the activity. This fact also corresponds to previous research, in which participants highly valued game activities and expressed positive opinions about the integration of DEERs into the curriculum [60,61] and where they felt satisfied with the overall experience [62]. The results of the conducted experiment can be seen as reinforcing and complementing previous research that found that educational escape rooms can be a fun and motivating teaching strategy; it appears that this statement also applies to secondary school vocational teaching in technical vocational subjects.

However, although the amount of literature [25,63,64] states that the cognitive abilities of the students increase with the implementation of ERs, it was not possible to confirm this fact in the experiment conducted. The main cause appears to be the insufficient time span, in the order of minutes, which is dedicated to the activity and thus the insufficient space for acquiring and deepening knowledge. The same experience can be found in the work of Mills and King [65], where the authors state that the necessary time constraints require simple problems that limit students to conceptual shallows and that ERs may not be suitable for teaching concepts of a higher level. The authors recommend using the greatest potential in the three-layer exposure of escape, where students play, watch, and then create. Similarly, Vörös and Sárközi [45] state that the EER method is suitable for the phenomenological study of a new phenomenon, but additional classes are needed for a deeper understanding. Buchner et al. announce that EERs, like other educational games, are exploratory problem-based learning scenarios that can be fun but do not really contribute to learning without additional instructional elements [10]. While the study showed that DEERs do not have such an effect on cognitive abilities, these questions must be thoroughly investigated.

The results of the experiment also show for technical vocational subjects that the inclusion of the DEER in teaching increases enthusiasm, curiosity, fun, satisfaction and positive emotions, which are values that are directly related to internal motivational aspects [24,66,67]. In addition to creating a high internal motivation in the players, the experiment also indicates other benefits of including the DEER in teaching in secondary vocational schools, namely prioritizing learning, even demanding more challenging tasks, but the experiment also shows the possibility of improvement in attitudes and teamwork, which also corresponds to previous research on the introduction of ERs into teaching [26,47,68].

Furthermore, the findings signify a high level of engagement of the students in the content in their efforts to solve various challenges and puzzles in the DEER game activities [69,70]. From the point of view of student engagement, it also appeared in this experiment that, compared to traditional teaching methods, student engagement in problem solving is greater, they receive immediate feedback, and students are focused on their main goal and try to succeed, which requires successful communication with a team partner [1,71]. Additionally, students assume responsibility for their own learning process. During the game, teachers primarily take on the role of observers.

From the students' assessment, it can be concluded that the inclusion of a digital educational escape room in teaching appears to be a motivating and innovative teaching strategy and it can be considered as a complementary function to traditional teaching. For most of the students interviewed, the digital educational escape room had a motivating, fun, and engaging character and helped to strengthen their knowledge of the topic covered.

Finally, the limitations of this study are listed. As a pilot study with only 16 secondary vocational school students focusing on technical vocational subjects, the target group represented a small sample and therefore the results may not be generalizable; moreover, there is a lack of a control group in a traditional classroom with which to compare variables. In addition, the range of topics focused only on HTML and computer networks does not allow an overall overview of all areas of technical professional subjects. In addition, testing only third grade students does not provide a comprehensive view of the various levels of education.

The biggest limitation for qualitative research was the focus group interview, where the respondents answered the questions too briefly and many times gave only one-word answers; the most common answer was "fine". The students had to be encouraged to discuss and the same questions had to be asked several times in a different way. From the observation, it is possible to relate this lack of group interview to the fact that these were secondary vocational school students who had never been the subject of research before, did not know the group interview method, and did not know how to respond appropriately. In the same way, the field studied by students in technical professional subjects does not develop enough soft skills and the ability to lead a discussion.

Future studies will try to remove these limitations.

5. Conclusions

This work shows an analysis of the experience of a digital educational escape room focused on the content learned in teaching (HTML and computer networks) with students of a vocational high school specializing in technical vocational subjects. The obtained results make it possible to know the students' perception of the digital educational escape room and to inform ourselves about the impact on the learning process. Experiences with ERRs in secondary vocational schools with a focus on technical vocational subjects have not been published so far, and the aim of this study is to fill the gap in this area.

