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Innovative Learning Activities for Ethnically Diverse Students in Macedonian Science Education

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A game-based approach is widely used to increase students' motivation through their active participation, whereby research is interwoven with fun and competition is incorporated with cooperation. Working in teams or groups encourages students to exchange their opinions, to try to find solutions together or to win a game. In this way, they learn and improve skills such as collaboration and responsibility. Several activities involving the 5E model as part of inquiry-based science education and an escape room as part of game-based learning were used in science classes (chemistry, biology and physics). The activities were designed on three different topics – gases, ecology and electrical circuits – within the project "Diversity in Science towards Social Inclusion – Non-formal Education in Science for Students' Diversity". The activities focused on the students' self-concept towards science, interest in the subject, motivation and career aspirations in STEM, as well as the effectiveness of the implemented activities. The study aimed to assess the potential advantages of implementing activities in an ethnically diverse environment, benefiting both students and teachers. Pre- and post-questionnaires were designed and distributed to 190 students from various primary and secondary schools in Macedonia. The present paper provides an overview of game-based activities as well as a brief analysis of the pre- and post-questionnaire responses from students, focusing on the topic of ecology.

Keywords: game-based activities, ecology, escape room, ethnically diverse classroom, science education

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Inovativne učne dejavnosti za etnično raznolike učence v makedonskem naravoslovnem izobraževanju

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Pristop, ki temelji na igrah, se pogosto uporablja za povečanje motivacije učencev z njihovim aktivnim sodelovanjem, pri čemer se raziskovanje prepleta z zabavo, tekmovalnost pa s sodelovanjem. Delo v ekipah ali skupinah učence spodbuja, da izmenjujejo svoja mnenja, poskušajo skupaj poiskati rešitve ali zmagati v igri. Tako se učijo in izboljšujejo spretnosti, kot sta sodelovanje in odgovornost. Pri pouku naravoslovja (kemije, biologije in fizike) je bilo uporabljenih več dejavnosti, ki so vključevale model 5E kot del na raziskovanju temelječega naravoslovnega izobraževanja in sobo pobega kot del na igri temelječega učenja. Dejavnosti so bile zasnovane na tri različne teme – plini, ekologija in električna vezja – v okviru projekta DiSSI (Diversity in Science towards Social Inclusion – Non-formal Education in Science for Students' Diversity). Dejavnosti so se osredinjale na samopodobo učencev v odnosu do naravoslovja, ter zanimanje za predmet pri učencih, njihovo motivacijo in poklicne želje na področju STEM ter na učinkovitost izvedenih dejavnosti. Namen študije je bil oceniti potencialne prednosti izvajanja dejavnosti v etnično raznolikem okolju, ki koristijo učencem in učiteljem. Pripravljeni so bili vprašalniki pred izvedbo dejavnosti in po njej; razdeljeni so bili 190 učencem iz različnih osnovnih in srednjih šol v Makedoniji. V tem prispevku sta predstavljena pregled na igri temelječih dejavnosti ter kratka analiza odgovorov učencev pred izpolnitvijo vprašalnika in po njej, pri čemer se osredinjamo na temo ekologije.

Ključne besede: na igri temelječe dejavnosti, ekologija, soba pobega, etnično raznolik razred, naravoslovno izobraževanje

Introduction

As education continues to evolve, innovative approaches to teaching and learning are gaining traction. One prominent trend in education is the integration of educational games, which leverage the power of technology and gamification to enhance student engagement and promote effective learning experiences. Educational games have proven to be highly engaging for students, capturing their attention and motivating active participation in the learning process (Gentry et al., 2019; Hakulinen & Auvinen, 2014; Smiderle et al., 2020; Tvarozek & Brza, 2014; Yu et al., 2020). Research by Connolly et al. (2012) demonstrated that educational games promote higher levels of engagement compared to traditional instructional methods. The immersive and interactive nature of games keeps students actively involved, leading to increased interest and a deeper investment in learning.

Numerous studies have indicated that educational games can enhance learning outcomes across various subject areas. For instance, a meta-analysis by Wouters et al. (2013) examined the impact of educational games on learning outcomes and found significant positive effects on knowledge acquisition, skill development and retention. The interactive nature of games enables students to apply their knowledge, engage in problem-solving and make connections between abstract concepts and real-world scenarios, leading to deeper understanding and improved learning outcomes.

Educational games often require students to think critically, analyse information and solve complex problems within the game's context. A study by Gee (2005) highlighted the fact that games provide opportunities for learners to engage in critical thinking, strategic planning and decision-making. The iterative nature of gameplay encourages students to experiment, learn from failures and develop effective problem-solving strategies, fostering the development of valuable skills applicable beyond the game environment. Furthermore, games provide immediate feedback, allowing students to learn from their mistakes, experiment with different strategies and refine their understanding of scientific principles (Young et al., 2012).

