The Waste Game: an interactive online tool designed to encourage waste prevention and recycling on campus

The Campus Living Labs Project is a partnership project between the Environmental Protection Agency (EPA) and the Irish Universities Association (IUA).

As part of this project, an online educational tool called The Waste Game was developed to transmit waste prevention and recycling knowledge to university students.

In this section, we discuss the game design and structure and the evaluation of the game (including trial design and implementation, findings, and learnings and recommendations).

One-page summary: The Waste Game design, findings and recommendations

Background
Despite improved waste management infrastructure, waste is still poorly segregated due to a lack of motivation and knowledge among students and staff. More cost-effective and systematic education methods are needed to complement current efforts to raise awareness about waste prevention and recycling.

Game design and structure
As part of the EPA-IUA Campus Living Labs Sustainability Project, an online educational tool called The Waste Game was developed. The tool aims to transmit waste prevention and recycling knowledge. The game is designed as a quiz and structured around the waste hierarchy framework, focusing on waste prevention followed by recycling. It includes gamification techniques to support learning and engagement. The game was designed in collaboration with participating universities and tailored to their local context.

➤ *Click to learn more about the game design and structure*

Trial design and implementation
The effectiveness of the game was evaluated through a randomised controlled trial (RCT). Staff and students were randomly assigned to either a simplified version of the game, an enhanced version with additional gamification elements, or a control group. The game was trialled throughout the autumn trimester of 2022 across four participating universities.

➤ *Click to learn more about trial design and implementation*

Findings
Our analysis yields several key findings that apply to all participating universities:
- The waste game is effective in improving knowledge and key predictors of waste prevention and recycling behaviours, both in the short and the long-term.
- Compared to the full version, the simplified version is more effective and engaging.
- Most students and staff found the game useful and rated the topics addressed in the game highly.
- Most participants are female students in post-graduate studies with strong pro-environmental identities.
- Principles tubes, disposable coffee cups and packets of crisps are the most challenging waste items to sort. Future educational campaigns should focus on composite packaging and soft plastics.

Together, the findings from the trial suggest that the waste game is effective and may be best presented in a simplified version going forward. Future dissemination efforts should focus on better targeting those who are underrepresented (e.g., males, 2nd to 4th year undergraduates, and those who do not have a pro-environmental identity).

➤ *Click to learn more about the findings*

The Waste Game: an interactive online tool designed to educate students

Background

Despite improvements in waste management infrastructure, waste continues to be poorly segregated by students due to a lack of motivation and knowledge.

While numerous efforts are made to raise awareness across universities about waste prevention and recycling, there is a need for a cost-effective and systematic way to transmit knowledge.

Game design

The Waste Game is an online interactive tool that provides waste prevention and sorting tips and helps motivate players to take action. The game aims to complement existing university-led initiatives around waste management, as given its online nature, it can easily be promoted at scale on campus year-on-year.

The game is designed as a quiz and structured around the waste hierarchy framework: the first level of the game focuses on waste prevention, while the second level focuses on waste recycling. Within each level, players have to complete three different challenges. Each challenge includes a set of quiz questions on specific waste-related topics. Quiz questions are generally designed to inform players about the magnitude of a given problem (e.g., the amount of disposable cup waste produced on campus) and to highlight the importance of a related solution (e.g., the impact of using a reusable cup).

At the end of each level, players can choose to commit to a set of actions in real life before moving down the waste hierarchy and unlocking the following level. Players can earn points throughout the game and can compete against each other with a chance to win a reward based on their performance.

The game includes a set of gamification and behavioural techniques to improve engagement, support learning and encourage players to follow through with waste prevention and recycling actions in their day-to-day lives. The content of the game was informed by a literature review, waste characterisation studies conducted by participating universities and the EPA and resources developed by MyWaste.ie.

The game was designed in collaboration with participating universities (UCD, DCU, MU and TCD) and relevant stakeholders (MyWaste.ie, An Taisce Green Campus and Regional Waste Authorities) and adapted to the specific context of each university. While the game was initially designed for students, it was also adapted to staff members.

Game structure

Introduction
The introduction sets the scene of the game by informing players about the amount of waste produced on campus and invites them on a mission to acquire the right skills and knowledge to reduce it.

Mentor selection
Players can choose a mentor that will help them build their waste prevention and recycling skills. Mentors are real-life figures that have insight into the waste management process (e.g., estate managers, cleaners, waste processing managers).

Level 1: Waste Prevention

Challenge 1: Preventing waste on campus
This first challenge focuses on reducing single-use waste on campus. It invites players to use reusable cups, flasks and lunch boxes on campus.

Challenge 2: Preventing waste when grocery shopping
This challenge focuses on reducing packaging waste and food waste when grocery shopping.

Challenge 3: Preventing waste at home
The last challenge of level 1 focuses on preventing waste at home. It looks into food storage, donating and collecting unwanted clothing and bulky items on campus.

Waste prevention commitments
Players are invited to commit to a set of waste prevention actions in real-life.

Level 2: Waste Recycling

Challenge 1: Reducing waste contamination
The first challenge of level 2 addresses the topic of waste contamination and its consequences.

Challenge 2: Uncovering waste recycling labelling
Challenge 2 aims to shed light on the meaning of different product labels (e.g., On-Pack Recycling labels).

Challenge 3: The ultimate waste sorting contest
To complete level 2, players can participate in a final contest where they must sort different items into appropriate bins.

Waste recycling commitments
Players are invited to commit to a set of waste recycling actions in real-life.

Gamification and behavioural techniques

Overarching narrative

The game is framed as a rite of passage where players must first acquire a set of skills to contribute to the collective waste reduction efforts made on campus. The purpose of the narrative is to provide meaning to waste prevention and recycling and to transmit a sense of collective responsibility.

Interactive experience

The game simulates a dialogue between the player and a mentor. Players can choose a mentor at the beginning of the game. They are fictional characters that represent real-world roles, each with a specific waste-related expertise (i.e., Estate managers, Waste processing managers, Green Campus staff).

Social norms and comparisons

Players are matched together during the final waste-sorting contest and are rewarded or penalised based on their collective performance. The purpose of this feature is to allow players to compare themselves to others (Chou, 2015) and foster a sense of collective responsibility.

Progression and accomplishment

The game is divided into two levels, each containing three different challenges. Players can earn points by solving a challenge and receive badges upon completing a level. Levels, points and badges are designed to transmit a sense of accomplishment and progression throughout the game and improve engagement (Chou, 2015).

