Breakout: sustainable development goals in teacher education through game-based learning

Breakout: Objetivos de Desarrollo Sostenible en la Formación Docente a través del aprendizaje basado en juegos
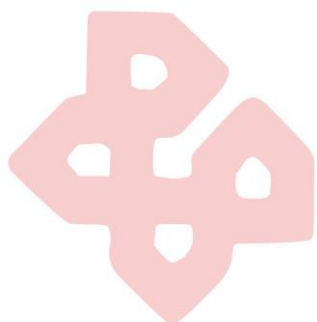
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Abstract:

The United Nation's Sustainable Development Goals (SDGs) are obligatory curricular content in primary and secondary education in many countries including Spain (LOMLOE, 2020). The main objectives of this study are to analyse student teacher perception towards the use of online breakout games and its effectiveness for the learning of the SDGs through game-based learning (GBL) in an online university context. The intervention consisted of a two-phase practical session using GBL through online breakout games with preservice teachers (N = 150) in the Master of Secondary Education in an e-learning university context. Participants subsequently answered a validated ad hoc questionnaire to determine perceptions towards their learning experience. Descriptive statistics were used to calculate central tendency. Non-normality was confirmed with Kolmogorov-Smirnov (Lilliefors corrected) and Shapiro-Wilk tests. Data analysis involved both parametric and nonparametric equivalents, involving the independent samples t-test, and Mann Whitney U respectively, to confirm findings. Results of the quantitative analysis show very positive perception and satisfaction towards the use of GBL through online breakout games in all areas and recommend its application in other subjects. There are statistically significant differences with medium effect size according to gender. Women consistently gave higher scores across all items, reporting significantly greater satisfaction, interest, and

engagement in GBL and its effectiveness for learning the SDGs. Findings furthermore suggest that GBL may be particularly useful in subjects with high levels of abstract content of which students have little previous knowledge.

Key words: active learning methodologies; game-based learning; higher education; sustainability; teacher training.

Resumen:

Los Objetivos de Desarrollo Sostenible (ODS) de Naciones Unidas son contenidos curriculares obligatorios en educación primaria y secundaria en muchos países, incluido España (LOMLOE, 2020). Los principales objetivos de este estudio son analizar la percepción de los futuros docentes hacia el uso de juegos online de breakout y su efectividad para el aprendizaje de los ODS a través del aprendizaje basado en juegos (ABJ) en un contexto universitario online. La intervención se llevó a cabo durante una sesión práctica utilizando juegos online de breakout con profesores en formación (N = 150) del Máster de Educación Secundaria en un contexto universitario de e-learning. Posteriormente, los participantes respondieron a un cuestionario ad hoc validado para determinar las percepciones sobre su experiencia de aprendizaje. Se utilizaron estadísticas descriptivas para calcular la tendencia central. La no normalidad de los datos se verificó mediante las pruebas de Kolmogorov-Smirnov (corregida por Lilliefors) y Shapiro-Wilk. El análisis de los datos incluyó tanto pruebas paramétricas como no paramétricas, empleando la prueba t para muestras independientes y la prueba U de Mann-Whitney, respectivamente, para corroborar los hallazgos. Los resultados del análisis cuantitativo muestran una percepción y satisfacción muy positiva hacia el uso de ABJ a través de juegos de breakout en todos los ámbitos y recomiendan su aplicación en otras asignaturas. Existen diferencias estadísticamente significativas con un tamaño del efecto medio según el sexo. Las mujeres otorgaron consistentemente puntuaciones más altas en todos los ítems, reportando una satisfacción, interés y compromiso significativamente mayores en ABJ para aprender los ODS demostrando su efectividad. Además, los hallazgos sugieren que ABJ puede ser particularmente útil en materias con altos niveles de contenido teórico sobre las cuales los estudiantes tienen poco conocimiento previo.

Palabras clave: aprendizaje basado en juegos, educación superior; formación docente; metodologías de aprendizaje activo; sostenibilidad.

1. Introduction

The Sustainable Development Goals (SDGs) as included in the 2030 Agenda for Sustainable Development (United Nations, 2015), form part of the obligatory curriculum of schools in many countries. They consist of 17 objectives that range from ending poverty, reducing consumption, and promoting peace. The SDGs are designed to foster an ethical and responsible education that leads students from all backgrounds and social contexts to understand their rights and obligations, not only within their immediate surroundings or society, but also within the global context of the world today. Defined as Education in Sustainable Development (ESD), they represent highly complex and multifaceted concepts for both educators and students.

In this context, this study proposes the use of game-based learning (GBL), defined as the use of games in educational contexts to enhance learning (Wiggins 2014), to potentially aid assimilation of content and knowledge transfer (Hamadi & El-Den, 2024). The use of GBL appears to be especially effective when dealing with higher order thinking skills and abstract content in higher education (Crocco et al.,

2016), while recognising the need for university contexts to incorporate technology into classes to promote meaningful learning (Štemberger & Konrad, 2021; Van Laar et al., 2020). Research suggests that GBL offers potential benefits that vary from task monitoring, automatic correction, and feedback in real time (Ricardo-Barreto et al., 2020) to greater student autonomy, and active and collaborative learning (Jarrah et al., 2022). The multitude of GBL resources encompass the use of escape rooms and educational breakout games (Cornellá Canals et al., 2020). Specifically, these tools have been found to generate greater engagement from students and promote motivation (Nadeem et al., 2023; Schaffhauser, 2017). They consist of a game, or series of games, in which the aim is to open boxes locked with different types of padlocks, requiring the students to find solutions to problems and challenges (Yllana-Prieto et al., 2023).

Within the framework of university education, teachers should be encouraged to modify pedagogical practices in a way that develops a skillset appropriate for the 21st century (Ishak et al., 2023; Kleimola & Leppisaari, 2022). The issue however remains as to how this may be achieved, with students frequently finding that formal education neither aligns with their interests and aspirations, nor the demands of society. This is the quintessential question for professionals in education who seek innovative teaching proposals to approach the new profile of students in the "digital era" (Timotheou et al., 2023).