Many educational games incorporate multiplayer or cooperative modes, promoting collaboration and social interaction between students. Research by Dondlinger (2007) showed that collaborative game-based learning environments foster positive social interactions, improve communication skills and enhance teamwork abilities. Students learn to work together, share knowledge and negotiate solutions, preparing them for collaborative work settings in the future. Collaborative educational games can enhance student learning and promote positive attitudes towards the subject matter (Stojanovska, 2021).

Game-based learning has gained significant attention as an innovative approach to education, particularly in science classrooms. This type of learning engages students emotionally, making learning memorable and increasing the likelihood of long-term retention of scientific knowledge (Plump & Meisel, 2020). It is well known that games, due to their nature, stimulate student interest. Incorporating interactive and immersive game elements captivates students' attention, fostering curiosity and motivation to explore scientific concepts (Annetta et al., 2009). Many science games incorporate competitive and collaborative elements, encouraging healthy competition between students and promoting teamwork skills (Naumovska et al., 2023). Science games often present complex challenges that require critical thinking and problem-solving skills, encouraging students to apply scientific knowledge in realistic scenarios (Squire, 2006). Game-based learning also promotes deep learning. Thus, games provide context-rich environments that connect scientific concepts to real-world applications, promoting meaningful learning experiences (Barab et al., 2007). They can help students develop a conceptual understanding of scientific ideas by providing multiple representations, simulations and models (Klopfer et al., 2009).

Immersive puzzle-solving experiences known as "escape rooms" have gained popularity in various domains, including education. In recent years, educators have recognised the potential of escape rooms as a powerful tool to foster engagement and enhance learning outcomes, particularly in science education (Dietrich, 2018; Lathwesen & Belova, 2021; Marin et al., 2021; Stojanovska et al., 2020b; Veldekamp et al., 2021). By combining elements of problem-solving, teamwork and critical thinking, escape rooms provide an interactive and experiential learning environment that captivates students' interest and promotes a deeper understanding of scientific concepts. Consequently, the utilisation of escape rooms as a teaching method aligns well with the objectives of the national science curricula in Macedonia (Stojanovska et al., 2020a), offering an immersive and interactive learning experience that stimulates student engagement and facilitates a deeper comprehension of scientific principles. The escape room approach involves designing a physical or digital "escape room" scenario, whereby students must work together to solve a series of puzzles and challenges related to science concepts in order to "escape" within a given time limit.

Escape rooms offer an exciting and immersive experience that captures students' attention and motivates them to actively participate in the learning process. The element of challenge and the time constraint associated with escape rooms create a sense of urgency, driving students to collaborate, think critically and apply their scientific knowledge to solve complex problems (Dichev & Dicheva, 2017). The captivating nature of escape rooms fosters high levels of engagement and promotes a positive learning atmosphere, as students become highly motivated to succeed and achieve their goals. Escape rooms encourage collaboration and teamwork, fostering the development of essential communication and interpersonal skills. Students must effectively communicate, share information and delegate tasks within their team to decipher clues and solve puzzles. Escape rooms require students to think critically, analyse information and apply scientific knowledge to overcome challenges. This approach encourages students to think creatively, collaborate and develop strategies to find solutions within the given constraints.

By employing questionnaires as a data collection tool, the present research aims to understand the potential influence of the escape room experience on students' self-concept towards science, interest in the subject, motivation and career aspirations in STEM, as well as their situational interest in different non-formal settings. The evaluation framework in the project "Diversity in Science towards Social Inclusion – Non-formal Education in Science for Students' Diversity" (DiSSI) aimed to capture students' *self-concept towards science*, which refers to their perception of their own abilities, competence and identity in the context of science learning (Marsh, 1990). This aspect is crucial, as it can influence students' engagement in science education. *Motivation* is another important factor that was evaluated. Students' motivation reflects their drive and enthusiasm towards learning science. It plays a significant role in their willingness to invest effort and persist in science-related activities (Eccles & Wigfield, 2002). The questionnaire used in the present study also measured students' *interest* in the subject of science. Interest refers to a positive affective response and curiosity that individuals experience towards a particular academic domain or topic. It involves a personal attraction and desire to engage with the subject matter, often leading to increased attention, long-term motivation and exploration of related content (Hidi & Renninger, 2006). The project was also aimed at gathering data on students' *career aspirations in STEM* (science, technology, engineering and mathematics). Assessing students' career aspirations provides insight into their long-term goals and aspirations in STEM fields, which can be influenced by their experiences and exposure to science education (Archer et al., 2010).