Immediate feedback

Throughout the game, mentors provide feedback immediately after a player responds to a given quiz question. The feedback includes information on the correct answer along with other relevant information. Evidence suggests that providing immediate feedback is an effective and engaging way to transmit information (Luo et al., 2018; Soma et al., 2020).
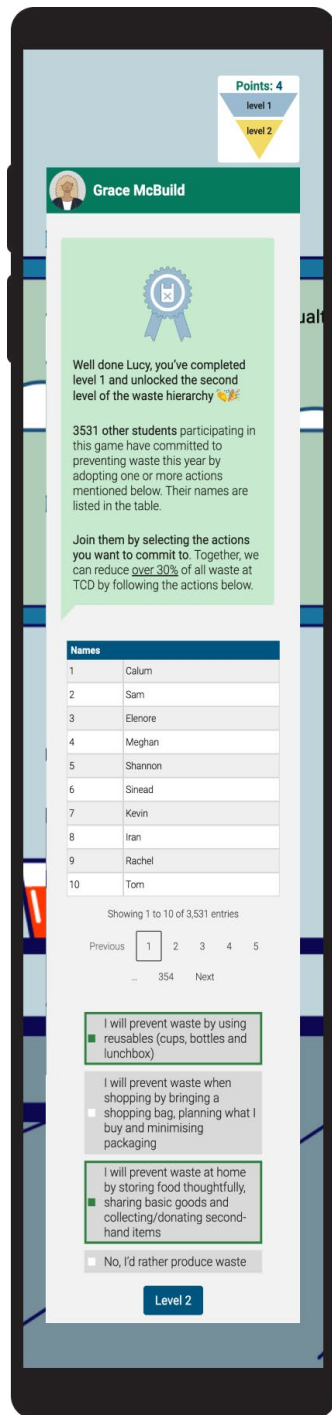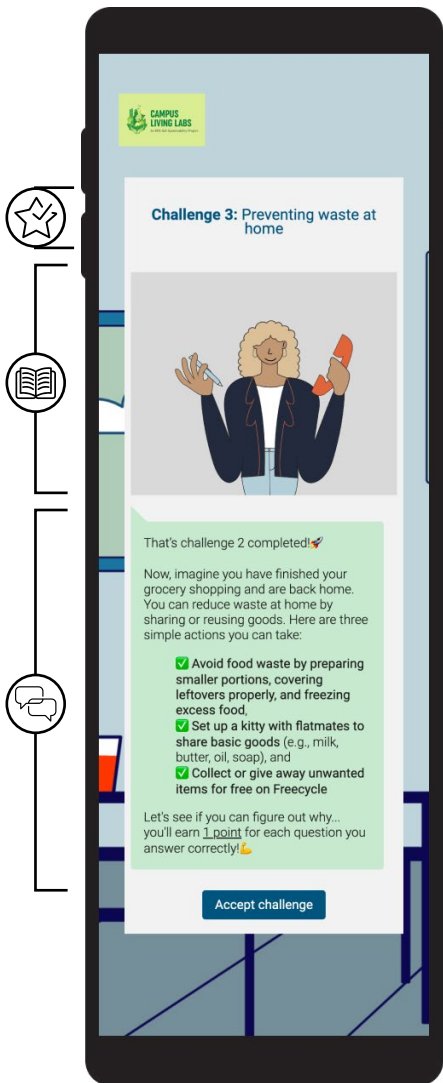
Commitment devices

At the end of each level, students can commit to a set of waste-related actions in real life. They are also presented with a leaderboard that includes the names of all the players who have committed. Evidence suggests that encouraging individuals to make public commitments increases the likelihood that they reduce and recycle waste (Mickaël, 2014; Wang & Katzev, 1990; Kauffman et al., 2020).

Your goal

We, the TCD community, produce over **1,790 tonnes of waste** per year. That's roughly equivalent to 1,430 MINI Coopers filled with waste.

We are putting effort into reducing our environmental impact by working down the waste hierarchy - our top priority is to prevent waste and then recycle any remaining waste as best as possible. **But we need your help!**

The Waste Hierarchy

Level 1
Prevent waste

Level 2
Recycle

Take part in this collective effort by acquiring the right skills and knowledge to reduce your waste impact. **Your mission is to complete levels 1 & 2 of the waste hierarchy.**

Don't worry, you are not alone ...

Start

Powered by Qualtrics

Points: 3
level 1
level 2

Grace McBuild

You're halfway there! In what bin does this packaging material go?

🔴 Incorrect. This packaging is certified as industrially compostable and should be placed in the food waste bin. Although they might look like regular plastics, do not place them with other plastics because they are designed to break down and can contaminate recyclable plastics.

You and 1 other student you share the bins with sorted this item incorrectly and contaminated the bin. You all lose 2 points! 🙁🙁

next

Point and level indicator designed to resemble the waste hierarchy framework

Simulation of an interaction with a waste management expert

Example of a quiz question, presented as a chat between the mentor and the player

Once players select their choice, true/false cues are displayed to provide feedback

Feedback and detailed explanation is provided, points are awarded for correct responses

Challenge 3: Preventing waste at home

That's challenge 2 completed!🚀

Now, imagine you have finished your grocery shopping and are back home. You can reduce waste at home by sharing or reusing goods. Here are three simple actions you can take:

☑️ Avoid food waste by preparing smaller portions, covering leftovers properly, and freezing excess food,
☑️ Set up a kitty with flatmates to share basic goods (e.g., milk, butter, oil, soap), and
☑️ Collect or give away unwanted items for free on Freecycle

Let's see if you can figure out why... you'll earn 1 point for each question you answer correctly!💪

Accept challenge

Points: 4
level 1
level 2

Grace McBuild

Well done Lucy, you've completed level 1 and unlocked the second level of the waste hierarchy 🎉

3531 other students participating in this game have committed to preventing waste this year by adopting one or more actions mentioned below. Their names are listed in the table.

Join them by selecting the actions you want to commit to. Together, we can reduce over 30% of all waste at TCD by following the actions below.

Names	
1	Calum
2	Sam
3	Elenore
4	Meghan
5	Shannon
6	Sinead
7	Kevin
8	Iran
9	Rachel
10	Tom

Showing 1 to 10 of 3,531 entries

Previous 1 2 3 4 5 … 354 Next

I will prevent waste by using reusables (cups, bottles and lunchbox)

I will prevent waste when shopping by bringing a shopping bag, planning what I buy and minimising packaging

I will prevent waste at home by storing food thoughtfully, sharing basic goods and collecting/donating second-hand items

No, I'd rather produce waste

Level 2

Level and number of points to indicate progress in the game

Talking to the mentor throughout to support the overarching narrative

Badges and congratulatory messages to reinforce players' sense of accomplishment

Use of social norms and comparison to foster a sense of shared responsibility

Encouraging players to make real life commitments to increase the likelihood of translating the knowledge they have gained through the game into action

Trial design and implementation

We evaluated the impact of the waste game on students' and staff's knowledge and key predictors of waste prevention and recycling behaviours through a randomised controlled trial (RCT).

Waste prevention and recycling predictors include participant's confidence and intentions to reduce and sort waste, their perceived social norm (i.e., how determined others are in reducing their waste impact) and the share of responsibility in waste segregation they assign to different parties (i.e., the student population, estate services, and waste operators).

Participants were randomly assigned to one of three experimental groups:

- **Control group:** participants responded to a short survey containing a set of outcome questions before playing the game.
- **Treatment group 1:** participants played a simplified version of the game before responding to a set of outcome questions.
- **Treatment group 2:** participants played the full version of the game that included additional gamification elements before responding to a set of outcome questions.

The additional gamification elements include a point system, the opportunity to choose a mentor, leaderboards containing the names of the students who have committed to a set of waste prevention and recycling actions, and matching players with others during the waste sorting challenge.

Participants in the treatment groups also received a follow-up survey three weeks after completing the game via email. The follow-up survey included the same outcome questions participants responded to when playing the game for the first time. The follow-up survey aimed to assess how memorable the information and tips provided in the game were over time.

