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Fostering Student Engagement with the United Nations Sustainable Development Goals using an Escape Room

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Abstract

This paper describes the use of gamification, in the form of an interactive puzzle-based escape room, as an innovative and cross-curricular approach to introducing the United Nation (UN) Sustainable Development Goals (SDGs) in higher education. Educational games encourage active and collaborative learning while both engaging and challenging learners. Here, we describe how sustainability literacy was incorporated into undergraduate chemistry programmes in the form of a puzzle-based game, known as an *Escape Room*. A printable escape room was developed for use in any face-to-face or virtual classroom. The escape room consists of a narrative, or storyline that leads players (students working in small teams) to progress through four levels of puzzles centred on introducing sustainability literacy and the SDGs. Each puzzle has different game mechanics, including a wordsearch, crossword, pictograms, maze, re-ordering activity and multiple-choice questions, requiring learners to adopt a range of problem-solving strategies. Educators reported the activity to be an effective and engaging pedagogical approach while students reported that it was fun and enjoyable and that it increased their awareness of the SDGs and sustainability. It engaged students in sustainability, whilst encouraging active citizenship. The escape room and supporting resources are freely available, along with a guide for educators explaining how to implement and run the session.

Keywords: escape room; gamification; learning resource; problem-solving; puzzle; sustainable development; SDGs; sustainability literacy.

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Introduction

Escape rooms were first developed as a commercial recreational activity. These live-action games involved a team of participants who were physically locked into a room and tasked with solving a series of puzzles to escape the room. A “gamemaster” introduced the scenario or theme of the room, as well as providing hints and tips to solve the puzzles if they were needed (Nicholson, 2015). Many features of these commercial escape rooms are retained in their educational cousins. Educational escape rooms have been developed for a wide variety of educational purposes and audiences (Veldkamp et al., 2020; 2022). They are themed around a scenario or storyline designed to immerse learners in the tasks at hand. Participants work together to solve a series of puzzles within the allotted class time and therefore to complete the room’s overall objective or mission. The educator is usually present in the classroom and takes the role of gamemaster to guide the activity, which typically involves a whole class divided into smaller groups. Educational escape rooms provide an active learning environment in which participants work collaboratively, applying critical thinking and problem-solving. They have been shown to support feelings of autonomy, competence, and connectedness, which are a basis to maintain learner’s intrinsic motivation and, therefore, can increase learner engagement (Hsu, 2022; Ryan & Deci, 2000). Participants can gain instant and unambiguous feedback and rewards from progression through the puzzles and “escape”, as well as having a safe space to fail and reattempt a task until successful and in so doing gain a sense of mastery of the task at hand (Veldkamp et al., 2020). By working collaboratively, escape rooms and other gamified learning activities encourage socialisation, which may be of particular benefit to learners who report lower self-efficacy, a group which includes ethnic or gender minority students and students from marginalised or socially disadvantaged communities (Manzano-León et al., 2022).

Increasing interest in educational escape rooms, particularly in the science, technology engineering and mathematics (STEM) disciplines, was motivated by restrictions put in place during the COVID-19 pandemic. Indeed, this led to our use of chemistry-themed escape rooms in first year undergraduate tutorials. Since restrictions prevented in-person laboratory, practical sessions that are characteristic of most STEM programmes, it created the need for alternative experiences to engage students and to replicate at least some of the learning experiences associated with practical laboratory-based work (Karayel et al., 2022). In recent years, the escape room format has been used with success in practical and laboratory-based learning across third and second level chemistry courses and programmes (Avargil et al., 2021; Clapson

et al., 2022; Dietrich, 2018; Watermeier & Salzameda, 2019), and as printable classroom-based, online digital and augmented reality (AR) / virtual reality (VR) enhanced activities (Abdul Rahim, 2022; Ang et al., 2020; Cai, 20122; deSouza & Kasseboehmer, 2021; Elford et al., 2022; Estudante & Dietrich, 2020; Peleg et al., 2019; Vergne et al., 2020; Yayon et al., 2019). Here, we describe a classroom-based, printable escape room that can also be used in an online environment, to introduce learners to the SDGs.

What does sustainability mean to students and how does it relate to their profession?