Recent changes to educational law, as is the case of Spain (LOMLOE, 2020) require the incorporation of SDGs of the 2030 Agenda as a framework to promote an education grounded in sustainability, equity, and inclusion. The LOMLOE (2020) emphasizes the transformative role of education in shaping critical and engaged citizens capable of addressing the global challenges of the 21st century, aiming to promote values such as social justice and environmental preservation. Consequently, schools are, at least legislatively, positioned as key agents in the construction of more sustainable, equitable, and resilient societies. However, there is a lack of research to indicate how this plays out in practice, in the classroom.

Therefore, this paper incorporates strategies for knowledge construction and dissemination of the SDGs, using a series of online breakout games as a digital variation of escape rooms. Such resources are perceived as "natural" to the so-called digital natives (Fernández-Raga et al., 2023), thus potentially becoming allies in education (Pineda-Martinez et al., 2023; Zhao et al., 2022). In this study, 150 preservice secondary teachers were asked to participate in a GBL experience involving the 17 SDGs with the aim of contributing to the student's ESD (Lim et al., 2022). The experiment took place in the context of a Master's in Secondary Education in an online university in Spain.

2. Theoretical Framework

2.1. The SDGs and their importance in the educational field

Universities need to promote actions in the field of ESD in relation to teaching,

research, management, and infrastructures. For this reason, the university community must be offered an education that brings them closer to the needs of today, raises awareness and promotes responsible and fair citizenship (Brundiers et al., 2021). In 2015, The United Nations General Assembly adopted the 2030 Agenda for Sustainable Development (United Nations, 2015) with an agenda that consisted of 17 SDGs and 169 targets. These are transdisciplinary goals covering natural, social, and human sciences, culture, communication, and education as interconnected knowledge that together address the new challenges of the millennium. The goals are categorized into the 5P's: People, Planet, Prosperity, Peace, and Partnerships (De Siqueira et al., 2022).

The SDGs are interconnected, designed as an integrated and indivisible whole, which cannot be addressed separately (Bento et al., 2019). As such, ESD should arguably be taught in multiple subjects to enable students to gain cross-curricular awareness of global issues and their impact on various communities and regions, from eradicating poverty to climate action (United Nations, 2020). This potentially fosters a broader understanding that promotes a global perspective in their education (Redondo & Ladage, 2023). Moreover, it helps prepare students to face challenges and opportunities related to sustainable development in their future professional careers and personal lives (Chankseliani & McCowan, 2021).

In this regard, addressing the SDGs is essential to provide students with a comprehensive and relevant education (McCowan, 2019; Vasconcelos et al., 2022), which prepares them to teach this content in their future classrooms (Gómez & García, 2023). The SDGs describe the key challenges for humanity, including eradicating hunger, ensuring healthy lives, achieving gender equality, promoting peace, taking urgent action against climate change, and ensuring quality education (Sachs et al., 2021; Rieckman, 2017), as can be seen in the following figure:

1. NO POVERTY
•End poverty in all its forms everywhere.

2. ZERO HUNGER
•End hunger, achieve food security and improved nutrition, and promote sustainable agriculture.

3. GOOD HEALTH AND WELL-BEING
•Ensure healthy lives and promote well-being for all at all ages.

4. QUALITY EDUCATION
•Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all.

5. GENDER EQUALITY
•Achieve gender equality and empower all women and girls.

6. CLEAN WATER AND SANITATION
•Ensure the availability and sustainable management of water and sanitation for all.

7. AFFORDABLE AND CLEAN ENERGY
•Ensure access to affordable, reliable, sustainable, and modern energy for all.

8. DECENT WORK AND ECONOMIC GROWTH
•Promote sustained, inclusive, and sustainable economic growth, full and productive employment, and decent work for all.

9. INDUSTRY, INNOVATION AND INFRASTRUCTURE
•Build resilient infrastructure, promote inclusive and sustainable industrialization, and foster innovation.

10. REDUCED INEQUALILTIES
•Reduce inequality within and among countries.

11. SUSTAINABLE CITIES AND COMMUNITIES
•Reduce inequality within and among countries.

12. RESPONSIBLE PRODUCTION AND CONSUMPTION
•Ensure sustainable consumption and production patterns.

13. CLIMATE ACTION
•Take urgent action to combat climate change and its impacts.

14. LIFE BELOW WATER
•Conserve and sustainably use the oceans, seas, and marine resources for sustainable development.

15. LIFE ON LAND
•Protect, restore, and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss.

16. PEACE, JUSTICE AND STRONG INSTITUTIONS
•Promote peaceful and inclusive societies for sustainable development, provide access to justice for all, and build effective, accountable, and inclusive institutions at all levels.

17. PARTNERSHIPS AND GOALS
•Strengthen the means of implementation and revitalize the Global Partnership for Sustainable Development.

Figure 1. 17 Sustainable Development Goals
Source: (United Nations Development Programme, 2022, p. 16). Figure created by authors.

As can be seen, the SDGs aim to highlight the values and principles that are fundamental for building a fair, sustainable, and equitable world. Teachers play an undeniable role in achieving the SDGs and the 2030 Agenda, as agents of social transformation, reflecting on and making decisions about the role of education and how it can contribute to advancing this development agenda that requires active and participatory citizenship from everyone.

2.2. Application of the SDGs through breakout games in Higher Education

Within teacher training degrees, there are arguably certain subjects which may be particularly theoretical and abstract with complex curricular content such as educational policy and legislation of which students potentially have little, or no prior knowledge. In these contexts, it is essential that the learning processes in higher education promote the development of transferable competencies for future professional work. Digital resources can help the educators create, select, or personalise activities (Heine et al., 2023), thus engaging students when covering highly

abstract curricular content. While studies (Altomonte et al., 2016; Amballoor & Naik, 2023) have highlighted the use of digital tools for developing Sustainability Education, their simple integration into teaching will not, in itself, contribute to achieving sustainability. Rather, the teaching processes should promote critical reflection through activities that require higher order cognition, such as creative thinking or problem-solving (Chang & Yeh, 2021) when dealing with challenging concepts.

