Journal of Education and Practice
ISSN 2222-1735 (Paper) ISSN 2222-288X (Online)
Vol.13, No.30, 2022

Escape Individually or in Groups: Comparison of the Effectiveness of the Two Organizational Methods

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Abstract
During the COVID epidemic some teachers tried to use educational escape rooms to motivate their students to learn from home. In most cases they had to play alone, but the breakout games were originally played in groups. The aim of this research was to compare the learning effects of individually played educational escape rooms with those which played in groups. According to the literature there was some uncertainty of the efficiency of this type of game too. The results of this study have shown that escape rooms can be effective learning tools either played alone or in teams. The knowledge of the students was measured right before the escape room, immediately after the game and one month later. Both classes produced significantly better results immediately after both post-tests than on pre-test. This paper also compares the improvements of the two classes. It has been found that the team players' performance has improved to a significantly greater extent than individual players'. Besides, the significant difference which was measured on the pre-test disappeared after the game in both post-tests.
Keywords: Educational Escape Rooms, individually played, team play, feedback, learning effects
DOI: 10.7176/JEP/13-30-02
Publication date: October 31st 2022

1. Introduction

There were more authors in the field of educational researchers who had defined escape rooms (ER). Wiemker (2015) said they were played by a team which had to 'escape' from a room with a help of solving the puzzles in the room within a given time limit. Nicholson (2015, p. 1) called ERs those "live-action team-games where players discover clues, solve puzzles, and accomplish tasks in one or more rooms in order to accomplish a specific goal (usually escaping from the room) in a limited amount of time."

Nonetheless, I have noticed during the COVID epidemic that some teachers tried to use educational escape rooms (ER) to motivate their students to learn from home. In most cases the children have to work individually, which was creative but not in the spirit of the previously mentioned definitions at the same time, because ERs were defined as a team activity by both authors. But we have to mention that either between commercial card games, books or between mobile apps can be found ER games, which can be played alone. Since there were already some counterexamples in the past for this rule, we could not think about it as a strict one.

There was also some uncertainty in the literature that an educational ER can be an effective tool for learning (Lathwesen & Belova, 2021; Veldkamp et al., 2020), therefore Veldkamp et al. (2020) suggested further experiments with multiple tests for measure the change of students' knowledge.

The questions of this research have come from these facts:

1. Can students learn from playing ERs in teams?
2. Can students learn from individually played ERs?
3. Which organizational method is more effective: individual or group activity?

2. Literature review

2.1 ERs and learning theory

Educational ERs' philosophy contains the elements of behaviourism, socio-cultural, cognitivist and constructivist learning theories. (Taraldsen et al., 2022; Zhang et al., 2018) Behaviourism – the feedbacks in the game could reinforce the activity of the students – and the socio-cultural learning theory – the communication and cooperation of the students could be the source of learning during the game – were the two most important in this research. The first one was especially important while the game was played individually.

Lathwesen & Belova (2021) recommended analysing the influence of different game components to the students' learning process, so this paper tries to compare the effect of feedbacks and communication too, because the communication is impossible when the ER is played individually, the only task was to minimize the amount of feedback in the other treatment group.

2.2 Organization of puzzles

Puzzles can be organized in ERs in different ways, and this created the opportunity to solve the problem of

minimizing the amount of feedback. Two types of them were used in this experiment. The first one is the sequential ER, in which the players must solve one puzzle to be able to unlock the next one. (Nicholson, 2015) This is a very popular game type since managing it is quite easy for the teacher, the players can check their progress and it is quite sure that all of the participants have seen all the information. (Lopez-Pernas et al., 2019; Cain, 2019) This setup gives the most feedback, at the end of each puzzle.

The second type is the open structure, in which there are more independent puzzles whose solutions are elements of the final meta-puzzle. The difficulty in this case is to get the players to flow because of the fragmented setup. (Nicholson, 2015) However this game was planned for 20 minutes so this was not a highlighted issue, and the open structure has the least feedback, with proper planning just at the end of the game.

2.3 ERs as serious games

ERs can be understood as a type of educational games (Lathwesen & Belova, 2021), also called as serious games. According to the meta-analysis of Wouters et al. (2013) serious games are very effective learning tools either the students play individually or in teams but learning in teams lead to better results. So, the hypotheses of my research were:

1. Student knowledge can improve in individually played educational escape rooms.
2. Student knowledge can improve in educational escape rooms played in teams.
3. Playing in group is more effective than playing individually

3. Description of the game

3.1 The goals

I asked the teacher who helped my research to select a lesson from the curriculum which they want to hold as a game, which is hopefully a more motivating way of learning. The most important viewpoint was that the educational material had to be divided into three independent parts. The rock-cycle was selected with some lexical knowledge – the definition of minerals, rocks and ores with some examples. The lesson was a part of the geography subject, but it was an interdisciplinary material with many elements of chemistry and physics curriculum. The target classes were 9th graders, one of them was a four-grade class from the high school, the other one was an eight-grade class, but they were taught by the same teacher.