Staff involved in administering the UN Sustainability Literacy Test, referred to as the Suilitest, to undergraduate chemistry students during the 2020-2021 academic year, observed that many students expressed surprise that sustainability was broader than the Environment and current climate crisis (Behan et al., 2022). In 1987, the UN Brundtland Commission defined sustainability as “meeting the needs of the present without compromising the ability of future generations to meet their own needs.” (Brundtland, 1987) Recognising that a product or process is not sustainable if it results in negative social repercussions is something to which the students had not given much consideration. Realising that a sustainable economy must address social and environmental issues is a journey that students need to take. Figure 1 depicts these aspects as interconnected. Students require knowledge and skills that will enable them to develop the mindset needed to participate effectively in achieving the SDGs.



Figure 1: Building a Sustainable Future Together

Design of the Sustainability-Themed Escape Room and Learning Outcomes

After establishing a Sustainability Team within the School of Chemical and BioPharmaceutical Sciences that comprises academic and technical staff across chemistry and chemistry-related sub-disciplines, the proposed activity was planned using a similar approach to that described by Winangun & Fauziah (2019). Key questions included: What are the learning objectives that can be achieved through the lesson / activity? What aspects of sustainability literacy should be included? What prior knowledge is required? What platform can be used for the escape room? It began by defining the sustainability education objectives, analysing the components of the School's existing chemistry module materials for introducing sustainability literacy and identifying which learning materials could be incorporated into an escape room activity. The aim of the escape room and two learning outcomes were defined by the team: The escape room is employed to introduce learners to the Sustainable Development Goals (SDGs) and to demonstrate the need for and importance of sustainability literacy to learners. The Sulitest, (Décamps et. al., 2017) UNSDG website (United Nations, 2023), and the UN SDG annual report (United Nations, 2022) were used as the primary sources for promoting sustainability literacy during this activity. At the end of the activity (the escape room), learners will be aware of the scope and able to discuss the overarching purpose of the UN's SDGs, and be more motivated towards building a sustainable future.

Implementation of the Sustainability-Themed Escape Room

The escape room activity described here can be used as part of a general introduction to sustainability literacy, and it takes a maximum of one hour to complete. It was first piloted in academic year 2021/22 but was further developed in 2023 to produce the final version that is described here. The sustainability escape room, named "Space Vessel Gaia", is a printable classroom-based activity but is also supported by a Google Form that can be used to run the activity in an online or hybrid format. The resources needed to run this escape room are freely available under a Creative Commons license and can be downloaded from the TU Dublin website (Chemistry Education Research Team [CERT], 2023). The resource comprises a slide deck of 21 slides which present the storyline and the puzzles. To support educators in running the activity, a written guide was produced, which can also be downloaded from the website and includes puzzle solutions along with clear guidelines for running the activity in person or online. Lesson plans are also described in the guide. The only additional resource needed to run the activity is several pairs of scissors, ideally one pair for each group. Unlike laboratory-based and other escape rooms that require physical props, this activity does not require

specialist equipment. It is designed to be flexible and easy to run in any in any learning space that allows group work. For Space Vessel Gaia, the storyline asks participants to imagine themselves in the role of the newly elected Space Vessel President Danu as they inspect the progress aboard an ancient space vessel called Gaia. Participants are told that the President's recent election followed a period of unrest caused by shortages aboard the spaceship, and that there was now a promise to work in partnership with the people to restore Gaia's balance through training and education programmes, action and the development of new technologies. As the narrative unfolds over the levels, President Danu is followed as she inspects Basic Training, Climate Management, Social Policy and finally the Economic Policy Division. After completing inspection, she then returns to quarters reassured that there is good reason to hope for the vessel's future, therefore ending the activity with a positive message for learners.

The activity involves four levels, each requiring the completion of one or more puzzles. Each puzzle requires a different problem-solving approach and addresses a different aspect of sustainability. Figure 2 shows a screenshot of representative slides from the learning resource to illustrate the variety of puzzles, with one slide from each level, including a wordsearch, a crossword, a trivia maze, and a multiple-choice question. More details are in the tutor guide which provides a description of each puzzle and solution along with tips to guide learners. No prior knowledge of sustainability is required, and information needed to solve each puzzle is provided in slides given to each group during the activity. The first level introduces learners to the SDGs by using keywords or phrases associated with each goal, so that even learners without prior knowledge will begin to appreciate the broad ambitions and scope of the SDG framework in addressing social, environmental, and economic impacts. The second level requires learners to use graphical information about carbon footprints associated with different foods (meat, dairy, vegetables, fruits, and nuts). The third level asks learners to find their way through a maze using statistics from the 2022 Sustainable Development report (United Nations, 2022). The final level asks learners to select the correct answers to questions about the purpose and implications of the SDGs (a little like a traditional MCQ, but with added fun provided by the puzzle mechanics). As learners arrive at a solution to each puzzle, they present it to the gamemaster or, if playing online, it is entered into an accompanying Google Form. The correct solution allows participants to access the next level (or to complete for the final puzzle). If using the printed version, the gamemaster will give the next set of handouts to each group as they complete a puzzle. If run in an online or hybrid setting, the code will open the next set of password-protected slides, hosted on a virtual learning environment (VLE) or Google Drive.