In addition, research in online settings emphasizes the importance of creating active (Ishak et al., 2022) learner-entered classrooms (Shohel et al., 2022), characterized by dynamism and interactivity (Chang & Yeh, 2021; Chen & Tang, 2023). In this regard, GBL potentially offers an active and engaging methodology which research suggests may facilitate knowledge acquisition (Ren et al., 2023). As such, it has gained ground in university classrooms, with the design and implementation of escape rooms a reflection of teaching innovation in higher education (Bárcena-Toyos, 2023; López-Pernas et al., 2019).

Specifically, online breakout games are a highly appropriate variation of escape rooms, being dynamic and more easily adapted to classrooms (Jiménez et al., 2020). According to Yllana et al. (2023), breakout games aim for students to manage to open a box with locks inside, containing a reward after overcoming a series of challenges. To obtain the codes that open said boxes, students need to solve problems, quizzes, and puzzles. The use of this technique in the classroom allows students to (a) adapt to any curriculum content, (b) promote collaboration and teamwork, (c) develop critical thinking and problem-solving skills, (d) improve communicative competence, (e) present challenges that require perseverance, (f) build deductive thinking, (g) learn to work under pressure, (h) be protagonists of learning, and, in addition, have a playful component that increases motivation.

In this sense, breakout games can be used to introduce a new lesson or concept, to reinforce and strengthen learning, or to conclude a lesson and reinforce learned skills more dynamically (Paz Gil et al., 2023), facilitating collaboration and knowledge transfer to solve different challenges (Wilkins et al., 2023; Rakha, 2023). Likewise, various authors (Trinh, 2022; Weisberg et al., 2022), highlight that breakout games generate greater commitment from students and promote engagement. In a similar vein, GBL can help students understand and apply content through new methodologies, keep interest, and meet the desired objectives in subjects (Plump & Meisel, 2020). Specifically, GBL also incorporates game-based elements with an educational focus and active learning (Karageorgiou et al., 2019; von Kotzebue et al., 2022; Mauri-Medrano et al., 2024) with less emphasis on the narrative typically found in gamification (Bárcena-Toyos, 2022).

In order to articulate this vision, this paper presents the results of an experiment involving a group of students undertaking the Masters of Secondary Education, the qualifying certificate of education to become a teacher of Secondary Education in Spain. The students were given the opportunity to participate in a GBL experience using breakout games to promote the learning of SDGs in teacher training. The experiment aims to analyse the implementation of the 2030 Agenda and the SDGs, focusing on the role that online breakout games play in achieving the SDGs (Alzahrani

& Alhalafawy, 2023).

3. Research questions and hypotheses

This research has two main objectives regarding the use of breakout games in teacher training in online Higher Education. Firstly, the authors aim to understand how students perceive the implementation of GBL through breakout games, with the objective of providing students with a practical example of how to gamify educational experiences. Secondly, the purpose is to explore the perceptions of future teachers regarding the learning and teaching of the SDGs through GBL. In addition, a third objective explored whether gender affects perception towards GBL. This is highly relevant taking into account that gender can affect interest and perception towards gameplay (Hartmann & Klimmt, 2006).

Therefore, this study poses the following research questions:

- RQ1) Is the use of GBL through breakout games perceived favourably in teacher training in an online higher education context?

- RQ2) Is the use of GBL through breakout games perceived favourably for the teaching and learning of the SDGs as obligatory curricular content in an online higher education context?

- RQ3) Is there a difference between male and female students in their perception towards the use of GBL through breakout games in an online higher education context?

As such, the study posits the following hypotheses:

- H1) The use of GBL through breakout games is perceived favourably in teacher training in an online higher education context.

- H2) The use of GBL through breakout games is perceived favourably for the teaching and learning of the SDGs as obligatory curricular content in an online higher education context.

- H3) There is a difference between male and female students in their perception towards the use of GBL through breakout games in an online higher education context.

The following figure presents the conceptual framework and relationship between the constructs:
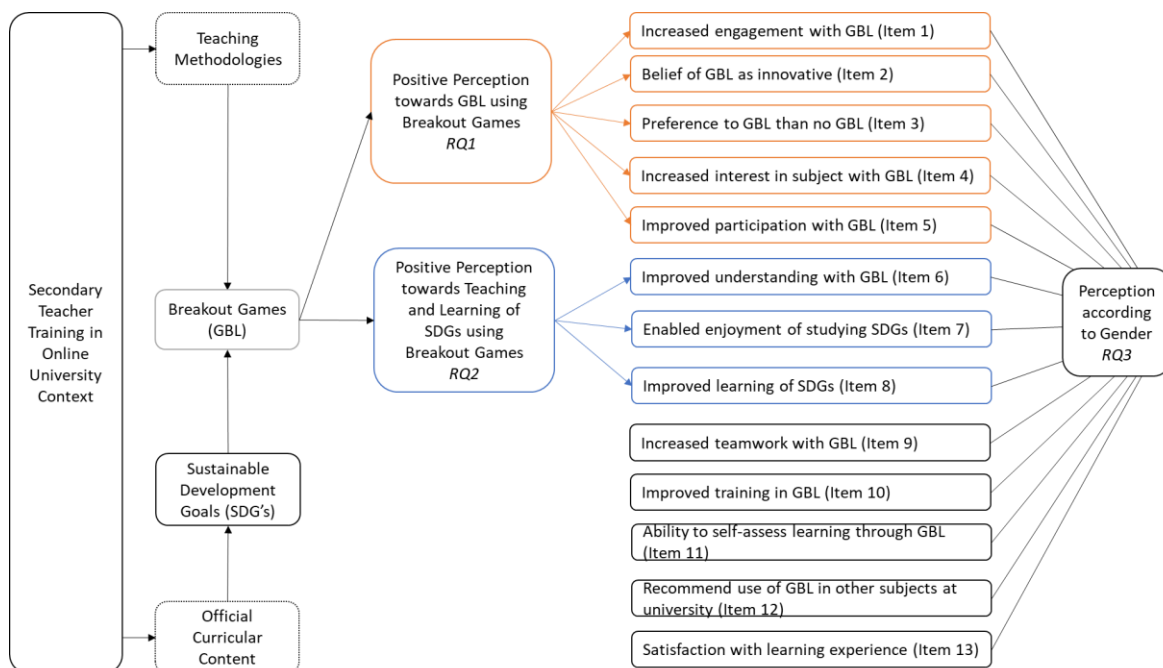
Figure 2. Conceptual model of GBL and the teaching of SDGs as obligatory content.
Source: Figure created by authors.