Based on the findings, the use of the digital educational escape room contributed to improvements in the various dimensions investigated and showed the potential of this gamified methodology. Although during the experiment there was no increase in knowledge using the digital educational escape room, which is due to the shortness of the DEER application in the teaching process, the motivation of students and the support of active learning increased significantly. In addition to motivation, there was an increase in students' satisfaction, engagement, and teamwork, their interest in the topics covered increased, and the students were able to solve even more difficult problems from the covered subject matter without any problems in a short time. The escape room activity immersed the students in learning and provided immediate feedback.

The experiment performed demonstrates that the application of a digital educational escape room to learn technical vocational subjects and, more specifically, to learn HTML and computer networks in the third year of vocational high school was highly motivating for the students and gave them the joy of learning, collaboration with their peers, and overcoming any difficulties and challenges encountered during the game.

However, it was found that the preparation and implementation of a digital educational escape room requires more preparation on the part of the teacher and is more time-consuming; nevertheless, the final outcomes obtained from application can mean a positive impact on the teaching process.

Finally, due to the limitations of this study, it should be noted that the sample of students consulted is small and without a control group. Although the conclusions from the use of the DEER in secondary vocational school are positive, it is also necessary to take into account the areas tested within informatics. In this case, positive results were achieved in work in the field of HTML and computer networks. It is appropriate to examine a wider range of subjects in ICT, as well as different levels of education. Future studies will try to remove these limitations.

The method of digital educational escape rooms also provides education with an activity based on challenges in secondary vocational schools focused on technical vocational subjects; if it is well designed, students may find the activity very attractive, and it also promotes active and meaningful learning.

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Institutional Review Board Statement: The research was conducted in compliance with the ethical standards required for research with humans, respecting the basic principles included in the Declaration of Helsinki and the code of good practice in research of the University of Ss. Cyril and Methodius in Trnava. The research was strictly anonymous and completely voluntary. Participants were informed before their participation that no identifiable data will be collected and that their participation is completely voluntary. The data are used for research purposes only. The study was approved by the management of the University of Ss. Cyril and Methodius in Trnava on 27 April 2022.

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Data Availability Statement: The HTML5 version of the digital educational escape room (English version): https://liluo.io/lh/escape-room—en- (accessed on 1 September 2022).

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References

1. Macías-Guillén, A.; Díez, R.M.; Serrano-Luján, L.; Borrás-Gené, O. Educational Hall Escape: Increasing Motivation and Raising Emotions in Higher Education Students. *Educ. Sci.* **2021**, *11*, 527. https://doi.org/10.3390/educsci11090527.
2. Peleg, R.; Yayon, M.; Katchevich, D.; Moria-Shipony, M.; Blonder, R. A Lab-Based Chemical Escape Room: Educational, Mobile, and Fun! *J. Chem. Educ.* **2019**, *96*, 955–960.
3. Quariachi, T.; Wim, J.L. Escape rooms as tools for climate change education: An exploration of initiatives. *Environ. Educ. Res.* **2020**, 26, 1193–1206.
4. Mystakidis, S.; Christopoulos, A. Teacher Perceptions on Virtual Reality Escape Rooms for STEM Education. *Information* **2022**, *13*, 136.
5. Avargil, S.; Shwartz, G.; Zemel, Y. Educational Escape Room: Break Dalton's Code and Escape! *J. Chem. Educ.* **2021**, *98*, 2313–2322.
6. Avargil, S. Knowledge and Skills of University Students in Chemistry-Related Departments as Expressed in a Specially Designed Escape-Room. *J. Sci. Educ. Technol.* **2022**, *31*, 680–690.
7. Brown, N.; Darby, W.; Coronel, H. An Escape Room as a Simulation Teaching Strategy. *Clin. Simul. Nurs.* **2019**, *30*, 1–6.
8. Veldkamp, A.; van de Grint, L.; Knippels MC, P.; van Joolingen, W.R. Escape education: A systematic review on escape rooms in education. *Educ. Res. Rev.* **2020**, *31*, 100364.
9. Antonova, A.; Bontchev, B. Exploring puzzle-based learning for building effective and motivational maze video games for education. In Proceedings of the 11th Annual International Conference on Education and New Learning Technologies, Palma, Spain, 1–3 July 2019; pp. 2425–2434.
10. Buchner, J.; Rüter, M.; Kerres, M. Learning with a digital escape room game: Before or after instruction? *RPTEL* **2022**, *17*, 10. https://doi.org/10.1186/s41039-022-00187-x.
11. Clauson, A.; Hahn, L.; Frame, T.; Hagan, A.; Bynum, L.A.; Thompson, M.E.; Kiningham, K. An innovative escape room activity to assess student readiness for advanced pharmacy practice experiences (APPEs). *Curr. Pharm. Teach. Learn.* **2019**, *11*, 723–728.
12. Veldkamp, A.; Daemen, J.; Teekens, S.; Koelewijn, S.; Knippels, M.-C.P.J.; van Joolingen, W.R. Escape boxes: Bringing escape room experience into the classroom: Escape boxes. *Br. J. Educ. Technol.* **2020**, *51*, 1220–1239.
13. Onecha Pérez, B.; Sanz Prat, J.; López Valdés, D. The limits of playfulness in the teaching of architecture. The technique of the Escape Room. *ZARCH J. Interdiscip. Stud. Archit. Urban.* **2019**, *12*, 122–133.
14. Sierra-Daza, M.C.; Fernández-Sánchez, M.R. Gamifying the university classroom. Analysis of an Escape Room experience in higher education. *REXE Rev. Estud. Exp. Educ.* **2019**, *18*, 105–115.