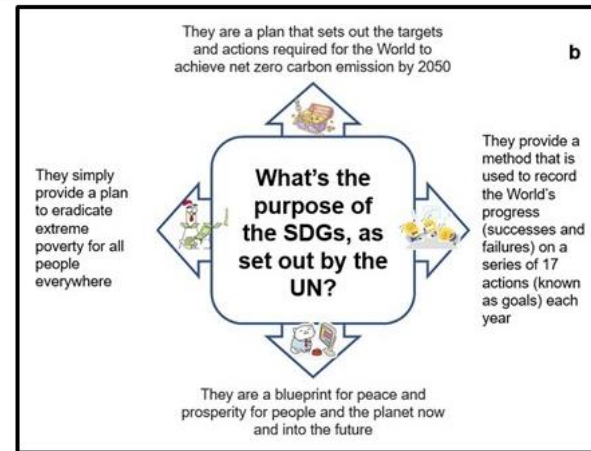
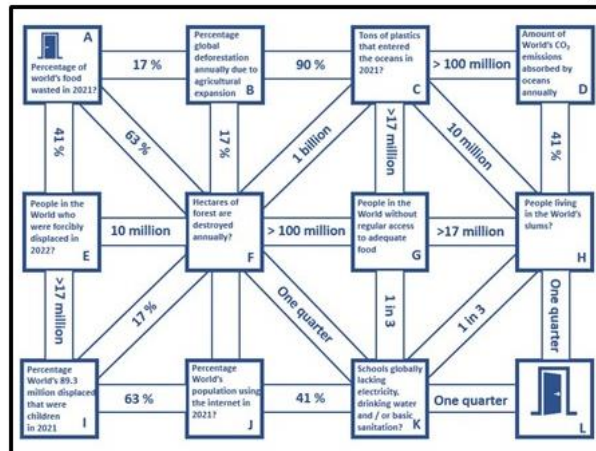
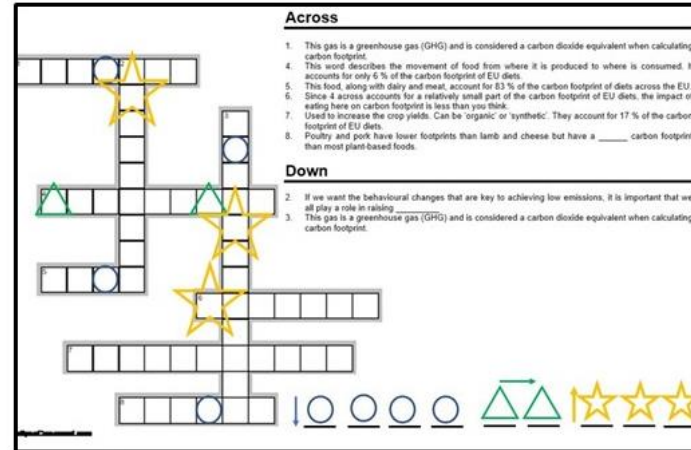
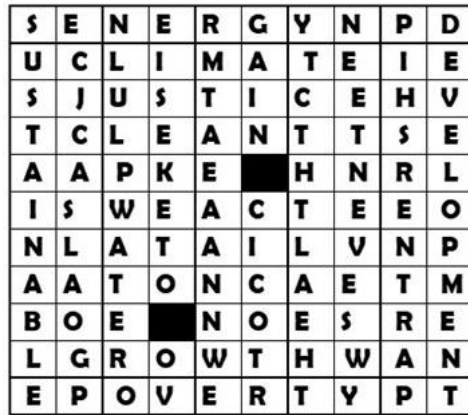


Figure 2: Screenshots taken from the escape room to illustrate a range of puzzle mechanics including (from top to bottom, left to right) a wordsearch from level 1, a crossword from level 2, a trivia maze from level 3 and a multiple-choice question from level 4.

Puzzles are more detailed and are found in the accompanying resource and the associated guide for tutors.