Utilising escape rooms as a teaching tool introduces students to an entirely new learning environment, distinct from traditional classroom settings. This shift in scenery prompted us to analyse situational interest, which refers to a temporary state reflecting how an activity impacts an individual, rather than their inherent preference for the activity (Hidi & Anderson, 1992). Five dimensions have been identified as influencing situational interest: novelty, challenge, attention demand, exploration intention and instant enjoyment, with instant enjoyment shown to have the most significant impact (Chen et al., 2001). Situational interest is crucial because the immediate appeal of an activity should translate into both short-term and long-term motivational effects on the learner (Renninger et al., 1992).

Additionally, the study seeks to evaluate the effectiveness of the implemented activities specifically designed around the topic of ecology during the escape room workshops.

Method

Participants

A total of 190 participants completed the questionnaire: 126 students from primary school (12–14 years old) and 64 from secondary school (15–18 years old). Detailed demographic data, including the breakdown of gender and ethnicity, are provided in Table 1.

Table 1
Participant demographic information

Grade level	Primary school	126
	Secondary school	64
Gender	Male	48
	Female	141
Language of instruction	Macedonian	125
	Albanian	53
	Turkish	12

Due to the Covid-19 pandemic, the data collection for the study required researchers to travel to schools located in various parts of Macedonia (the administration of the questionnaires was conducted during May and June 2022). A purposive sampling approach was employed to ensure a diverse sample, including both urban and rural schools, encompassing students from different ethnic backgrounds. By implementing this sampling strategy, the researchers aimed to gather comprehensive data that represents a wide range of students and educational settings, despite the challenges posed by the pandemic.

Instruments

The evaluation framework utilised questionnaires to gather data on students' self-concept towards science and interest in the subject (OECD, 2009), motivation (Ryan & Deci, 2000) and career aspirations in STEM (Kier et. al, 2014), as four subcategories that the project participants were interested in exploring. After the workshops, questionnaire data about the success of the workshops were collected, focusing on the situational interest in the different non-formal settings (Chen et al., 2001) and the effectiveness of the implemented activities (Bartlett & Anderson, 2019; Dugnol-Menéndez et al., 2021; Gordillo et al., 2020; Karageorgiou et al., 2020). These measures aimed to assess the effects of the tools and interventions employed in the project activities and provide valuable insights into the impact on target groups.

Prior to administering the questionnaires, the participants were provided with detailed information about the study and its voluntary nature. Consent was obtained from all of the participants, ensuring their willingness to participate. Furthermore, the participants were informed about the potential use of photographs for research purposes, thus promoting transparency and ethical considerations throughout the study. In the present paper, the pre- and post-questionnaires for students on the topic of ecology are analysed.

Research design

In this study, the escape room was designed as an engaging and interactive face-to-face activity, whereby students from primary and secondary schools from all over Macedonia participated in teams comprising 3–6 members. This group-work setting allowed for collaboration and teamwork among the participants, fostering a dynamic and cooperative learning environment. By conducting the escape room experience in person, students had the opportunity to interact directly with their teammates, share ideas and collectively work towards solving the puzzles and challenges presented to them. This format not only promoted social interaction, but also facilitated the development of important skills such as communication, problem-solving and critical thinking. The inclusion of primary and secondary school students ensured a diverse participant pool, encompassing different age groups and educational and ethnic backgrounds. This diversity brought unique perspectives and experiences to the escape room activity, contributing to a rich learning environment and encouraging peer-to-peer learning and support. The escape room workshops were conducted in various locations, including the university, schools and a botanical garden. The selection of locations aimed to provide diverse and engaging settings for the escape room experience, enhancing the immersion and authenticity of the activity.

The face-to-face nature of the escape room experience also allowed for real-time feedback and guidance from the instructor or facilitator. The instructor played a pivotal role in coordinating the workshops, providing the necessary instructions and overseeing the progress of the teams. This direct interaction with the instructor further enhanced the learning experience and provided an opportunity for personalised support when needed. To form the groups, the instructor randomly selected participants by using coloured strips. This approach not only facilitated random group allocation, but also promoted *collaboration* and *communication* between the students, which are considered essential skills for their future endeavours.