4. Methodology

A quantitative methodological approach was used to measure the preservice teachers' self-reported perceptions towards GBL through breakout games, and their effectiveness in aiding the teaching and learning of the SDGs. The intervention consisted of a two-phase practical session with participants subsequently answering a validated ad hoc questionnaire.

4.1. Sample

The selection of participants was conducted through non-probabilistic and intentional sampling. All participants were studying the subject of Educational Processes and Contexts as an obligatory subject worth 6 ECTS in the first semester of their one-year Master's in Teaching Secondary and Further Education in an online context at a Spanish University. The subject covers material such as educational legislation, curriculum, education policy, and centre documentation. The sample consisted of 150 student teachers, of whom 92 were women (61%) and 58 were men (39%), with an age range from 22 to 55 years old, and an average age of 37. Fieldwork took place during the first semester of 2023-2024, and the questionnaire was administered in December 2023.

4.2. Ethics

The research design and questionnaire were submitted and approved by the Ethics Committee of the Universidad del Atlántico Medio (Spain) with the code CEI/01-005. Participation in the study was anonymous and voluntary. All participants were adequately informed of the method and purposes of the research. All participants

were required to give their informed consent by ticking the consent box before completing the questionnaire.

4.3. Research Design

The intervention took place in two phases in the virtual classroom using online breakout games to cover content related to the SDGs. After completion of phase 2, participants completed an ad hoc questionnaire.

4.3.1. Phase 1: Experimentation

The online breakout game "Protecting the planet: learning the Sustainable Development Goals" was created using Genially. Students were placed in teams and given 40 minutes to overcome a series of challenges and missions related to the SDGs and the 2030 Agenda to unlock the keys. The activities have been detailed below to enable their replication:

Introduction (10 minutes): Explain to the students what a breakout game consists of and how it relates to the Sustainable Development Goals. Divide the students into working groups and assign them a name for their team.

Playing the breakout game "Protecting the Planet: Learning the Sustainable Development Goals" (30 minutes): Explanation of the rules of the game, provision of the link to start the challenge, and assistance in reading the initial clues until reaching the first challenge or mission related to the SDGs. In line with Torrado Cespón and Díaz Lage (2022), this initial guidance promotes a feeling of student involvement. Students must solve the challenges and collect clues that allow them to progress in the online breakout game. As teams progress through different screens, they can access new, more challenging tests and clues. Teams must work together, communicate, and make decisions to overcome obstacles and progress in the game. The teacher can continue to act as guide, providing additional clues when necessary.

4.3.2. Phase 2: Analysis

A second phase used challenges aimed at encouraging reflection and critical thinking related to the SDGs, through quiz 1 and 2 with a time limit of 30 minutes. These incorporated GBL through interactive and animated questionnaires with audio to allow students to apply and practice. The two games were also designed as a collaborative group activity to review, reinforce, and check knowledge about the SDGs, and to promote active and meaningful learning. Students continued to work collaboratively in teams as a form of scaffolding and to stimulate a feeling of inclusion, which can be lacking in an online context. The flow of the activities in phase 1 and 2 can be seen in the following figure, as well as the links to each:
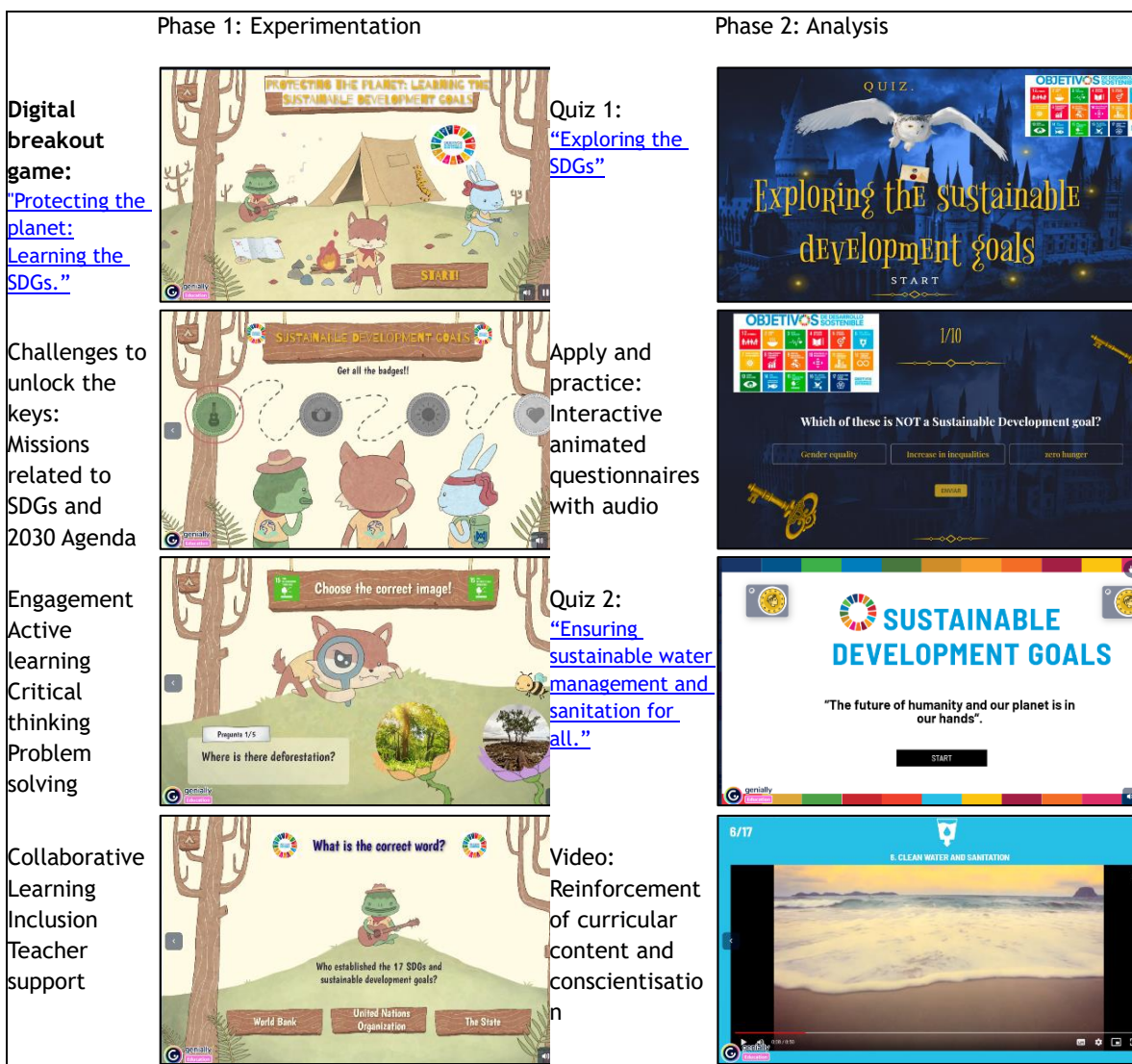
	Phase 1: Experimentation		Phase 2: Analysis
Digital breakout game: "Protecting the planet: Learning the SDGs."		Quiz 1: "Exploring the SDGs"	
Challenges to unlock the keys: Missions related to SDGs and 2030 Agenda		Apply and practice: Interactive animated questionnaires with audio	
Engagement Active learning Critical thinking Problem solving		Quiz 2: "Ensuring sustainable water management and sanitation for all."	
Collaborative Learning Inclusion Teacher support		Video: Reinforcement of curricular content and conscientisation	