The escape room was developed for early stage (years 1 and 2) undergraduate students but has also been used with students in the final years of their programmes (year 3 and 4). It would also be suitable for second level learners. No prior knowledge of sustainability or the SDGs is required and learners who already have experience and knowledge of this area should still enjoy the team and problem-solving aspects of this activity.

The first iteration of this escape room was directly linked to existing learning materials, tools, approaches, and activities developed by TU Dublin's community of practice of a multi-disciplinary team of educators with a common interest in advancing education for sustainable development (ESD), SDG Literacy, (Behan et al., 2022; Freeman et al., 2022). Therefore, in the original iteration of Space Vessel Gaia, two of the four puzzles centred around information and learning gained by completing the Sulitest. To make this resource more broadly applicable to a wider audience, at the start of 2023 these two puzzles were redesigned so that, whilst using the same puzzle mechanics, the information used to create each puzzle is drawn directly from the SDGs themselves and resources that are freely and easily available to any educator. Prior to redesigning the two puzzles, the original version was used successfully with circa. 50 students. However, this article focuses primarily on the latest version of the Space Vessel Gaia escape room, which was most recently used with a group of 20 second- and third-year TU Dublin students.

Student and Staff Feedback

In academic year 2021-22, three escape rooms were used in first year tutorials and a first-year professional development module. Two of these escape rooms were chemistry themed and the third was the first iteration of Space Vessel Gaia. Although the students participating were not surveyed on the individual escape rooms, a small number of those invited (10 of more than 50 students) responded to a survey, providing initial feedback on their experience as participants in these activities. All responses given were anonymous. Student participation was optional and was not linked to any assignment or assessment. Whilst there were only 10 respondents some interesting insight was gained from the responses. Responses to questions that asked students to rate their learning and their enjoyment are shown in Figure 3 (a) and (b) below, with only one negative response to these questions. They were asked to rate the importance of enjoyment for learning (Figure 3(c)); one student gave a neutral response and nine responses to this question rated enjoyment as important (6 of these indicating it was "very" important).

There is some indicative evidence from the responses that the students found the escape room learning activities both fun and effective and that they perceive there to be a link between enjoyment and their likelihood of learning.