Control group	Treatment group 1	Treatment group 2
Outcome questions	The Waste Game Simplified version	The Waste Game full version
The Waste Game full version	Outcome questions	Outcome questions
	Outcome questions	Outcome questions
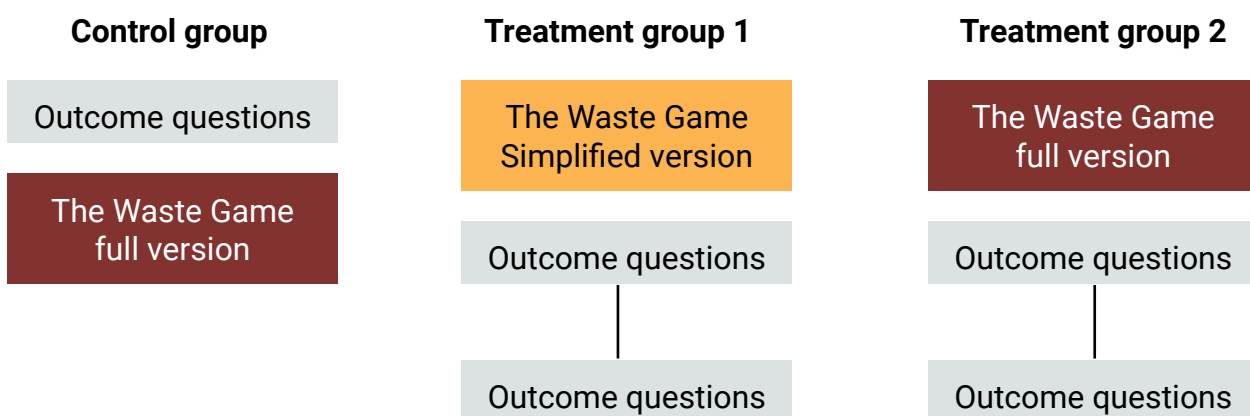
The design of this trial allowed us to assess the game's impact in both the short term and the long term. It also allowed us to assess the relative impact of adding gamification elements to the game and study the correlations between players' characteristics and key predictors of waste prevention and recycling behaviours.

Four universities were involved in the evaluation of The Waste Game: University College Dublin (UCD), Dublin City University (DCU), Maynooth University (MU) and Trinity College Dublin (TCD). The game was administered to students and staff members in all four universities. We estimated a minimum sample size of 3,000 across all four universities to provide adequate statistical power for the trial.

Universities engaged in multiple dissemination waves to raise awareness and encourage students and staff members to play the game. Overall, dissemination efforts spanned throughout the autumn trimester of 2022 using various channels: direct email blasts, social media, posters, promoting the game during in-person events, and leveraging existing communication channels used by the Student Union and other entities. A detailed table of the different dissemination efforts and their launch date is available in the appendix (see Table A1).

Results

Participant profile

In this section, we provide background information on university students and staff members who participated in the waste game. We also discuss the results from correlational analysis that helps us better understand the associations between different socio-demographic characteristics and between different outcomes of interest.

Background information
The table below provides summary statistics on the number of students and staff members opening, starting and completing the game for each of the participating universities. A total of 6348 individuals opened the game, among which 4702 started and 2590 completed the game. On average, 74.1% and 40.8% of those who opened the game started and completed the game respectively.

University	Opened	Started	Completed
DCU	2145	1518 (70.8%)	806 (37.6%)
MU	801	665 (83.0%)	387 (48.3%)
TCD	1836	1529 (83.3%)	943 (51.4%)
UCD	1566	990 (63.2%)	454 (29.0%)
Total	6348	4702 (74.1%)	2590 (40.8%)

Students and staff from TCD make up the largest proportion of the waste game participants who completed the game, followed by DCU, UCD, and MU. The waste game participants are over-represented by females (about 67.8% of those who completed the game). We also found that among students who have completed the game, the majority of them are postgraduate students, followed by 1st year undergraduates who make up the second largest group. Finally, most of the individuals who have completed the game reported that it is extremely or very important for them to live a sustainable lifestyle (36.4% and 43.0% respectively).

Who is more likely to play the game?
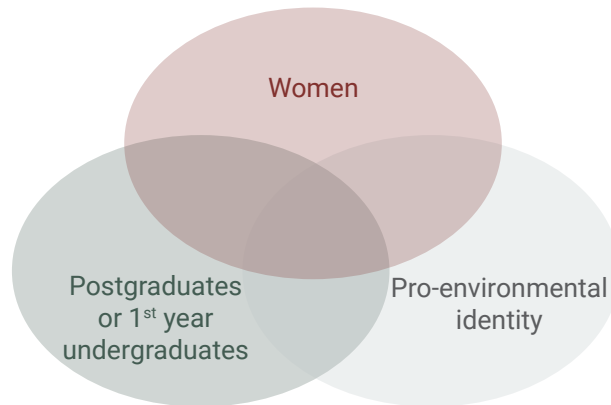
Participants' gender and green identity profiles are similar across all four participating universities. However, while the majority of participants who completed the game in TCD and UCD are postgraduate students, the largest group of participants in MU and DCU are 1st year undergraduate students.

Common profile of participants by university

	TCD	MU	DCU	UCD
Women	68.8%	65.9%	63.3%	74.9%
Postgraduates	33.1%	23.3%	24.8%	34.6%
1st year undergraduates	27.6%	27.2%	26.7%	15.8%
Pro-environmental identity	79.3%	79.1%	79.5%	79.7%

Graphs detailing the distribution of universities, gender, year of studies, and pro-environmental identity among players is available in the appendix (see graphs A1-A7).

Correlations

Our correlational analysis yields a number of interesting observations that apply to all participating universities. We found that females are generally more motivated to reduce their waste impact and more knowledgeable about waste prevention and sorting, even though they have less confidence in their knowledge. It is also observed that females generally assign more responsibility to all parties for segregating waste correctly. On the other hand, we found that despite having more confidence in their waste sorting and reduction knowledge, 1st-year undergraduate students are actually less knowledgeable.

What does the game tell us about its players?

- More knowledgeable
- More motivated to prevent and recycle waste
- Less confident in their waste sorting knowledge
- Greater sense of responsibility

- Less knowledgeable
- Less motivated to prevent and recycle waste
- More confident in their waste sorting knowledge
- Lower sense of responsibility

Those who performed better in the waste game also had better knowledge, a higher level of confidence to reduce and sort waste, greater motivation, and a higher likelihood of committing to reducing and sorting waste properly. Further, those with a higher level of confidence to reduce and sort waste also tend to have greater motivation, a more positive perceived social norm, a greater share of responsibility assigned to all parties, and a higher likelihood of committing to reducing and sorting waste properly.

These findings indicate that the outcomes of interest used to evaluate the game are good predictors of waste prevention and recycling intentions. They also highlight the importance of transmitting knowledge, confidence, a sense of collective effort and motivating staff and students.

What key aspects are associated with performing well in the game?

More likely to make a commitment

More knowledgable

Higher performance in the waste game

More motivated to reduce and sort waste

Higher level of confidence

Interestingly, there is a stronger positive relationship between performance in the waste game and making a commitment than between knowledge and making a commitment. This could be because, during the game, participants received immediate performance feedback, motivating them to continue their waste prevention and sorting efforts. The commitment device offered as part of the game allowed participants to continue their efforts beyond their participation in the game and for the long term.

In addition, we found that those who assigned a greater share of responsibility to campus services also tend to do the same to waste operators. This observation suggests that participants may not think there is much of a difference when it comes to the share of responsibility for segregating waste correctly between the two actors.