15. Rosenkrantz, O.; Jensen, T.W.; Sarmasoglu, S.; Madsen, S.; Eberhard, K.; Ersbøll, A.K.; Dieckmann, P. Priming healthcare students on the importance of non-technical skills in healthcare: How to set up a medical escape room game experience. *Med. Teach.* **2019**, *41*, 1285–1292.
16. Cain, J. Exploratory implementation of a blended format escape room in a large enrollment pharmacy management class. *Curr. Pharm. Teach. Learn.* **2019**, *11*, 44–50.
17. Clapson, M.L.; Gilbert, B.; Mozol, V.J.; Schechtel, S.; Tran, J.; White, S. ChemEscape: Educational Battle Box Puzzle Activities for Engaging Outreach and Active Learning in General Chemistry. *J. Chem. Educ.* **2020**, *97*, 125–131.
18. Edwards, T.; Boothby, J.; Succheralli, L. Escape room: Using an innovative teaching strategy for nursing students enrolled in a maternity clinical course. *Teach. Learn. Nurs.* **2019**, *14*, 251–253. https://doi.org/10.1016/j.teln.2019.05.001.
19. Kinio, A.E.; Dufresne, L.; Brandys, T.; Jetty, P. Break out of the classroom: The use of escape rooms as an alternative teaching strategy in surgical education. *J. Surg. Educ.* **2019**, *76*, 134–139.
20. Beguin, E.; Besnard, S.; Cros, A.; Joannes, B.; Leclerc-Istria, O.; Noel, A.; Roels, N.; Taleb, F.; Thongphan, J.; Alata, E.; et al. Computer-Security-Oriented Escape Room. *IEEE Secur. Priv. Mag.* **2019**, *17*, 78–83.
21. Lathwesen, C.; Belova, N. Escape Rooms in STEM Teaching and Learning—Prospective Field or Declining Trend? A Literature Review. *Educ. Sci*. **2021**, *11*, 308. https://doi.org/10.3390/educsci11060308.
22. Grande-de-Prado, M.; García-Martín, S.; Baelo, R.; Abella-García, V. Edu-Escape Rooms. *Encyclopedia* **2021**, *1*, 4.
23. Ho, A.M. Unlocking ideas: Using escape room puzzles in a cryptography classroom. *PRIMUS* **2018**, *28*, 835–847.
24. Borrego, C.; Fernández, C.; Blanes, I.; Robles, S. Room escape at class: Escape games activities to facilitate the motivation and learning in computer science. *JOTSE* **2017**, *7*, 162–171.
25. Lopez-Pernas, S.; Gordillo, A.; Barra, E.; Quemada, J. Examining the Use of an Educational Escape Room for Teaching Programming in a Higher Education Setting. *IEEE Access* **2019**, *7*, 31723–31737.
26. Adams, V.; Burger, S.; Crawford, K.; Setter, R. Can You Escape? Creating an Escape Room to Facilitate Active Learning. *J. Nurses Prof. Dev.* **2018**, *34*, 1–5.
27. Ross, R.; de Souza-Daw, A. Educational Escape Rooms as an Active Learning Tool for Teaching Telecommunications Engineering. *Telecom* **2021**, *2*, 10.
28. Fotaris, P.; Mastoras, T. Escape rooms for learning: A systematic review. In Proceedings of the ECGBL 2019 13th European Conference on Game-Based Learning, Odense, Denmark, 3–4 October 2019; pp. 235–243.