There were some difficulties with the planning. This research needed two games with which the learning goals were achievable, and they contained the exact same puzzles, but they were structured either to sequential or to open structure. Veldkamp et al. (2020) recommended an other important point too, that as many students as possible should escape successfully. The students could learn only those elements of the curriculum which they had found in the room, or which had been taught to them by their teammates. E.g., in this experiment an adventure sheet was used as one of the possibilities for teaching each other if they played in a group and as lesson notes too.

As this study asked how game's feedback impacts on learning, the teacher must not give any. Hint cards were used to help the students, this way we could minimize the probability of the teacher's unwitting reactions. The players could ask for one card per puzzle.

3.2 The puzzles

Every puzzle started with a short cartoon which told the story and contained the necessary knowledge elements. In the first exercise the students had to find a place on an image, where a type of rock could be formed. There they could find a number with which a card could be chosen from a small deck.

In the second exercise they had to choose the deep igneous pair of andesite based on the mineral composition of the rocks. Any possibility had a number, with which a card could be chosen again.

The third one was a crossword-puzzle, whose solution was a number spelled out. This was a weak point of the game, because it definitely gave feedback to the players who played in groups. They could know for sure if their answers were correct or not. On the other hand, it fitted in didactically very well, so I accepted this fact.

The fourth exercise was a meta-puzzle which resulted a word, the final solution of the game. It was planned to contain the most important elements of every other puzzle. This conception was important because of two reasons. The first one was that for technical reasons the two classes had the same 20 minutes for the game, and with individual play it was almost impossible to solve every exercise. The second one was that these puzzles were the most important possibility for the students to teach each other. So, this was the longest and most difficult challenge.

In the meta-puzzle the players had to organize the previously selected cards based on the major rock types which were on the backside of the cards. When they were ready, they had to answer the questions on the frontside. The answers were chemical signs of elements contained by a mineral. If they had found all of these, they got the solution of the game when they read the chemical signs together.

Cain (2019) mentioned that pilot testing was crucial before they played the ER, so I got someone to test the

ER too. This led to very important results, I had to correct some serious confusing wording errors. This created the teacher's opportunity not to give other hints but the cards.

3.3 Structure of the game

As I mentioned earlier, I chose the sequential way for individual play and the open way for playing in a group. In the first case they got only the first puzzle and the adventure sheet. If they solved the exercise, the number which they got also helped them to "find" the next envelope. They could choose a furniture and there were some cards on the teacher's desk on the first side with them (cupboard, shelves, etc.). They could check the backside of the chosen furniture, and if their answer is correct, they found the motto of the next puzzle's envelope.

In the second case they got every element of the ER in three envelopes at the beginning of the game. The groups were created from three or four students based on sympathy, they were bench mates on other lessons too.

4. Methods

4.1 The experiment

The lesson began with a pre-test. They could get a maximum ten points in the test from eight exercises. The first question needed a short answer for three points – the main types of the rocks. The others were simple-choice questions with three answer possibilities.

After that the teacher explained the rules of the ER. The game started when all of the needed envelopes were handed out. The players had to finish in 20 minutes, then they wrote the post-test which contained the exact same questions as the pre-test. A short debrief was planned immediately after the game ended, but there was not enough time in either class.

After one month the test was completed a third time in order to measure the long-term effects of the game. The teacher ensured that this topic did not come up in the lessons until this post-test. I have taken into consideration only those students who filled out all the tests.

4.2 Assessment

Results of the pre-test and the two post-tests were statistically analysed. At first the participants' improvement was calculated for every student from both post-tests results with this formula: (post-test result - pre-test result) /pre-test result * 100. Descriptive statistics of every test of both groups and both improvement variables were compared. I analysed the change of the groups' performance and compared what they achieved at the test written at the same time. In addition, I also compared them using one- and independent-samples t-test to find out if there was a significant difference anywhere between the groups' achievement or between the results of the pre- and post-tests of either group.

5. Results

The sample of the individual players, who were the eight-grade class, was a little bit smaller (n=31) than the team players (n=34). There were just two students in the first group who could finish the ER, but we planned the game so that the first three puzzles contained all the elements of the learning goals. Besides, the fourth exercise was the longest and toughest one, so presumably all participants were able to see the entire learning material. In the other class six out of twelve groups solved all the puzzles.

5.1 Statistical analysis of scores

Table 1. The descriptive statistics of the two classes

	Individual players			Team players		
	pre-test	1st post-test	2nd post-test	pre-test	1st post-test	2nd post-test
average	6.16±2.10	7.81±1.90	7.39±2.08	5.18±1.68	7.76±1.33	7.41±1.48
median	7.00	9.00	8.00	5.00	8.00	7.50
mode	8	9	9	4	7	9
minimum	2	4	2	3	4	4
maximum	10	10	10	9	10	10

As shown in Table 1 the individual players' pre-test statistics were better than the team players on every field except the minimum of their results. The independent samples t-test points out a significant difference between the two groups ($t = 2.10$ and $p = .040$). The difference may be caused by the fact that this class was the eight-grade high school class so they might have learned at a higher level in the past few years.