📎 *Graphs detailing our correlational analysis are available in the appendix (see graph A8 and table A2).*

Effectiveness of the game

Overall effectiveness of the game
In this section, we present the main experimental findings from the trial across all participating universities (DCU, UCD, MU and TCU). The graph below shows the effect of the waste game on university students' and staff's waste prevention and recycling knowledge. Our analysis shows that the waste game had a statistically significant positive effect on knowledge both in the short and the long term. Students in the treatment groups scored on average 1.13 points (right after playing the game) and 0.59 points (3 weeks after playing the game) higher than the control group (who on average scored 5 points out of 8) in the knowledge assessment. While these numbers may not seem large on their own, they represent a 12-23% increase relative to the control group's knowledge score.
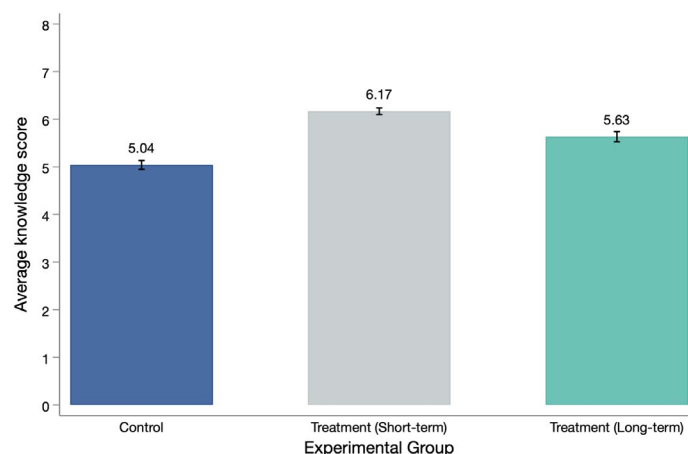
We also found that the waste game had a statistically significant positive effect on university students' and staff's confidence to reduce and sort waste. As shown in the graphs below, the confidence levels to reduce and sort waste for the treatment groups increased by 0.90 and 0.53 points in the short term respectively, when compared to the control group who on average reported 7.02 and 6.91 points (on a scale of 0 to 10). These effects are considerably large as they represent a 12.9% and 7.7% increase respectively relative to the control group's confidence to reduce and sort waste. Encouraging, these positive effects persisted 3 weeks after participants played the game.
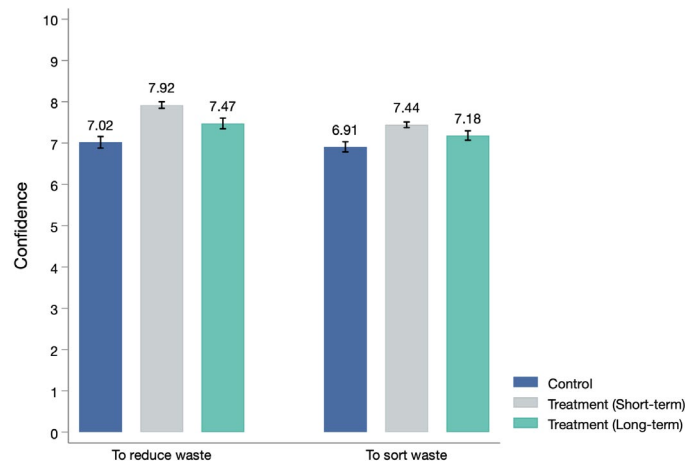
Further, we found that the waste game had a statistically significant positive effect on both motivation to reduce waste impact and perceived social norm (i.e., how determined others are in reducing their waste impact). As shown in the graphs below, the motivation level in the treatment groups increased on average by 0.72 points (from the 7.73 points out of 10 reported by the control group) in the short term. Similarly, the perceived motivation of others increased on average by 0.64 points for the treatment groups (from the 5.36 points out of 10 reported by the control group) in the short term. Again, these effects are considerably large as they represent a 9.3% and 11.9% increase respectively when compared to the control group. While the effect on motivation did not persist over time, the positive effect on perceived social norm persisted 3 weeks after participants played the game.
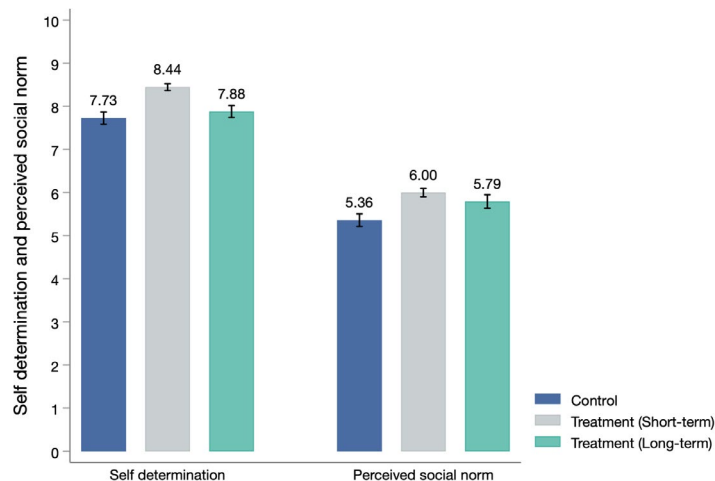
When asked to determine each party's share of responsibility in waste segregation, our analysis shows that both control and treatment groups thought that the student population is the most responsible for segregating waste correctly, compared to estate services and operators at waste processing plants. Those in the treatment groups assigned more responsibility to the students in the short term, with an increase of 0.17 points from the 8.52 points reported by the control group. While this effect only represents a 2% increase, it is statistically significant at the 5% level. Nevertheless, we do not observe similar significant effects on estate services' and waste operators' shares of responsibility. In other words, there are no differences between the control and the treatment groups when it comes to how responsible they think estate services and waste operators are for segregating waste correctly.

Further, we found no significant differences in the likelihood to make a commitment to preventing and sorting waste between those who received the full version of the commitment device and those who received the simplified version. Encouragingly, this is driven by the extremely high commitment rates observed in all groups, where more than 99% of those who completed the game made at least one commitment. This suggests a strong intention to prevent and recycle waste among the participants. In terms of the number of commitments made, we found that those who received the full version made slightly less commitments than those who received the simplified version. More specifically, those who received the full version made on average 0.25 less commitments than those who received the simplified version (who made on average 5.47 commitments out of the 6 offered to them).

📎 *Tables outlining the trial's balance check and overall effect of the game on key predictors of waste prevention and recycling behaviours are available in the appendix (see tables A3-A5).*

Full version vs simplified version of the game
While our analysis shows that the waste game, in both versions, was effective in improving the key predictors of waste prevention and recycling behaviours (i.e., knowledge, confidence, perceived social norms, perceived responsibility of the issue, and intentions), one may be interested in the relative effectiveness of the full version of the game when compared to the simplified version. To assess and identify the version that performed better, we discuss the comparative effects of the waste game in its full version (compared to the simplified version) in this section.

The graph below shows the comparative effect of the fully featured waste game on university students' and staff's game performance (as measured by their game quiz score) and knowledge (as measured by their knowledge assessment score). Our analysis shows that those who played the full version of the game performed significantly better in the game, with an improved score of 15.6 out of the maximum 24 points in the game quiz (compared to the 15 points scored by those who played the simplified version). Interestingly, however, the better performance in the game did not translate into an improvement in knowledge for those who played the full version. In fact, those who played the full version scored 0.22 points lower in the knowledge assessment, when compared to those who played the simplified version (who scored 6.3 out of the maximum 8 points).