29. Michaeli, T.; Romeike, R. Investigating Students' Preexisting Debugging Traits: A Real World Escape Room Study. In Proceedings of the 20th Koli Calling International Conference on Computing Education Research, Koli, Finland, 19–22 November 2022; pp. 1–10.
30. Hacke, A. Computer Science Problem Solving in the Escape Game Room-X. In *Transactions on Petri Nets and Other Models of Concurrency XV*; Springer Science and Business Media LLC: Berlin/Heidelberg, Germany, 2019; pp. 281–292.
31. Dochtsis, R.; Kotsifakos, D.; Douligeris, C. An Escape Room Game for Learning Digital Electronics in Vocational Education and Training (VET). In *Internet of Things, Infrastructures and Mobile Applications*; Auer, M.E., Tsiatsos, T., Eds.; Springer: Cham, Switzerland, 2020; pp. 664–674.
32. Ang, J.W.J.; Ng, Y.N.A.; Liew, R.S. Physical and Digital Educational Escape Room for Teaching Chemical Bonding. *J. Chem. Educ.* **2020**, *97*, 2849–2856.
33. Huang, S.-Y.; Kuo, Y.-H.; Chen, H.-C. Applying digital escape rooms infused with science teaching in elementary school: Learning performance, learning motivation, and problem-solving ability. *Think. Ski. Creat.* **2020**, *37*, 100681.
34. Vidergor, H.E. Effects of digital escape room on gameful experience, collaboration, and motivation of elementary school students. *Comput. Educ.* **2021**, *166*, 104156.
35. Mystakidis, S.; Papantzikos, G.; Stylios, C. Virtual Reality Escape Rooms for STEM Education in Industry 4.0: Greek Teachers Perspectives. In Proceedings of the 6th South-East Europe Design Automation, Computer Engineering, Computer Networks and Social Media Conference, Preveza, Greece, 24–26 September 2021.
36. Makri, A.; Vlachopoulos, D.; Martina, R.A. Digital escape rooms as innovative pedagogical tools in education: A systematic literature review. *Sustainability* **2021**, *13*, 4587.
37. Mustafa, S.M.S.; Elias, H.; Noah, S.M.; Roslan, S. A proposed model of motivational influences on academic achievement with flow as the mediator. *Procedia-Soc. Behav. Sci.* **2010**, *7*, 2–9.
38. Kaur, N.; Vadhera, R.P. Predicting students' achievement in science from selected affective factors. *SN Soc. Sci.* **2021**, *1*, 33.
39. Kleftodimos, A.; Evangelidis, G. Augmenting educational videos with interactive exercises and knowledge testing games. In Proceedings of the 2018 IEEE Global Engineering Education Conference (EDUCON), Canary Islands, Spain, 18–20 April 2018; pp. 872–877. https://doi.org/10.1109/EDUCON.2018.8363322.
40. Kleftodimos, A.; Lappas, G.; Evangelidis, G. Edutainment and practice in video-based learning: Enriching educational videos with interactive activities and games. *Int. J. Entertain. Technol. Manag.* **2020**, *1*, 5–33.
41. Hosťovecký, M.; Babušiak, B. Brain activity: Beta wave analysis of 2D and 3D serious games using EEG. *J. Appl. Math. Stat. Inform.* **2017**, *13*, 39–53.