Figure 3. Design of GBL through breakout games using Genially
Source: Figure created by authors.

After completing the above activities, participants asked to complete a questionnaire to determine their perceptions towards the activities.

4.4. Questionnaire design, validation and reliability

The ad hoc questionnaire was administered post intervention. All items had previously undergone a process of selection, modification, and validation by a team of 12 experts in the field who had a Ph.D. and related publications. The final version consisted of three sets of questions.

The first set contained multiple-choice questions regarding the participants' demographics. The second set consisted of 13 items of quantitative dependent variables that used a 6-point Likert scale to measure attitudes and the degree of agreement (Matas, 2018), with 1 being *Totally Disagree* and 6, *Totally Agree*. These were related to student perception and their motivation towards breakout games and their interest in the SDGs. Cronbach's alpha was used to measure reliability and

internal consistency of each research question.

Table 1
Reliability per Research Question

RQ	Cronbach's Alpha	N items	Items
1	.831	5	1,2,3,4,5
2	.841	3	6,7,8
3	.935	13	1,2,3,4,5,6,7,8,9,10,17,18,19

As can be seen in the above table, all RQ have relatively high (RQ1, RQ2) to high (RQ3) internal consistency.

4.5. Data analysis

Items were split into two categories: i) independent variables with demographics such as age and gender, and ii) quantitative dependent variables by RQ1, RQ2 and RQ3. Quantitative data analysis used IBM statistics/es SPPS, version 29. The significance level was set at .05, ($p < .05$) An asterisk was used * to indicate a p value equal or less than .01 (*$p \leq .01$).

Normality was tested via Kolmogorov-Smirnov (Lilliefors corrected) and Shapiro-Wilk tests. Both returned p- values smaller than .01 in all variables, indicating that the sample does not show normal distribution. Q-Q plots corroborated this finding. Data was then analysed for central tendency using descriptive statistics to determine the mean and standard deviation (see 5.1).

Despite the assumption of non-normality, the large sample size (N=150) enabled use of the parametric independent samples t-test (Altman & Bland, 2009; Fagerland, 2012) to determine whether there was a significant difference in the mean ($\bar{x}$) of students' responses according to age and gender. Age was not found to be a determining factor. Conversely, gender was found to be a determining factor in multiple areas (items 1,2,3,5,7,8,11,12) both when age was controlled and when not. Variables were computed for RQ1 and RQ2 (see table 1) and analysed using Levene's Test for Equality of Variances to determine if equal variances between gender (male/female) could be assumed. The non-parametric Mann Whitney U was run to confirm findings. The same items were found to be statistically significant when crossed with gender, with the addition of item 13. This is further explored in the analysis of RQ3.

In addition, and in the understanding that the *p* value can only inform the reader of the statistical significance, the items that indicated statistically significant difference were tested for effect size to understand the substantial significance (Arts et al., 2013, Sullivan & Fein, 2012). Defined as a quantitative reflection of the magnitude of the phenomenon (Kelley & Preacher, 2012), effect size with the parametric t-test can be obtained with Cohen's d (*d*) point estimate in designs such as the present study with no control group (Pardo & San Martín, 2010, p.143). Effect size was subsequently contrasted against the Scales of Magnitude (Cohen, 1988) to determine the size of the effect, with the following standard: Small = 0.10 to < 0.30, medium = 0.30 < 0.50, and large ≥ 0.50. Furthermore, when the value falls closer to the upper value than the small value, e.g. -0.47, this has been labelled as small to

medium. Additionally, and to ensure correct reporting, the effect size *r* was used with Mann Whitney U (Tomczak & Tomczak, 2014) to corroborate findings. These were in a similar vein and are explored in greater detail in section 5.4.