The instructor set a time limit of one hour for the game itself, while the overall workshop duration was two hours. The workshop commenced with an intriguing story that captivated the students' interest, such as finding a cure for an illness or saving the school. Following the story, the instructor explained the concept of the escape room and provided the rules of the game. The puzzles within the escape room did not follow a linear structure, allowing the teams to solve them in any order. There was a total of five puzzles, each designed to challenge the students' critical thinking and problem-solving abilities (Stojanovska et al., 2022). The puzzles used in the escape room were printed on coloured paper and laminated, thus allowing students to write directly on them and making them reusable for subsequent workshops. The puzzles were placed in envelopes and strategically hidden within the classroom or somewhere in the botanical garden, creating an environment of mystery and exploration. During the escape room activity, the students worked collaboratively within their groups to solve all of the puzzles and successfully complete the game. In order to promote independent thinking and problem-solving, no additional literature or access to mobile phones was allowed for seeking answers. All of the necessary materials for puzzle-solving were provided to each group. After successfully solving all of the puzzles, each group opened locks and discovered several pieces of a jigsaw puzzle in a box. All of the groups were then required to collaborate and combine their puzzle pieces to reveal the final prize. In this way, the activity emphasised the importance of collaboration over competition and reinforced the value of teamwork.

The design and development of the educational escape room activities was a collaborative effort involving designated individuals from various educational backgrounds. University professors, science teachers, school principals and one advisor from the Bureau of Development of Education all played a significant role in the design process, lending their expertise and advice as part of the project's National Advisory Board. Their involvement ensured that the activities were aligned with educational objectives, pedagogical principles and the specific needs of students in primary and secondary schools. Their valuable insights and recommendations contributed to the refinement and effectiveness of the escape room experiences, ultimately enhancing their educational value and relevance.

Analysis of the data

The data from the pre-questionnaires were analysed by considering all of the items for each scale. Mean, standard deviation and the reliability coefficient Cronbach's alpha, as a measure of internal consistency (Taber, 2018), were calculated. Independent *t*-tests were used to investigate significant differences between the mean scores of males and females, as well as between primary and secondary school students, across the four scales of the pre-questionnaire.

The results obtained from the post-questionnaires were analysed by calculating the percentage frequencies of agreement for each statement from the corresponding categories.

Results and discussion

In order to evaluate the impact of the escape room experience, comprehensive questionnaires were administered to all of the participants both before and after the workshop. The questionnaires primarily consisted of Likert-type statements, whereby participants were asked to indicate their level of agreement or disagreement. A scale of 1 to 5 was used, with 1 representing "strongly agree" and 5 representing "strongly disagree." The questionnaires were designed to capture important aspects of students' attitudes and perceptions. They specifically assessed students' self-concept towards science, interest in the subject, motivation and career aspirations in STEM before starting the activity. Moreover, the questionnaires included sections to gather the students' perceptions of the conducted activity. The participants' responses provided valuable insights into their experiences and opinions regarding the educational escape room.

I. Initial assessment and pre-intervention findings

The results were analysed considering all of the items for each scale, and the mean, standard deviation and reliability coefficient Cronbach's alpha as a measure of internal consistency were calculated (Table 2).

Table 2
Means, standard deviations and Cronbach's alpha reliability coefficient for the pre-questionnaire.

Scale	Number of items	Pre-questionnaire		
		M	SD	Cronbach's alpha
Interest in science	5	1.69	.80	.853
Career aspirations in science	7	2.27	1.22	.752
Self-concept towards science	6	1.88	.95	.863
Motivation for learning science	10	2.18	1.14	.766
Total	28	2.05	1.09	.895

Table 2 shows the Cronbach's alpha coefficient, indicating the internal consistency of the four scales utilised in the study. The results indicate acceptable internal consistency, with Cronbach's alpha values ranging from 0.752 to 0.863 for the individual scales and 0.895 for the overall pre-questionnaire. These findings align with the cutoff criteria established by Cohen (2000), suggesting acceptable internal consistency across all four scales. It is worth noting that similar studies in the literature (Korkmaz & Erdoğmuş, 2020; Taber, 2018; Zakariya, 2022) have also reported high values for the Cronbach's alpha reliability coefficient, further supporting the reliability of the measures employed in this research.

An analysis to compare the mean scores of females and males on the four scales of the pre-questionnaire was conducted. Independent t-tests were employed to examine whether there was a significant difference between the mean scores of males and females. The results of these tests can be found in Table 3.

Table 3
Comparison of male and female mean scores on the four scales for the pre-questionnaire.