On the first post-test the two groups achieved a similar average, the minimums and the maximums are even, just the median and the mode shows a little difference. The independent samples t-test points out that there is no significant difference between the two groups' results ($t = .10$ and $p = .918$).

The averages of the second post-test were also similar, the modes and the maximums are even, just the medians and the minimums are different. The independent samples t-test cannot show significant difference

again (t = -0.06 and p = .956)

As we can see in Table 1 almost every result improved after the ER in both classes except the minimum of the individual players' achievements in the second post-test. The one sample t-tests shows significant differences between individual players' pre-tests and first post-tests (t = -4.80 and p < .001), between their pre-tests and second post-tests (t = -3.34 and p = 0.002), between the team players' results on pre-test and first post-test (t = -7.54 and p < .001) and between their pre-tests and second post-tests (t = -6.95 and p < .001).

5.2 Analysis of improvements

Table 2. The descriptive statistics of the improvements

	Individual players		Team players	
	1st post-test	2nd post-test	1st post-test	2nd post-test
average	37.74±48.54	28.18±45.93	63.74±55.05	54.86±50.41
median	16.67	12.50	50.00	50.00

I have calculated the changes of the students in relation to themselves in percentage value, so improvement = (post-test - pre-test) / pre-test * 100. This can be even a negative number if someone's result decreased.

As shown in Table 2, average and median of team players are higher than individual players', but the standard deviations were quite large. In any case the independent-samples t-test shows a significant difference between the improvements of the two groups in either case (1st post-test: t = -2.01 and p = 0.049; 2nd post-test: t = -2.22 and p = 0.030).

6. Discussion

6.1 Individual players

The first hypothesis says that the knowledge of students can improve if they play alone in an educational escape room. This may be accepted, because their post-tests' results are significantly better than their pre-tests'. It also has been proved that even after a month their knowledge was significantly greater, so the individually played game helps even long-term learning.

6.2 Team players

The second hypothesis says that the knowledge of students can improve if they play in a team in an educational escape room. This may be accepted too, as their post-tests' results are also significantly better than their pre-tests'. In this case too, the analysis has shown that this organizational method helps long-term learning. So, in our experiment ER was an effective learning tool in both cases, to answer our first question whether it can have even a positive impact on the learning process.

6.3 Comparison of the two groups

The third hypothesis of this research is that playing in a group in an educational escape room is more effective than playing individually. This can be also accepted, because of multiple calculations. Firstly, the significant difference between the two groups disappeared after the game. Secondly the improvements of team players have been significantly better than the change of the individual players. This result also indicates that the feedback has less effect on the learning process than the communication.

7. Limitations

There are limitations of this research. First, the samples' size was relatively small, n = 31 and n = 34 which limits the research.

Some circumstances could have an impact on the comparison of the two classes. The two groups played a slightly different game to give some impressions about the scale of the feedback's effect. On the other hand, the group with less improvement got even more feedback, so I suppose this circumstance rather helped them and their results might have been worse with the exact same ER. But one exercise was a crossword puzzle and that has given feedback for the team-players too which also limits the results.

The other very important factor is that both teams got to a level where there were no significant differences between them, so this can be the objective limit of these concrete ERs. It can be the truth that these puzzles can improve the students to this level from any decent previous knowledge. In this case the comparison is not correct again. Nevertheless, this is not very likely since Wouters et al. (2015) analysis has shown that this is the case in other serious games too.

Finally, only two players escaped individually but six teams This can have an effect on motivation and on practice either, therefore in the end on their results.

8. Conclusion

This research was built around the impact of the educational ERs on learning. In this experiment students have

learned from the game either they played individually or in teams. In both classes they achieved significantly better results on the post-tests than at the beginning of the lesson either it was filled out immediately after the game or a month later.

The team players' improvement was significantly better than those who played the ER individually. Based on this we can suppose that social-learning is a more important part of ERs than feedback. Nevertheless, feedback also had a positive effect so I plan a new experiment in which every class will play in teams but half of them will get more feedback from the game. I think this is an important question in the field of design, because it can be a point for choosing between the different game structures. More studies mentioned that a sequential ERs, which gives by the way the most feedback, helps to manage the game (Lopez-Pernas et al., 2019; Cain, 2019) but that is still a question how much it affects learning.

Based on the analysis of this paper, playing in groups is supposed to be a better option than playing alone. Of course, we cannot do anything about the fact if e.g., our class gets into quarantine, to mention what kind of situation inspired me, but if we have a choice it seems to be a better to play educational ERs in teams, and there are possibilities for this in the online world too. And the reason is not only the definition, in which the ERs are specified as team play, but the team play's better impact on the learning process too.

Besides this it is a much better choice from financial and from a preparation viewpoint too. It was more expensive, and it needed much more time to prepare for the individual play than for the team play. But these factors could have been reduced if I would have planned a digital game. Another point in planning is that my experience is the exact same as Cain's, presumably without a pilot test this ER would not have worked either.

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