5. Findings

5.1. Descriptive statistics

The results of descriptive statistics from items 1-13 show a high level of acceptance of both breakout games as a didactic tool in Higher Education (RQ1) and the effectiveness of this methodology to teach and learn the SDGs (RQ2). In all items, both the median, as the 50th percentile, and the mode, representing the most frequently occurring value, was 6, (Mdn = 6) (Mo =6) respectively, the highest value that represented totally agree. This indicates that the majority of participants found the breakout games to be enjoyable, engaging, interesting and helpful for improving the learning of the SDGs. In addition, the measures of standard deviation are all below 1.5, showing a low range of dispersion of the scores, and in consequence, the high degree of convergence in the participants' perceptions.

Table 2
Descriptive statistics. All items (Likert scale 1-6). Central tendency, by highest mean.

Item	N	Mean	Std. Deviation	Median	Mode	Min.	Max.
2. I believe that the GBL activities were innovative	150	5.61	0.68	6	6	3	6
12. I would recommend the use of GBL in other subjects in Higher Education	150	5.58	0.74	6	6	2	6
13. I am satisfied with the learning experience	150	5.58	0.75	6	6	2	6
11. I have been able to self-assess my learning through using GBL	150	5.57	0.81	6	6	2	6
1. I feel more engaged when the teacher uses GBL	150	5.57	0.71	6	6	3	6
5. I believe that GBL has improved in-class student participation	150	5.55	0.81	6	6	1	6
7. GBL has enabled me to enjoy studying the 17 SDGs	150	5.52	0.81	6	6	2	6
8. GBL activities have increased my learning of the SDGs	150	5.45	0.90	6	6	2	6
6. I feel that GBL has improved my understanding of the topic/subject	150	5.30	0.95	6	6	2	6
10. I believe my training in GBL has improved	150	5.29	1.09	6	6	1	6
3. I prefer learning with GBL activities as opposed to nongame-based activities	150	5.28	1.02	6	6	1	6
4. I think that GBL has increased my interest in the topic/ subject	150	5.27	0.97	6	6	2	6
9. I believe that GBL has increased in-class teamwork	150	4.97	1.42	6	6	1	6

Item 2 (*I believe that the GBL activities were innovative*) was rated the highest overall with a mean of 5.61. This was very closely followed by item 12 (*I would recommend the use of GBL in other subjects in Higher Education*), and 13. (I am satisfied with the learning experience), both with a mean of 5.58.

5.2. Findings related to RQ1: Is the use of GBL through breakout games perceived favourably in teacher training in an online university context?

The items that related to the student's motivation, attitude to and interest in the use of GBL (1,2,3,4,5) were grouped together and analysed. Descriptive statistics indicate that both the means of men and women were very high, with a low standard deviation. Nevertheless, women had a higher mean of 5.58 as opposed to 5.26 for men, indicating overall a greater interest in GBL as the classroom methodology than the men.

Table 3
Descriptive statistics. Items related participants' motivation and attitude towards GBL, by gender (Likert scale 1-6).

Gender	N	Mean ($\bar{x}$).	Std. Deviation	Std. Error Mean
Male	58	5.26	0.68	0.09
Female	92	5.58	0.61	0.06

To test for statistical difference between the responses related to the motivation, interest, and attitude according to gender, we ran an independent samples t-test, as can be seen in table 4:

Table 4
Independent samples t-test. Items related participants' motivation and attitude towards the teaching methodology of GBL, by gender (Likert scale 1-6). Effect sizes using Cohen's d, according to Scales of Magnitude (Cohen, 1988).

Levene's Test for Equality of Variances	t-test for Equality of Means		Magnitude
	Sig. (2-tailed)	Cohen's d	Effect Sizes
Assumed	0.003*	-0.51	Medium

p<0.05; *p≤0.01.

Results indicate that equal variance for the two groups could be assumed. The 2-tailed p value is statistical significant (p = .003), indicating that female students reported higher motivation, attitude to and interest in the use of GBL as a methodology as compared to men. The standardised measure of Cohen's d was 0.51, indicating medium effect size. This reflects a moderately substantial difference in aspects related to the participants' motivation and interest towards the methodology of GBL according to gender.

5.3. Findings related to RQ2: Is the use of GBL through breakout games perceived favourably for the teaching and learning of the SDGs as obligatory curricular content in an online higher education context?

Scores from items 6,7,8 related to the participants' perception towards the learning and teaching of the SDGs through GBL. This was to determine how students perceived the effectiveness of their learning and interest towards this curricular

content. These included the following items which dealt with understanding, enjoyment and learning of the content through GBL.

The mean of both male and female participants was very high, with a low standard deviation of below 1. Following a similar tendency to RQ1, women reported a more positive perception towards GBL to learn the SDGs, with a mean of 5.54, as opposed to the mean of 5.24 as reported by men:

Table 5
Descriptive statistics. Items related to the students' perception of the effectiveness of using GBL to study the SDGs, understanding, and enjoyment of content by gender (Likert scale 1-6).

Gender	N	Mean ($\bar{x}$)	Std. Deviation	Std. Error Mean
Male	58	5.24	0.81	0.11
Female	92	5.54	0.73	0.08

This difference in gender was analysed through an independent samples t-test which indicated a significant difference of .017 (p = .017) between how male and female participants regarded the use of GBL to learn the SDGs, with women reporting a more positive perception towards GBL to learn the SDGs. Nevertheless, the standardized measure of effect, Cohen's d showed a small to medium effect size (d = 0 .40), indicating that the effect was relatively small in absolute terms.

Table 6
Independent samples T-Test, with effect sizes using Cohen's d, according to Scales of Magnitude (Cohen, 1988). Items related to the perception of learning, understanding, and enjoyment of content by gender (Likert scale 1-6).