Scale	Groups	M	SD	*t*	*p*
Interest in science	f	1.72	.80	1.812	.070
	m	1.61	.80		
Career aspirations in science	f	2.22	1.21	−.457	.648
	m	2.25	1.19		
Self-concept towards science	f	1.91	.92	1.280	.201
	m	1.82	1.04		
Motivation for learning science	f	2.19	1.14	.517	.605
	m	2.16	1.12		
Total	f	2.06	1.08	1.339	.180
	m	2.01	1.09		

Table 3 presents the mean scores, standard deviations (SD), t-values and p-values for the comparison of females (f) and males (m) on the four scales of interest: Interest in science, Career aspirations in science, Self-concept towards science, and Motivation for learning science. The total column provides the overall mean score for each group. Overall, the results of the independent t-tests indicate that there were no significant differences in the mean scores between females and males across the four scales and the total score. In contrast to the results of Lee et al. (2018) and Siregar et al. (2023), where male students scored higher, as well as the findings of Luttenberger et al. (2019) and Sellami et al. (2023) stating that females outperform males in terms of their self-concept and motivation, our data suggest that gender did not have a significant impact on these aspects of science education.

Furthermore, a comparison was made between the mean scores of primary (p) and secondary (s) school students on the four scales of the pre-questionnaire. Independent t-tests were conducted to assess whether there were significant differences between the mean scores of primary and secondary students. The results of these analyses can be found in Table 4.

Table 4

Comparison of mean scores of secondary and primary school students' mean scores in the four scales for the pre-questionnaire.

Scale	Groups	M	SD	*t*	*p*
Interest in science	s	1.87	.90	4.931	.000
	p	1.60	.73		
Career aspirations in science	s	2.23	1.19	−.991	.322
	p	2.30	1.24		
Self-concept towards science	s	2.01	1.03	3.097	.002
	p	1.82	0.91		
Motivation for learning science	s	2.44	1.21	7.264	.000
	p	2.05	1.08		
Total	s	2.19	1.14	6.706	.000
	p	1.98	1.06		

The results indicate significant differences between secondary and primary students in their scores for interest in science, self-concept towards science and motivation for learning science, as well as for their total scores. However, no significant difference was found between the two groups in career aspirations in science. These findings suggest that secondary students exhibit higher levels of interest, self-concept, motivation and overall scores in science compared to primary students. The observed differences in the results could be attributed to several factors. Firstly, the secondary students surveyed may have had more exposure to science-related topics and concepts, leading to a greater interest in and self-concept towards the subject. They may also have received more specialised instruction and guidance in science, which could contribute to higher motivation levels.

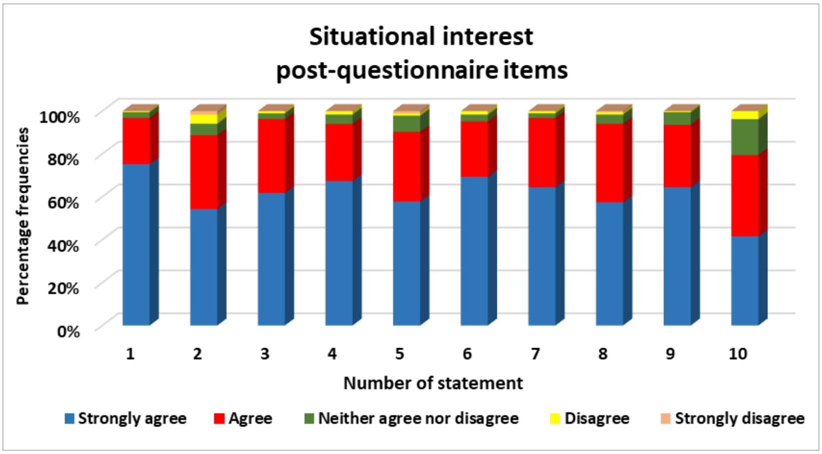
II. Post-intervention outcomes and questionnaire results

The results of the post-questionnaire are presented in six diagrams (Figure 1–6) based on the percentage frequencies.

Ten items from the post-questionnaire focused on assessing situational interest, which can be considered as a construct associated with five dimensions: novelty, challenge, attention demand, exploration intention and instant enjoyment (Chen et al., 1999; Chen et al., 2001). Figure 1 shows that more than 50% of the participants strongly agreed with all of the statements, indicating that they found the workshop interesting and were able to maintain their focus and attention. For this group of statements, the mean value is 1.45. This suggests that the activities presented in the workshop successfully fostered a high level of situational interest among the participants.

Figure 1

Results from the analysis of the situational interest post-questionnaire items.