42. Kim, S.; Song, K.; Lockee, B.; Burton, J. What is Gamification in Learning and Education? In *Gamification in Learning and Education*; Springer Science and Business Media LLC: Berlin/Heidelberg, Germany, 2018; pp. 25–38.
43. Tsekleves, E.; Cosmas, J.; Aggoun, A. Benefits, barriers and guideline recommendations for the implementation of serious games in education for stakeholders and policymakers. *Br. J. Educ. Technol.* **2014**, *47*, 164–183.
44. Charlo, J.C.P. Educational Escape Rooms as a Tool for Horizontal Mathematization: Learning Process Evidence. *Educ. Sci.* **2020**, *10*, 213.
45. Vörös, A.I.V.; Sárközi, Z. Physics escape room as an educational tool. *AIP Conf. Proc.* **2017**, *1916*, 050002.
46. Kroski, E. What Is a Digital Breakout Game? *Libr. Technol. Rep.* **2020**, *56*, 5–7.
47. Pan, R.; Lo, H.; Neustaedter, C. Collaboration, Awareness, and Communication in Real-Life Escape Rooms. In Proceedings of the 2017 Conference on Interaction Design and Children, Stanford, CA, USA, 27–30 June 2017; pp. 1353–1364.
48. Berthod, F.; Bouchoud, L.; Grossrieder, F.; Falaschi, L.; Senhaji, S.; Bonnabry, P. Learning good manufacturing practices in an escape room: Validation of a new pedagogical tool. *J. Oncol. Pharm. Pract.* **2019**, *26*, 853–860.
49. Caldas, L.M.; Eukel, H.N.; Matulewicz, A.T.; Fernández, E.V.; Donohoe, K.L. Applying educational gaming success to a nonsterile compounding escape room. *Curr. Pharm. Teach. Learn.* **2019**, *11*, 1049–1054.
50. Doroudian, A.; Loos, E.; Vrugt, A.T.; Kaufman, D. Designing an Online Escape Game for Older Adults: The Implications of Playability Testing Sessions with a Variety of Dutch Players. In Proceedings of the International Conference on Human-Computer Interaction, Copenhagen, Denmark, 19–24 July 2020; Springer: Cham, Switzerland; pp. 589–608.
51. Vergne, M.J.; Smith, J.D.; Bowen, R.S. Escape the (Remote) Classroom: An Online Escape Room for Remote Learning. *J. Chem. Educ.* **2020**, *97*, 2845–2848.
52. Bodaker, L.; Rosenberg-Kima, R.B. Online pair-programming: Elementary school children learning scratch together online. *J. Res. Technol. Educ.* **2022**, 1–18. https://doi.org/10.1080/15391523.2022.2036653.
53. Morrell, B.L.M.; Eukel, H.N.; Santurri, L.E. Escape the Generational Gap: A Cardiovascular escape Room for Nursing Education. *J. Nurs. Educ.* **2020**, *59*, 111–115.
54. Eukel, H.N.; Frenzel, J.E.; Cernusca, D. Educational gaming for pharmacy students—Design and evaluation of a diabetes-themed escape room. *Am. J. Pharm. Educ.* **2017**, *81*, 6265.
55. Jiménez, C.; Arís, N.; Magreñán Ruiz, Á.; Orcos, L. Digital Escape Room, Using Genial. Ly and A Breakout to Learn Algebra at Secondary Education Level in Spain. *Educ. Sci.* **2020**, *10*, 271.
56. Strauss, A.; Corbin, J.M. *Basics of Qualitative Research: Grounded Theory Procedures and Techniques*; Sage Publications Inc.: Los Angeles, CA, USA, 2005.
57. Gómez, A.; Padrós, M.; Ríos, O.; Mara, L.-C.; Pukepuke, T. Reaching Social Impact through Communicative Methodology. Researching with Rather Than on Vulnerable Populations: The Roma Case. *Front. Educ.* **2019**, *4*, 1–8.