Further analysis shows that these effects are driven by only some of the participating universities. While participants from DCU and TCD who played the full version of the game performed significantly better in the game quiz, we found no such evidence for those from MU and UCD. In terms of the effect on knowledge, we found that only those from DCU who played the full version scored significantly lower in the knowledge assessment, but not participants from the other three universities.
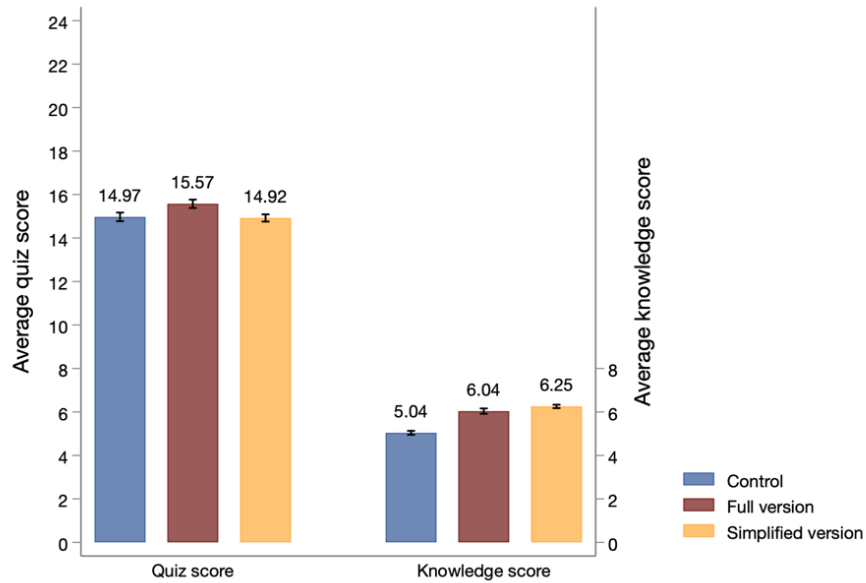
In addition, we found that those who played the full version of the waste game displayed significantly lower confidence in reducing and sorting waste. As shown in the graph below, the confidence levels to reduce and sort waste for those who played the full version are 0.24 and 0.20 points lower respectively, when compared to those who played the simplified version (who on average reported 8.01 and 7.52 points respectively). We also found that those who played the full version of the game assigned significantly more responsibility to estate services and waste operators (with an increase of 0.36 and 0.42 points respectively) than those who played the simplified version, but not to students.
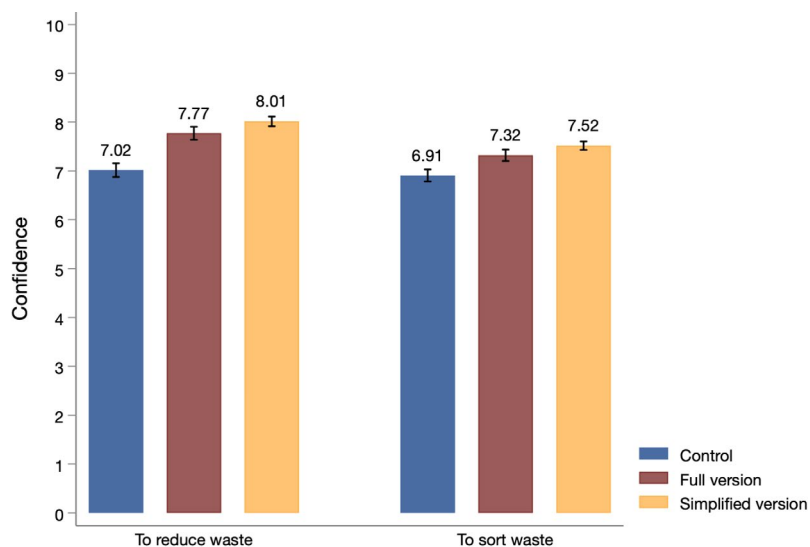
Further, we found that there are no significant differences in the likelihood to make a commitment to preventing and sorting waste between those who played the full version and those who played the simplified version. Encouragingly, this is largely driven by the extremely high commitment rates observed in all groups, where more than 99% of those who completed the game made at least one commitment. In terms of the number of commitments made, those who played the full version made slightly fewer commitments than those who played the simplified version.

Tables outlining the differential effects of the waste game in its full version compared to the simplified version are available in the appendix (see tables A6-A8).

Effects of the game on different participant profiles

While the waste game was, in general, effective in improving the key predictors of waste prevention and recycling behaviours (i.e., knowledge, confidence, motivation, perceived social norms, perceived responsibility of the issue, and intentions), we were interested in whether the game was similarly effective for different participant profiles. Therefore, we conducted heterogeneity analyses based on a range of socio-demographic characteristics, including gender, year of studies, universities, and whether the participants are students or staff members.

In general, our analysis showed that the waste game has similarly positive effects for both females and males. However, there are differential effects for other population segments. The game has a greater positive effect on knowledge for 4th year undergraduates than for 1st year undergraduates, for students than for staff, and for TCD, UCD, and MU than for DCU participants. Furthermore, while the game significantly increased the confidence to sort waste for DCU and TCD participants, no such evidence was found for MU and UCD.

Key effects of the waste game by university

|	TCD	MU	DCU	UCD
Increase in knowledge	+25.3%	+24.6%	+16.1%	+23%
Increase in confidence to sort waste	+10.4%	+3.3% (not significant)	+10.2%	+2.0% (not significant)
Increase in motivation to sort waste	+11.4%	+10.4%	+6.7%	+8.3%

Tables outlining the effects of the waste game on different participant profiles are available in the appendix (see tables A9-A12).

User experience

Engagement

In terms of participants' engagement with the waste game, we found that those who were randomly assigned to the simplified version of the game were significantly less likely to drop out. Compared to the other two groups that had 63.8% and 65.9% of participants dropping out, 48.2% of those who received the simplified version dropped out of the game. Importantly, this finding applies to all four participating universities.

The graph below illustrates the proportion of participants in each experimental group that completed each section of the game. Two observations stood out from the graph. First, the largest drop off in engagement was right after the landing screen of the game, where many participants stopped progressing. This trend can be observed for both versions of the game. Second, participants who received the simplified version of the game were much more likely to engage and complete the waste game, as highlighted by the proportion of participants who progressed to the end of the game.
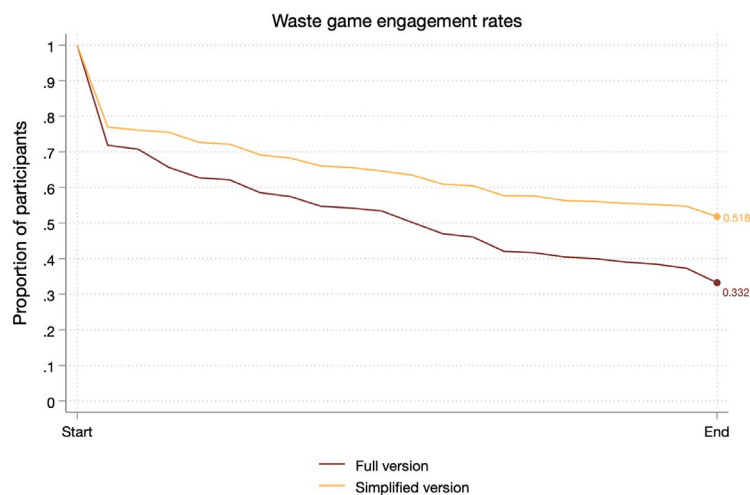
In terms of the amount of time participants spend in the waste game, students and staff spent a median of 8.6 minutes on the entire game, which consists of 2 levels with 3 challenges within each level. In each challenge individually, we found that participants spent a median of 0.8 to 1.8 minutes.