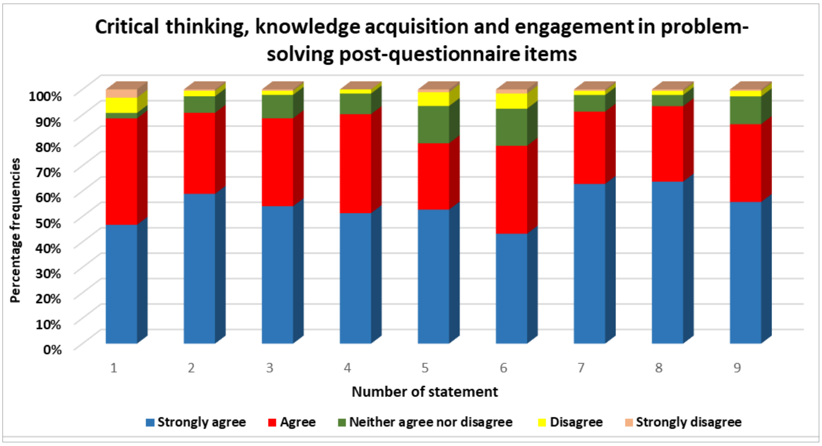


Statements: 1. The lesson in today's workshop was interesting. 2. Dealing with the subject matter was challenging today. 3. I was focused on this activity. 4. I enjoyed today's activity. 5. Today I understood well what we learned in the workshop. 6. Today's workshop was fun for me. 7. There was a lot going on at today's workshop, it was varied. 8. I was attentive in today's workshop, from the beginning to the end. 9. Today's material at the workshop attracted me, so I participated. 10. I want to delve into the details of the material we discussed at today's workshop.

The second section of the post-questionnaire was designed to assess the effectiveness of the implemented activities and examine the impact of the methods and tools utilised within the group. These findings are presented in five sets of statements (Figures 2–6). Specifically, the results from Figure 2 indicate a high mean value of 1.58 for the statements evaluating the promotion of critical thinking, knowledge acquisition and engagement in problem-solving. Analysis of the students' perceptions revealed that they were encouraged to approach the material differently and review the concepts related to the topic. Furthermore, approximately 80% of the participants expressed (agreed or strongly agreed with statement 5) that they felt they learned better through the game-based approach compared to a traditional lecture format.

Figure 2

Results from the analysis of the post-questionnaire items promoting critical thinking, knowledge acquisition and engagement in problem-solving.

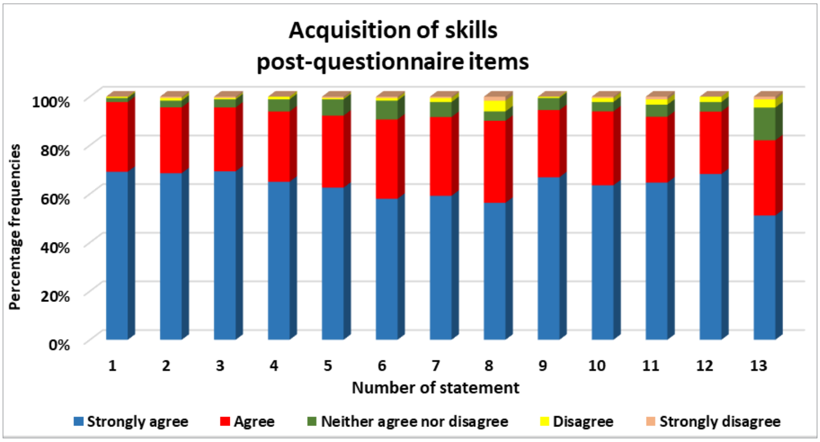


Statements: 1. I was learning while playing. 2. The escape room activity encouraged me to think about the material in a different way. 3. The escape room activity was an effective way to review the concepts of this theme. 4. The escape room activity was an effective way to learn new information related to this theme. 5. I learn better through a game than through a classic lecture. 6. I wanted to explore all aspects of the game, even if there were false directions. 7. The game had a clear purpose. 8. There were different types of puzzles. 9. There were puzzles that made me think "outside the box".

The third set of items analysed the degree of acquiring and improving skills through the escape room method that students believed they achieved (Figure 3). From Figure 3 it can be seen that the participants acquired skills for problem-solving, decision-making and logical reasoning, as well as improving their communication abilities, collaboration and teamwork. The results show a high mean value of 1.38. Similar results were obtained in a study on the use of escape room activities in occupational therapy courses, in which students believed they had developed curricular skills with a mean value between 3.84–4.28 on a scale where 5 is "strongly agree" (Dugnol-Menéndez et al., 2021). The participants in the latter study felt that they had strong organisational skills while performing the activities and effectively developed strategies within their groups, thereby enhancing their ability to manage time efficiently. Additionally, they exhibited persistence in completing the activity and demonstrated a high level of adaptability to new situations.

Figure 3

Results from the analysis of the post-questionnaire items promoting acquisition of skills.