58. Abdul Rahim, A.S.; Abd Wahab, M.S.; Ali, A.A.; Hanafiah, N.H.M. Educational escape rooms in pharmacy education: A narrative review. *Pharm. Educ.* **2022**, *22*, 540–557.
59. Kuo, H.-C.; Pan, A.-J.; Lin, C.-S.; Chang, C.-Y. Let's Escape! The Impact of a Digital-Physical Combined Escape Room on Students' Creative Thinking, Learning Motivation, and Science Academic Achievement. *Educ. Sci.* **2022**, *12*, 615.
60. Chou, P.-N.; Chang, C.-C.; Hsieh, S.-W. Connecting digital elements with physical learning contexts: An educational escape-the-room game for supporting learning in young children. *Technol. Pedagog. Educ.* **2020**, *29*, 425–444.
61. Vicari, C. Escape the Planet: Empowering Student Designers to Create a Science-Based Escape Room with Augmented Reality. *Int. J. Des. Learn.* **2020**, *11*, 80–95.
62. Mystakidis, S.; Cachafeiro, E.; Hatzilygeroudis, I. Enter the Serious E-scape Room: A Cost-Effective Serious Game Model for Deep and Meaningful E-learning. In Proceedings of the 2019 10th International Conference on Information, Intelligence, Systems and Applications (IISA), Patras, Greece, 15–17 July 2019; pp. 1–6.
63. Dib, H.; Adamo-Villani, N. Serious Sustainability Challenge Game to Promote Teaching and Learning of Building Sustainability. *J. Comput. Civ. Eng.* **2014**, *28*, A4014007.
64. Fuentes-Cabrera, A.; Parra-González, M.E.; López-Belmonte, J.; Segura-Robles, A. Learning Mathematics with Emerging Methodologies—The Escape Room as a Case Study. *Mathematics* **2020**, *8*, 1586. https://doi.org/10.3390/math8091586.
65. Mills, J.; King, E. Exploration: ESCAPE! Puzzling out learning theories through play. In *The Power of Play in Higher Education*; James, A., Nerantzi, C., Eds.; Palgrave Macmillan: Cham, Switzerland, 2019; pp. 33–41.
66. Giang, C.; Chevalier, M.; Negrini, L.; Peleg, R.; Bonnet, E.; Piatti, A.; Mondada, F. Exploring Escape Games as a Teaching Tool in Educational Robotics. In Proceedings of the International Conference Educational Robotics 2018 (EDUROBOTICS), Rome, Italy, 11 October 2018; pp. 95–106.
67. Voštinár, P.; Dobrota, R. Minecraft as a Tool for Teaching Online Programming. In Proceedings of the 2022 45th Jubilee International Convention on Information, Communication and Electronic Technology (MIPRO), Opatija, Croatia, 23–27 May 2022; pp. 648–653. . https://doi.org/10.23919/MIPRO55190.2022.9803384.
68. Segura-Robles, A.; Parra-González, M.E. How to implement active methodologies in Physical Education: Escape Room. *Educ. Sport Health Phys. Act.* **2019**, *3*, 295–306.
69. Saltz, J.; Heckman, R. Using Structured Pair Activities in a Distributed Online Breakout Room. *Online Learn.* **2020**, *24*, 227–244.

70. Karageorgiou, Z.; Mavrommati, E.; Fotaris, P. Escape Room Design as a Game-Based Learning Process for STEAM Education. In Proceedings of the ECGBL 2019 13th European Conference on Game-Based Learning, Elbæk, Lars, Odense, Denmark, 3–4 October 2019; pp. 3–4.
71. López-Belmonte, J.; Segura-Robles, A.; Fuentes-Cabrera, A.; Parra-González, M.E. Evaluating Activation and Absence of Negative Effect: Gamification and Escape Rooms for Learning. *Int. J. Environ. Res. Public Health* **2020**, *17*, 2224.