> *Tables detailing drop out rates and time spent on the waste game are available in the appendix (see tables A13, A14 and graph A9).*

Performance in the game
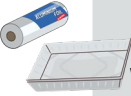
On average, participants in the game responded correctly to 15 out of 25 quiz questions, achieving a score of 60%. Staff appear to have performed better than students in the game by five percentage points, with an average score of 65%. When looking at how staff and students performed across universities, Trinity College Dublin (TCD) performed best, followed by Maynooth University (MU), Dublin City University (DCU) and University College Dublin (UCD).

Performance in the waste game

2nd MU score: 61%	**1st** TCD score: 63%	**3rd** DCU score: 59%	**4th** UCD score: 58%
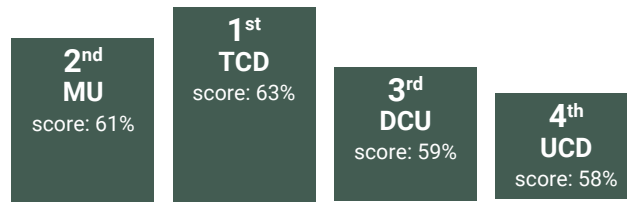
The final waste-sorting contest was generally the most challenging part of the game. Participants were asked to sort ten waste items into different bins. The waste items included in the game represent items that commonly contaminate waste streams based on waste characterisation studies conducted by the EPA and participating universities. On average, the waste items that participants were more likely to sort incorrectly in the waste game were Pringles tubes (71%), followed by packets of crisps (67%), disposable coffee cups (59%), and aluminium wraps and trays (46%). This suggests that staff and students might not be aware of recent changes in rules (i.e., since 2020, soft plastics, including packets of crisps, should be placed in recycling bins) and struggle with composite packaging (e.g., the pringles tubes and disposable coffee cups).

Waste items most commonly sorted incorrectly by university

	TCD	MU	DCU	UCD
Aluminium wrap and trays	40%	50%	52%	53%
Disposable coffee cups	56%	57%	65%	60%
Packets of crisps	69%	65%	67%	67%
Pringles tubes	71%	69%	69%	73%

For more information on participant's performance in the game by university and the share of students and staff that sorted waste items correctly see graphs A10-A15 in the appendix.

Perceived usefulness
In terms of the perceived usefulness of the game, almost all participants think the waste game is somewhat or very useful, as shown in the graph below. However, we found that those who played the full version were less likely to perceive the game as very useful. This observation applies to all four participating universities.

However, we found that those who played the full version were overall less likely to perceive the game as very useful. Interestingly, this finding only applies to participants from MU and TCD as we do not find significant differences for those from DCU and UCD.


Perceived usefulness of the waste game
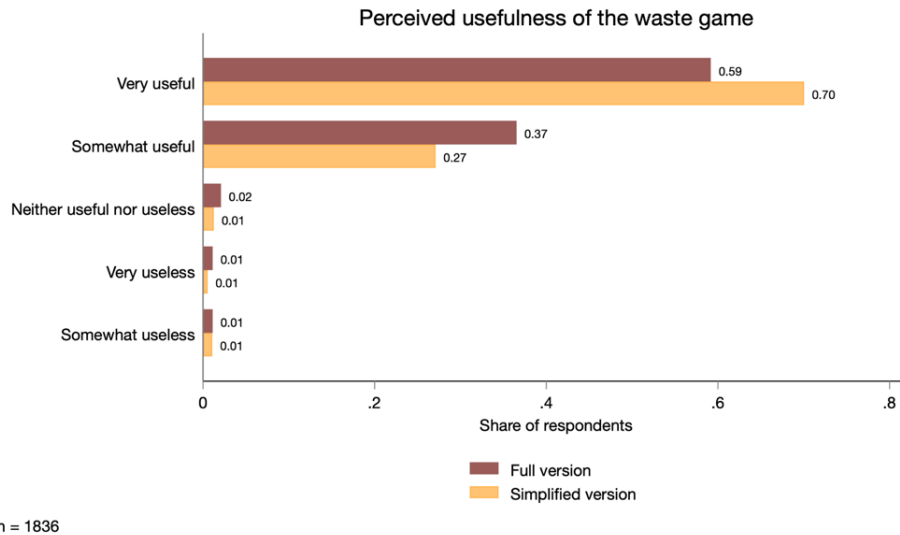
For more information on the perceived usefulness of the game see tables A15, A16 and graph A16 in the appendix.

Length and relevance

In the staff version of the game, we asked for feedback on both the length of the game and the relevance of each topic included in the game. We found that 2 in 3 staff members think that the length of the game is just right (i.e., neither long nor short), while the rest think that the game is somewhat or too long.

Feedback on the length of the waste game
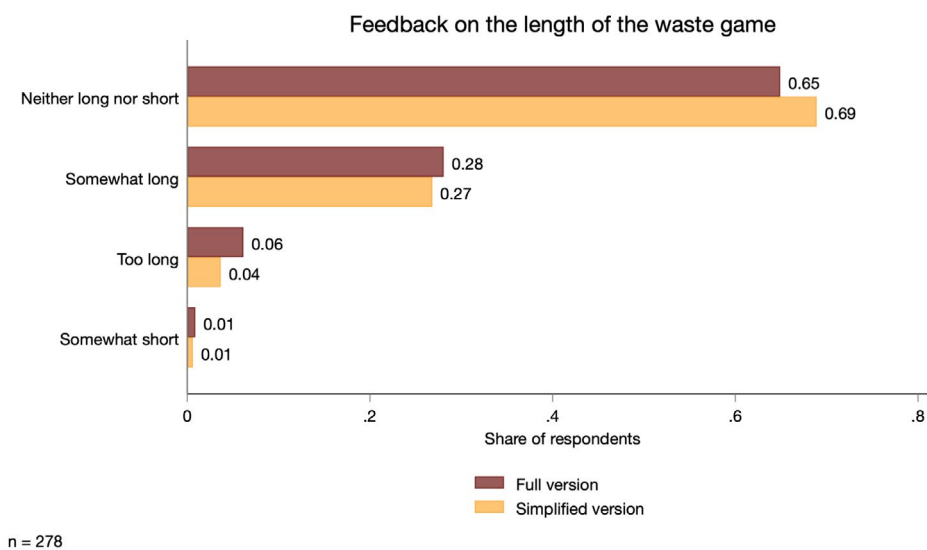
In terms of the relevance of the different topics in the game, all six topics are deemed very relevant by most staff members. Challenge 1 of level 2, which focused on recyclable waste contamination, was rated slightly more relevant than other topics across all participating universities. While there are some staff members who reported very low relevance for the topics, all six topics received around the same number of negative feedback (7-8% of the staff who answered this question). In other words, none of the six topics was identified to be more irrelevant than the others overall.