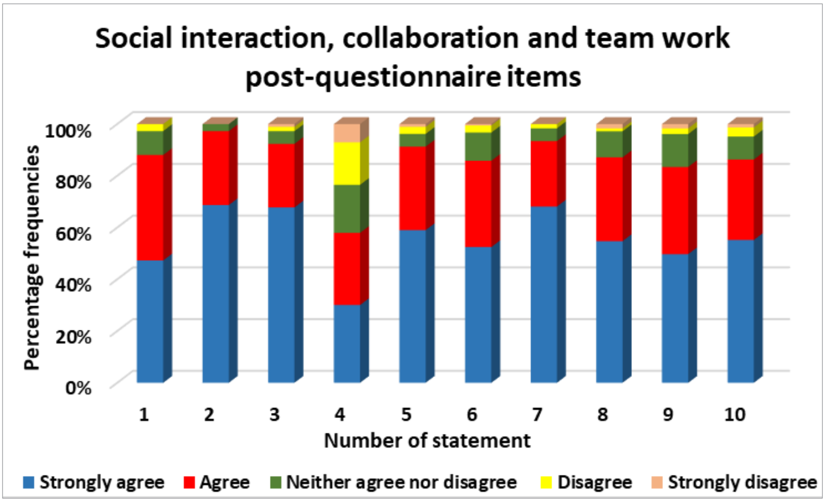


Statements: 1. Communication. 2. Teamwork and collaboration. 3. Problem-solving. 4. Decision-making. 5. Adapting to new situations. 6. Planning and time management. 7. Analyse and synthesise. 8. Critical thinking. 9. Logical reasoning. 10. Creativity. 11. Organisation. 12. Persistence. 13. Autonomous learning.

The effects of the game activities on social interaction were analysed in greater detail through a set of items presented in the fourth diagram (Figure 4). The results indicate that the activities facilitated collaboration and the sharing of knowledge among participants, fostering a friendly environment and increasing confidence levels within the group. The mean value for this set of statements was 1.59. Similar high scores for students' perception of shared knowledge have been observed in other studies (Bartlett & Anderson, 2019). Furthermore, in educational escape rooms designed for teaching software modelling, students reported a high level of involvement from team members (Gordillo et al., 2020).

Figure 4

Results from the analysis of the post-questionnaire items promoting social interaction, collaboration and teamwork.



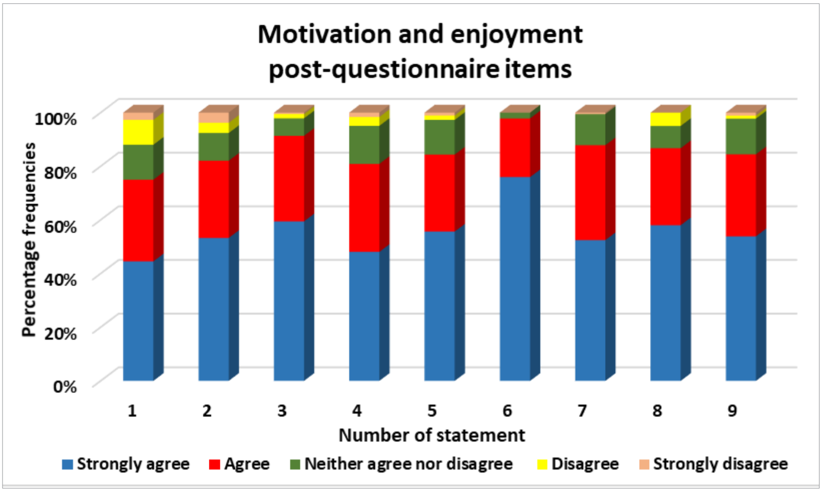
Statements: 1. I was able to learn from my peers during the escape room activity. 2. I was able to learn something new on this theme through discussion with classmates from the group. 3. I felt like a part of the team. 4. I prefer to participate in escape room activities as part of a team. 5. I would like to get more help while solving the puzzles. 6. All team members were almost equally involved in solving the puzzles. 7. The abilities of the team and the difficulty of the puzzles were at about the same level. 8. Throughout the game I cooperated and communicated with all of the team members. 9. After the game, I had a better understanding of what cooperation means. 10. After the game, I gained more confidence in my peers.

Figure 5 presents the results obtained for a set of statements related to motivation in the game activities. The mean values for individual statements range from 1.22 to 1.71, indicating a generally high level of agreement with the statements. The participants reported being engaged in completing or winning the game and becoming motivated to learn. They also expressed a sense of excitement and enjoyment, feeling immersed in the game's story and finding the game to be fun. Additionally, solving puzzles in the game increased participants' confidence and provided an unforgettable experience. The mean value for the group of statements related to motivation is 1.56, suggesting the game activities had a positive impact on the participants' motivation.