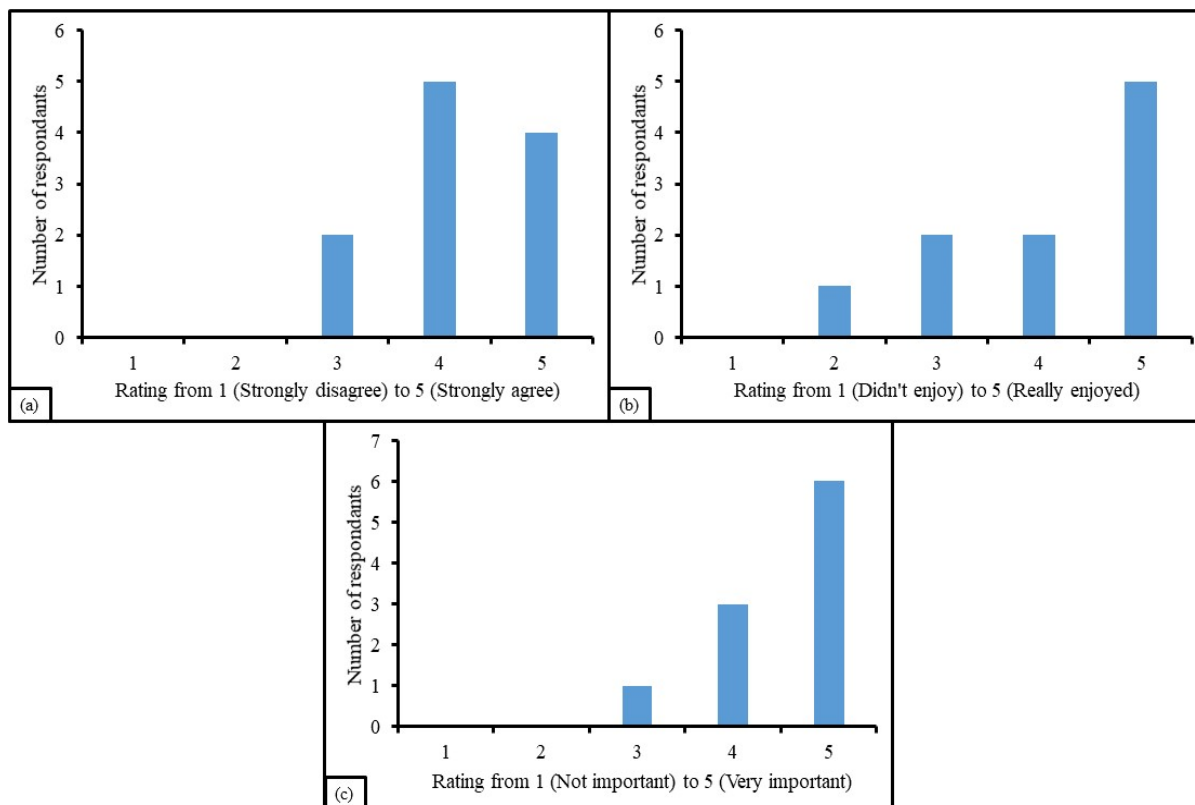


Figure 3. (a) Results from question “Did you learn some chemistry (or sustainability literacy) by doing the escape room?”, (b) Results from question “Rate the escape rooms in terms of your enjoyment”, and (c) “How important is enjoyment for your learning?”

In addition, students were prompted to provide feedback about their thoughts and feelings in the form of an open text question and the responses included:

“They stressed me out a bit, good fun though”, “I thought they were a very fun way to learn and definitely a nice break from the usual” and “they are a really useful and enjoyable learning resource”. Another student offered the following feedback “Thanks for the escape room. It was challenging and had nice puzzles.”

This year, 20 participants were surveyed immediately on completion of the Space Vessel Gaia escape room. Whilst it is not essential (see the accompanying user guide (Chemistry Education Research Team [CERT], 2023)) to provide an introductory lecture prior to the escape room

activity, these students did have one or more lectures that introduced sustainability, describing the relationship and interdependency between the three pillars of sustainable development: economic viability, environmental protection, and social equity. It was made clear that participation in the survey was anonymous, optional and not linked to any assessment, and that its purpose was for enhancing teaching and learning and to share good practice. The first question related to their view of the benefit of the escape room to their learning and the results are presented in Figure 4(a). The next question related to their enjoyment of the escape room and the results are presented in Figure 4(b).

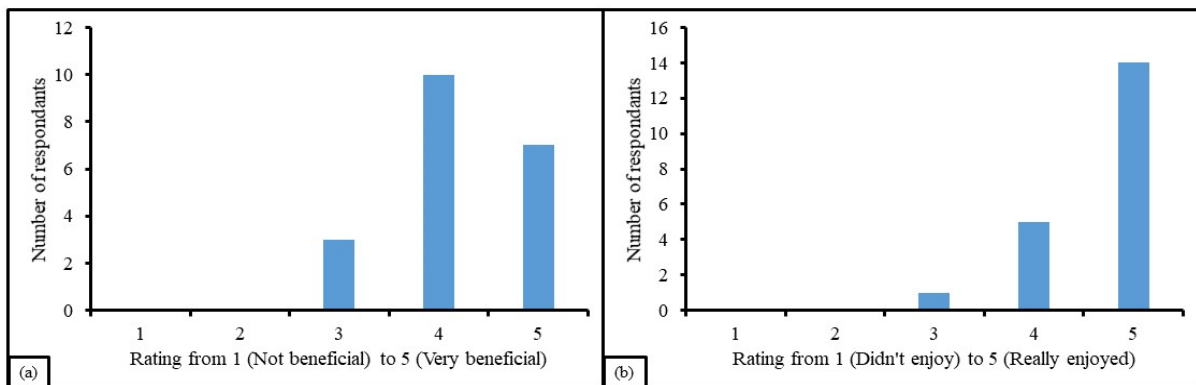


Figure 4. (a) Benefit of escape room to learning, and (b) Student response to enjoyment of escape room.

When asked whether the escape room increased their awareness of the SDGs, or sustainability more generally, eight of the students selected the option “*Yes (somewhat helpful and I feel a little more aware)*”. Eleven of the students selected “*Yes – (I feel much more aware of these issues)*”. Only one of the 20 participants selected one of the two negative responses available.

“No - I was already aware of many of the topics and facts given the activity and don't think I gained new knowledge or awareness.”

The students were also asked an open text response question in which they were invited to give one fact or detail that they learned from the activity. Five students responded that they had learnt that there were 17 SDGs and other responses varied but included:

“seeing the statistics of some of the information was pretty shocking.”