Feedback on the relevance of the waste game

n = 276
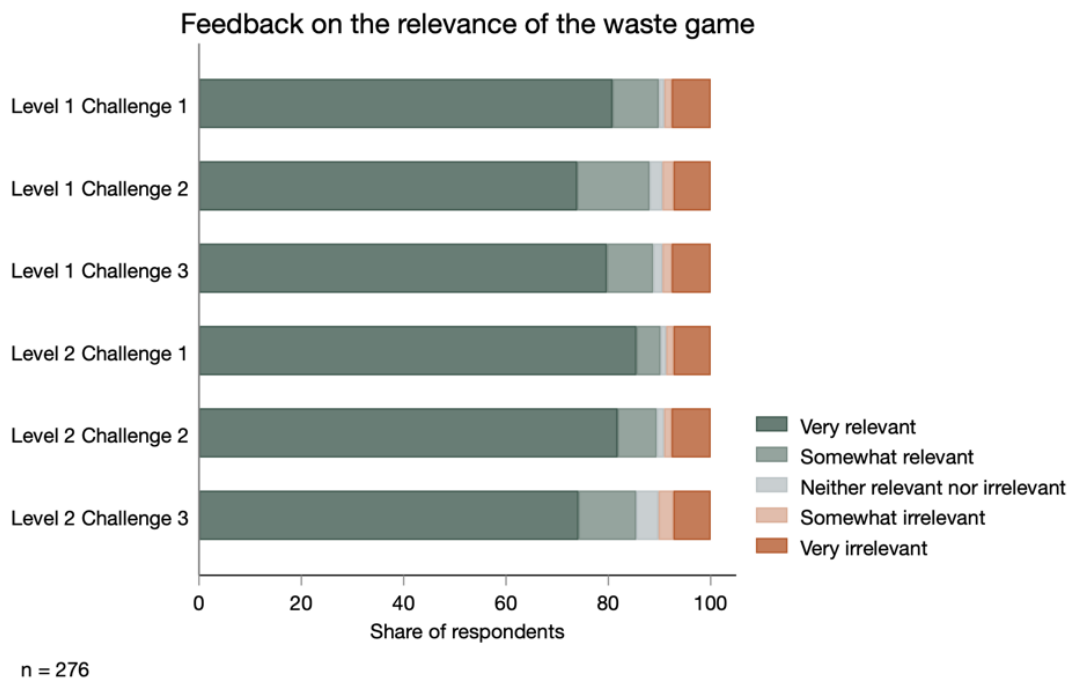
📎 *For more information on the length of the game and the relevance of difference topics addressed in the game see graphs A17 and A18 in the appendix.*

Qualitative feedback
Participants of the waste game were asked to provide feedback on the game and, more generally, on what would help them better reduce or recycle their waste on campus.

Overall, the game was received very positively. Students and staff found the game to be informative and engaging. Some players suggested including more visuals and making it more interactive. Other players suggested including a downloadable summary at the end of the game that players can keep beyond the game.

However, some players that received the full version of the game found that getting paired with other players during the final waste-sorting contest was frustrating. While pairing players with others helped transmit the concept of collective responsibility, players did not appreciate being penalised for the performance of others.

Below are examples of quotes that we collect from participants.

"it seems very informative and allows for a variety of challenges which really gets you thinking! well done!" **– Participant A**

"This was great game. Maybe a few more pictorial representations like real life images could be nice to go with different facts. Just an idea that popped into head right now. All in all, it was really interesting. Thank you" **– Participant B**

"Send a summary of everything learned (maybe wrong questions) to email address. Might help for participants to remember longer period of time." **– Participant C**

"Don't put students into groups, I lost lots of points even though I responded correctly, it was very frustrating and I lost motivation to read the explanations" **– Participant D**

Across all four universities, the most common feedback shared by participants relates to increased and improved waste bins , followed by increased and improved signage and more educational campaigns. Other commonly mentioned areas of improvement include, banning single-use materials on campus, and increasing the number of water fountains as well as providing information on their locations.

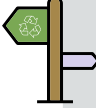Below are examples of quotes that we collect from participants.

"Add explanations on the bins of what should not go there (in addition to what should go) in reference to the commonly made mistakes (perhaps based on the data from this game)" **– Participant E from Trinity College Dublin**

"There should be more general, recycling, compost bins rather than just the green bag bins that are all around campus. Signs displaying some of the information from this game placed above bins would make people more conscience of their actions. Ex. tell them that one contaminant leads to the whole recycling bin going to general waste." **– Participant F from University College Dublin**

"Please please please put signs around the campus directing students towards water refilling stations. Having 15 of them around the campus is great but totally no good if no one knows they're there." **– Participant G from Maynooth University**

"More clearly labelled bins in classrooms or more than one bin in classrooms and lecture halls, often there will only be one or a few bins with no labels so I just assume they are general waste" **– Participant H from Dublin City University**

**Key actions that would help staff and students sort waste better by university**

	TCD	MU	DCU	UCD
More and better bins	42%	31%	32%	23%
Improved signage	29%	31%	24%	23%
More educational campaigns	16%	15%	13%	8%

For a detailed account of participants' feedback on the waste game and on how to better reduce and recycle waste on campus please see graphs A19-A22 and tables A17-A18.

Dissemination

In this section, we assess the effectiveness of different channels and activities used to promote the game. The graphs below visualise the waste game cumulative open and completion rates, along with the promotional activities for each of the four universities.

In general, sharp increases in both the open and completion rates are observed on the days when the promotional activities were conducted. Across all universities, emails appear to be the most effective dissemination channel as the sharpest increase in the open and completion rates are when emails were sent to students to promote the game as well as to remind them to complete the game. On the other hand, the effectiveness of social media channels (e.g., Instagram and Twitter) is less conclusive; while there are increases in the open and completion rates in some instances, they are less stark (social media posts were, however, often launched at the same time as the emails). Lastly, posters and events appear to be the least effective.
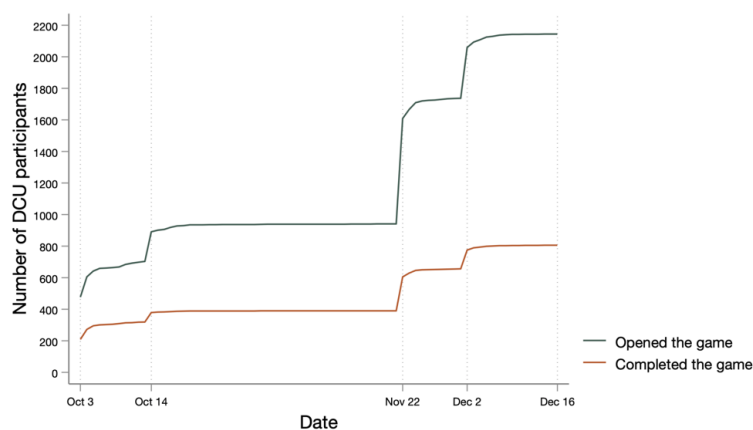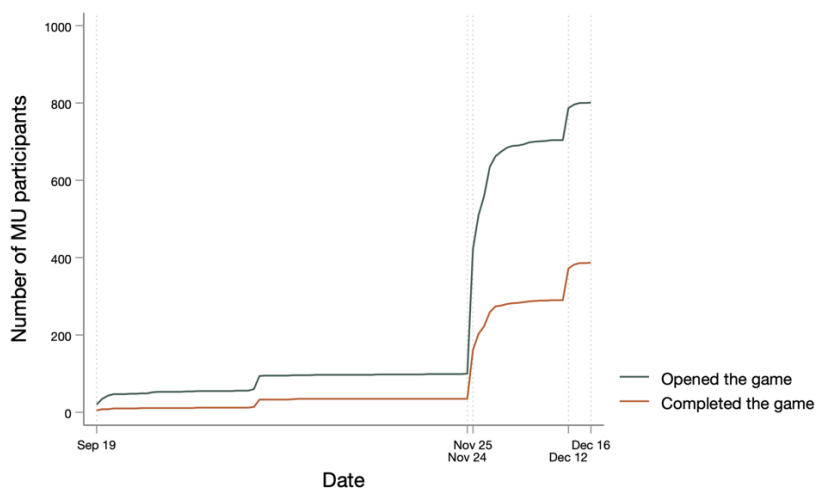