Levene's Test for Equality of Variances	t-test for Equality of Means		Magnitude
	Sig. (2-tailed)	Cohen's d	Effect Sizes
Assumed	0.017	-0.40	Small to medium

$p<0.05$

5.4. Findings related to RQ3: Is there a difference between male and female students in their perception towards the use of GBL through breakout games in an online higher education context?

Scores from all 13 items were analysed using descriptive statistics to determine the perception of male and female studies differed towards the use of GBL through breakout games in an online higher education context. As can be seen in the following table, all 13 items were reported more favourably by women than by men, with all items showing a higher mean ($\bar{x}$) in women than men.

Table 7
Descriptive statistics. All items (Likert scale 1-6), by gender

Item	Gender	N	Mean ($\bar{x}$)	Std. Deviation	Std. Error Mean
1. I feel more engaged when the teacher uses GBL	Male	58	5.41	0.73	0.10
	Female	92	5.66	0.68	0.07
2. I believe that the GBL activities were innovative	Male	58	5.38	0.77	0.10
	Female	92	5.75	0.59	0.06
3. I prefer learning with GBL activities as opposed	Male	58	5.00	1.18	0.16

to nongame-based activities	Female	92	5.46	0.87	0.09
4. I think that GBL has increased my interest in the topic/ subject	Male	58	5.16	0.87	0.11
	Female	92	5.34	1.02	0.11
5. I believe that GBL has improved in-class student participation	Male	58	5.33	0.82	0.11
	Female	92	5.70	0.77	0.08
6. I feel that GBL has improved my understanding of the topic/subject	Male	58	5.17	0.90	0.12
	Female	92	5.38	0.98	0.10
7. GBL has enabled me to enjoy studying the 17 SDGs	Male	58	5.29	0.94	0.12
	Female	92	5.66	0.68	0.07
8. GBL activities have increased my learning of the 17 SDGs	Male	58	5.24	0.94	0.12
	Female	92	5.59	0.85	0.09
9. I believe that GBL has increased in-class teamwork	Male	58	4.88	1.38	0.18
	Female	92	5.02	1.44	0.15
10. I believe my training in GBL has improved	Male	58	5.26	0.98	0.13
	Female	92	5.30	1.16	0.12
11. I have been able to self-assess my learning through using GBL	Male	58	5.36	0.85	0.11
	Female	92	5.71	0.75	0.08
12. I would recommend the use of GBL in other subjects in Higher Education	Male	58	5.36	0.81	0.11
	Female	92	5.72	0.65	0.07
13. I am satisfied with the learning experience	Male	58	5.48	0.66	0.09
	Female	92	5.64	0.81	0.08

An independent samples t-test with Levene's Test for Equality of Variances was run, with 5 items showing significant difference in variance. In addition, the two-tailed *p*-value [Sig (2-tailed)] was used to determine if the means of the two groups (male/female) indicated statistically significant difference.

8 of the 13 items were found to be statistically significant when crossed with gender (1,2,3,5,7,8,11,12). Item 2, *I believe that the GBL activities were innovative*, and item 12, *I would recommend the use of GBL in other subjects in Higher Education* showed the greatest statistical difference by gender with medium effect size, possibly reflecting a moderate gender difference in how students view other subjects in Higher Education that follow comparatively more conventional methodologies.

Table 8
Independent samples t-test with Levene's Test for Equality of Variances. Items with statistical significance by gender (Likert scale 1-6), In order of lowest p value (2-tailed), and effect sizes using Cohen's d, according to Scales of Magnitude (Cohen, 1988).

	Levene's Test for Equality of Variances	t-test for Equality of Means		Magnitude
	Sig.†	Sig. (2-tailed)	Cohen's d	Effect size
2. I believe that the GBL activities were innovative	0.001	0.002*	-0.56	Medium
12. I would recommend the use of GBL in other subjects in Higher Education	0.003	0.006*	-0.50	Medium
5. I believe that GBL has improved in-class	0.010	0.006*	-0.47	Small to

student participation				medium
3. I prefer learning with GBL activities as opposed to nongame-based activities		0.007*	-0.46	Small to medium
11. I have been able to self-assess my learning through using GBL	0.006	0.013*	-0.44	Small to medium
7. GBL has enabled me to enjoy studying the 17 SDGs	0.003	0.011*	-0.47	Small to medium
8. GBL activities have increased my learning of the 17 SDGs		0.025	-0.39	Small
1. I am more engaged when the teacher uses GBL		0.035	-0.36	Small

†Indicates where variances are not assumed with a Sig. value lower than 0.05 ($p<0.05$). *$p≤0.01$ (2-tailed).

When compared to the non-parametric Mann Whitney U (table 9), the same 8 items were found to be statistically significant when crossed with gender, with only a very slight adjustment in the p value. The most significant finding of the non-parametric tests was the addition of item 13, *I am satisfied with the learning experience*. Closer analysis of item 13 showed that the mean was similar for female ($\bar{x}$ = 5.59) and male ($\bar{x}$ = 5.48) and is therefore not statistically significant in the parametric t-test, with both male and female participants reporting similar levels of satisfaction. In contrast, Mann Whitney U analyses the mean rank, showing a statistically significant difference between females (80.92) and males (66.91). This was confirmed with histograms.

Table 9
Mann-Whitney U Test. Items with statistical significance by gender (Likert scale 1-6), In order of lowest p value (2-tailed), and effect sizes using r.