“a quarter of (primary) schools (are) lacking drinking water and electricity. It stuck to my head because... so many schools still don't have drinking water /electricity.”

“... that only 1 out of 3 people ... do not have regular access to food was alarming.”

“Learning what types of food contributes most to carbon footprint is interesting.”

A final open text response question asked students for suggestions to improve the activity and provide any other feedback. This question was optional and there were seven respondents. One student suggested that one of the levels could be improved. They had found the maze puzzle (Level 3) frustrating as it simply required a trial-and-error process that had not been useful. Three of the remaining comments were positive.

“It would be fun do more escape rooms like this in the future as it was engaging and enjoyable”, “It was fun”, and “(It was a) good way to learn facts.” Interestingly, one of the students responded that there should be *“Less use of handout paper (o)n campus”*.

The results of our surveys are consistent with prior literature, with students often reporting high levels of enjoyment and indicating that they would like escape room activities to be run more often. Yet, there is some debate as to whether the learning is as effective in comparison to that gained from more traditional teaching approaches, with participants often noting that they missed part of the puzzle or information provided, and that they covered less material than a traditional class. It has been proposed that collaborative and deeper learning can be enhanced by addition of a discussion and reflection at the end of an escape room activity to help link it with the subject knowledge, and this is certainly something that we will be incorporating into our own lesson plans (Veldkamp et al., 2020; 2022).

Eight staff members who acted as gamemasters were asked (via an anonymous online survey) to comment on their experiences. Whilst this feedback relates to the two chemistry themed escape rooms as well as Space Vessel Gaia, it is useful to include it here for educators interested in implementing this approach. Gamemasters were asked to comment on their thoughts before running the activity and their impression immediately afterwards. They reported that they were “cautious” but also “*curious*” beforehand. All gamemasters agreed the class was a positive experience for them and for participating students, with one educator commenting that escape rooms seem to be a “*very effective and engaging pedagogic approach*”. They reported improved student engagement and observed that learners were obviously enjoying the activities, whilst learning to work collaboratively. It was observed that escape rooms can contribute to a culture of learning and teamwork, and that co-operation was encouraged by the relaxed nature of the activity, which provides the scope for everyone to contribute. As mentioned above, the socialisation aspect of this approach may have a significant benefit for learners who have typically reported lower self-efficacy (Manzano-León et al., 2022).

Conclusion

We have reported an innovative and engaging activity that represents a cross-curricular approach to introduce the SDGs in higher education. Whilst piloted with chemistry students, the learning activity is transferrable to any discipline. A printable, classroom-based escape room activity, called Space Vessel Gaia, has been developed to introduce learners to the broad ambitions of the SDGs and to the importance of sustainability literacy. No prior instruction in sustainability literacy is required and its four levels introduce the SDGs, their purpose and implications and highlight carbon footprints associated with foods and progress on the achieving the SDGs. The escape room lays the foundation for addressing global challenges by fostering awareness, knowledge, and a sense of responsibility for sustainability. By equipping individuals with knowledge tools to comprehend the interconnectedness of environmental, social, and economic factors, it empowers them to contribute meaningfully to the pursuit of the SDGs, therefore advancing a more sustainable future for all. Our approach to date has used this activity alongside the Sulitest and an associated reflective writing assignment to encapsulate key elements of authentic assessment. The escape room can also be used as a standalone activity, although learning is likely to be deeper and more effective when followed by guided discussions and opportunity to reflect. Escape rooms are reported to increase learner engagement and intrinsic motivation by supporting feelings of autonomy and competence, whilst the groupwork involved creates a collaborative learning environment of benefit to learners who report lower self-efficacy (Carroll & Morse, 2022). The academic staff involved in delivering escape room activities reported that it encouraged teamwork, engagement and participation. A large majority (95 %) of the student participants reported that they gained increased awareness of the SDGs and found the activity fun and enjoyable.

The Space Room Gaia escape room is freely available to download and is supported by a user guide to assist with implementation (Chemistry Education Research Team [CERT], 2023). Whilst the activity has been used in an online setting, and a suggested approach for online delivery is included in the accompanying guide, a future collaboration with the Faculty of Arts and Humanities could be used to improve the design of a digital version and remove the need for paper-based materials. Future research will focus on assessing the impact of the escape room on student learning through the introduction of pre- and post-implementation quizzes to assess learners' awareness of the overarching purpose of the SDGs, and on their motivation towards building a sustainable future. The results of this work will be used to inform the design of new iterations of the resource that can be adapted through additional or alternative puzzles.

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