Oct 3 - Launched and sent to students via email
Oct 14 - Promoted via student union newsletter and sent to staff
Nov 22 - Reminder sent to students via email and to staff via intranet
Dec 2 - Reminder sent to students via email
*The waste game was also promoted during the Walk-tober event, which spanned over the month of October
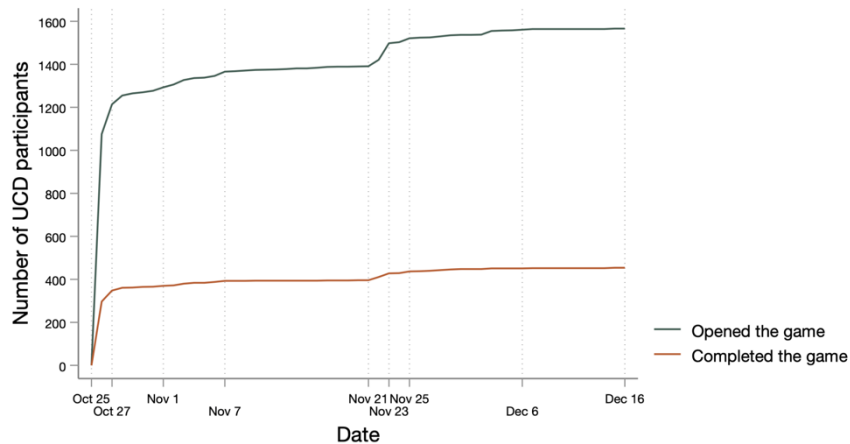
Oct 25 - Launched and promoted on Instagram
Oct 27 - Promoted on Instagram and sent via email to all students
Nov 1 - Sent to staff via intranet
Nov 7 - Promoted on Instagram
Nov 21 - Promoted on Instagram
Nov 23 - Sent via email to student residents
Nov 25 - Sent to estate staff via intranet
Dec 6 - Promoted in an email sent to student residents in collaboration with the pop-up recycling centres
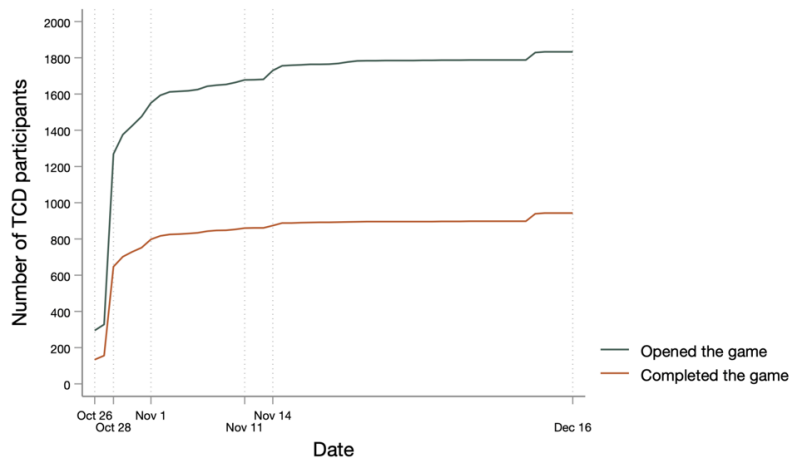
Oct 26 - Launched and sent to staff via email
Oct 28 - Sent to students via email
Nov 1 - Promoted via social media and student union newsletter
Nov 11 - Reminder sent to staff via email
Nov 14 - Promoted via social media

Sep 19 - Launched and promoted via Twitter, Instagram, and posters
Nov 24 - Promoted on Green Campus website
Nov 25 - Promoted on Instagram and sent to students via email
Dec 12 - Sent to staff via email

Learnings and recommendations

Participant profile

The waste game participants are overrepresented overall and in each university by:

Female students and staff

Postgraduate and 1st year students

Individuals who regard living a sustainable lifestyle as very or extremely important

Future dissemination efforts should focus on better targeting those who are underrepresented (e.g., males, 2nd to 4th year undergraduates). Campaigns that highlight social norms around waste prevention and recycling behaviours can be an effective approach to address these profiles (Geislar, 2017).

Effectiveness and experience of the waste game

Overall effectiveness

The waste game was **highly effective** in improving the key predictors of waste prevention and recycling behaviours, **both in the short and the long term** across all participating universities. Almost all of the participants made **at least one commitment to reducing and sorting waste properly.**

Short-term effects:
Better waste sorting and reduction knowledge
Higher confidence to reduce and sort waste
Improved motivation and perceived social norms
Higher share of responsibility in waste segregation assigned to the student population

Long-term effects:
Most of these positive effects persisted over time (i.e., 3 weeks after the game was played)

Simplified vs Enhanced version

The findings from the trial suggest that the waste game is effective and may be better presented in a simplified version going forward. Further research should be conducted to identify specific gamification elements to help drive engagement and enhance the effectiveness of the game.

**Participants who played the Simplified Waste Game**

- 👎 Performed worse in the game
- 👍 Performed better in knowledge assessment
- 👍 Reported higher confidence in sorting and reducing waste
- 👍 Assigned less responsibility in waste segregation to estate services
- 👍 Were more likely to complete the game
- 👍 Were less likely to drop out

The overall feedback on the game is largely positive: almost all individuals think the waste game is informative and useful. Suggestions to improve the game included providing key take-aways at the end, improving its usability, and avoiding elements where participants can lose points because of their group members' performance.

Effects of the game on different participant profiles

The waste game had...

Similarly positive effects on women and men

 =
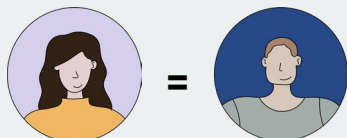
Greater positive effects on knowledge

| for...	than...
4th year undergraduates	1st year undergraduates
Students	Staff
TCD, UCD and MU students	DCU students

Significantly increased the confidence

for...	than...
DCU and TCD participants	MU and UCD students

The waste game differentially influences participants and further research should be conducted to study why such phenomenons exist and inform future game designs.

Experience and feedback

TCD students and staff acheived the highest score in the game:

2nd MU score: 61%

1st TCD score: 63%

**3rd DCU** score: 59%

4th UCD score: 58%
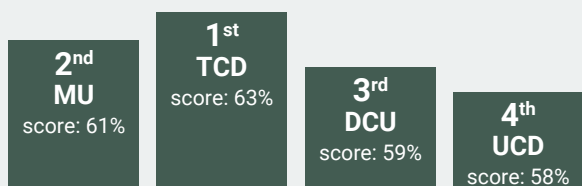
Across universities, participants struggled the most with sorting the following items:

Future educational campaigns should focus on raising awareness about soft plastics and composite packaging. Also, findings suggest that gamified online tools are valued by both staff and students as an effective educational tool.

Participants' feedback on what would help them better reduce or recycle waste on campus included improving signage to bins and water fountains, replacing single-use packaging with reusable lunchboxes and cups and providing more education on recycling.
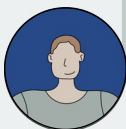
Dissemination
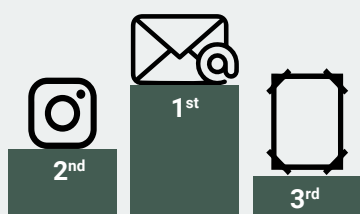
Across all universities, sharp increases in both the waste game open and completion rates are observed on the days when promotional activities were conducted. Emails appear to be the most effective dissemination channel, followed by social media while posters and university events appear to be the least effective

2nd **1st** **3rd**

Future dissemination efforts should leverage email blasts and reminder emails to engage staff and students in sustainability initiatives.

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