Item	Mann-Whitney U	Z	Sig. (2-tailed)	n	Effect size *r*	
2. I believe that the GBL activities were innovative	1890,0	-3,74	0,0002	150	0,31	Medium
5. I believe that GBL has improved in-class student participation	1938,5	-3,49	0,0005	150	0,29	Small to medium
12. I would recommend the use of GBL in other subjects in Higher Education	1968,5	-3,33	0,0009	150	0,27	Small to medium
11. I have been able to self-assess my learning through using GBL	2007,0	-3,24	0,0012	150	0,26	Small to medium
7. GBL has enabled me to enjoy studying the 17 SDGs	2047,0	-2,90	0,0038	150	0,24	Small to medium
8. GBL activities have increased my learning of the 17 SDGs	2026,0	-2,94	0,0033	150	0,24	Small to medium
1. I am more engaged when the teacher uses GBL	2095,0	-2,68	0,0074	150	0,22	Small
3. I prefer learning with GBL activities as opposed to nongame-based activities	2043,5	-2,70	0,0069	150	0,22	Small
13. I am satisfied with the learning experience	2169,5	-2,38	0,0174	150	0,19	small

In terms of effect size, findings between the t-test and Mann-Whitney U test were similar. The only item to show a medium effect in both was item 2, *I believe that the GBL activities were innovative*. This was followed in both tests by items 12, *I would*

recommend the use of GBL in other subjects in Higher Education, and 5, *I believe that GBL has improved in-class student participation,* thus corroborating findings. Overall, therefore, findings did indicate significant differences between sexes in their perception towards the use of GBL in an online Higher Education context, but with only small to medium effect size, these should not be overstated.

6. Discussion and conclusions

The objective of this study was to analyse the perception of breakout games and GBL to teach the SDGs in an online university context. Although educational games and escape rooms are now very popular, and research shows a reduced but steadily increasing use of GBL in sustainability education, only a very limited number of studies research its use within teacher education (Gumbi et al., 2024; Pineda-Martinez et al., 2023). This research aimed to fill that gap and explore how future teachers perceive the use of breakout games and GBL for learning SDGs, using readily available software such as Genially. This approach was adopted by the authors with the didactic aim of offering the participants, as trainee teachers, possible methodologies and strategies they can subsequently, and relatively easily, adopt for use with their future secondary level students. The results of this study show a high level of acceptance both of GBL and breakout games as didactic tools in Higher Education (RQ1), indicating that online breakouts and GBL on the SDGs can be an effective incorporation within teacher training.

Similarly, this study demonstrates the positive perceptions that students had towards the effectiveness of using these methodologies to teach and learn the SDGs (RQ2). The majority of participants self-reported that they found the breakout games to be fun, engaging, interesting, and useful for enhancing learning of SDG related content within a dense and highly theoretical subject in higher education. While it is imperative for learning that students are engaged with the content, teachers can struggle to find strategies that interest their students when teaching subjects such as that featured in this study. Content is obligatory and must be covered, but it can be hard going in class for both teachers and learners, with lower student engagement. Findings are consistent with previous studies (Amballoor & Naik, 2023; Mosca et al., 2024) that also reported improved students' perceptions towards the use of GBL to study SGDs. While the low standard deviation across responses in this study show that GBL was *perceived positively* as a useful tool for teachers to incorporate in these technical subjects to potentially improve students' engagement and motivation, this study did not research whether using breakout games can significantly enhance *learning* of the SDGs. The authors recommend future studies into the use of breakout games in sustainability education for trainee teachers to determine its impact on content learning.

The findings of the study have practical implications by highlighting the suitability of using breakout games in different disciplines, promoting active and learner-centred activities in online higher education, especially when students have little, or no previous knowledge related to the subject of the SDGs. In this line, the

three items with the highest mean showed the students felt the methodology to be innovative and recommended its use in more higher education subjects. Similarly, participants report a high level of engagement. We believe that these findings need to be contextualised to higher education and possibly private universities which often have a higher teaching load and less preparation time. University teachers are sometimes expected to teach previously designed subjects and course content. This is especially true in countries like Spain where university courses are subject to external evaluation and approval, and subsequent modifications must be submitted for approval from the authorising body which is a time consuming and lengthy process. This inflexibility is likely a contributing factor to the continuance of teacher-led lectures and traditional methodologies in these contexts. However, this study highlights that while the teacher may have limited ability to modify course content, they can choose the methodologies with which they teach said course content. In this regard, results are in line with previous studies that also found that this type of intervention had a positive impact on student perceptions in online university contexts (Cramarenco et al., 2023; Getenet et al., 2024; Quraishi et al., 2024).

Another major finding of this study attests to substantial differences by gender in multiple areas related to learning, whereas age was not found to have an impact on perception. Women self-reported greater interest, commitment, motivation, and an overall more positive perception towards the breakout room than men. Additionally, female participants showed significantly greater enjoyment than males in using breakout games to study the SDGs. The authors speculate that this division could be due to the greater participation and involvement in online class activities by female students as compared to male, leading to a more active and participative learning. In this respect, the teacher noted a greater use of both the class chat and oral interventions by female students. This is consistent with findings by Denden et al. (2021), Khan et al. (2017) and Oceja and González (2020), who reported that the design of the intervention may affect how female and male students responded to GBL. Interventions that encourage greater student interaction would appear to promote greater engagement among female participants. In this sense, Admiraal et al (2014) found that while both male and female students respond positively to GBL, there are gender differences in how this response manifests itself: female students respond positively to "discovery and exploration" (p.1216), while their male counterparts prefer competition and achievement (Hartmann & Klimt, 2006; Williams et al., 2009). The authors underscore the need for further research to test this hypothesis.

A limitation of this research design is the difficulty in collecting observational data in class to shed light on the attitudinal gender divide that was detected towards the use of breakout games. In future research this could be addressed through the collection of qualitative data. Furthermore, while the study found statistically significant differences, these are limited to a small to medium effect size. This suggests that while the study had a beneficial impact, this is of limited effect in absolute terms. This finding is consistent with similar studies that indicate while digital technology can be perceived positively in ESD, its impact depends on multiple factors such as the quality of the intervention and the individual characteristics of the participants (Awidi & Paynter; 2024; Wang, 2023). Additionally, it would be advisable

to increase the sample size to enable a greater extrapolation of results. This has been facilitated in the study by the inclusion of the didactic intervention as an open resource that can be applied to any academic content, and which is easily replicable by other researchers.

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