In their study in courses on occupational therapy, Dugnol-Menéndez et al. (2021) reported increased engagement and immersion in the activity when utilising escape room applications. Similarly, a study conducted in a technical high school demonstrated that the confidence of students increased after solving each puzzle in an escape room setting (Karageorgiou et al., 2020). These findings highlight the positive impact of escape rooms in fostering engagement, immersion and confidence among participants in various educational contexts.

Figure 5

Results from the analysis of the post-questionnaire items promoting motivation and enjoyment.

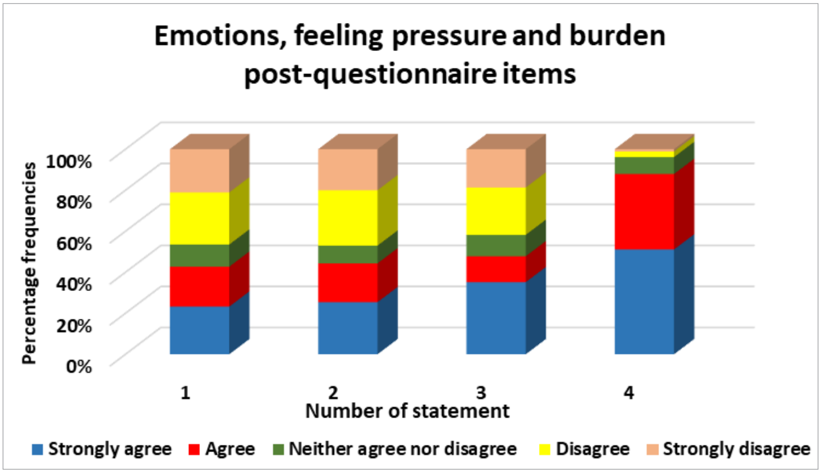


Statements: 1. Games motivate me to learn. 2. While playing I was trying to complete/win the game. 3. I almost didn't notice how quickly the time passed. 4. I was excited while playing. 5. I felt like a part of the game's story. 6. The escape room game was fun for me. 7. My confidence increased after solving each puzzle. 8. The game was an unforgettable experience. 9. After the game I felt more confident.

The next diagram (Figure 6) provides a summary of the results obtained for a set of statements and refers to the created positive or negative emotions, created stress or feeling distracted. The mean scores range from 1.59 to 2.94, indicating varying levels of agreement or disagreement with the statements. The results suggest that while some participants experienced difficulty focusing and perceived certain elements of the escape room activity as distracting, there was a prevailing presence of positive emotions. Other researchers have found similar results with regard to such statements (Bartlett & Anderson, 2019; Karageorgiou et al., 2020).

Figure 6

Results from the analysis of the post-questionnaire items promoting emotions, feeling pressure and burden.



Statements: 1. I found it difficult to focus on the activity/study because I felt stressed or overwhelmed. 2. Some parts of the escape room activity (e.g., codes, puzzles, etc.) distracted me/interfered with my learning. 3. I felt scared/anxious at the beginning of the game. 4. Positive emotions prevailed over negative ones.

It is important to note that a subset of the participants reported feeling scared or anxious. These findings highlight the diverse range of experiences and emotions that individuals may have during an escape room activity, indicating the need for consideration and support in creating an optimal learning environment.

Conclusions

In the DiSSI project, a framework was developed to evaluate the effects of tools on target groups, specifically focusing on students' perceptions of their self-concept towards science, interest in the subject, motivation and career aspirations in STEM. In order to assess these variables, a questionnaire was employed utilising established scales. The study also aimed to understand the influence of the escape room experience on situational interest in non-formal settings and to evaluate the effectiveness of escape room activities and their impact on student engagement and attitudes towards science.

The data presented in the text indicates substantial support for the effectiveness of escape room activities in science education. Specifically, the decision to conduct the escape room as a face-to-face, group work activity with teams consisting of 3–6 participants seems to have ensured an immersive and interactive learning environment that potentially fostered collaboration, communication and critical thinking among students from different ethnic backgrounds.

It is important to note that the sample used in the study was not selected randomly, which may limit the generalisability of the findings. Future research could aim to address this limitation by utilising random sampling methods in order to enhance the generalisability of the findings. Additionally, further investigations could explore the integration of other methods, such as the use of tip cards, to enhance the implementation of educational activities. Further insights may also be gained through the analysis of questionnaires distributed among other target groups and on different topics (such as gases and electrical circuits). It would also be valuable to assess the knowledge gained through the application of escape room methodologies in participating countries outside the project.

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