



**Trinity College Dublin**  
Coláiste na Tríonóide, Baile Átha Cliath  
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# **CSU44099 Final Year Project**

## **Interim Report**

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### **A Social Mobile App Implementing Gamification Frameworks to Meaningfully Motivate Pro-Environmental Behavioural Change**

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## 1. Description

### 1.1. Background

The problem this project addresses is the existence of a knowledge-action gap, where society is aware of the threat of climate change but does not take nearly enough meaningful action to tackle this issue. This is evident from Ireland setting their goal of reducing emissions in 2021 by 4.8% but in fact have increased emissions in 2021 by 5.4% (Environmental Protection Agency (EPA) (2022)).

### 1.2. Goals and Objectives

The overall goal of this project is to apply a social mobile app implementing gamification frameworks to motivate pro-environmental behavioural change. To achieve this goal, the objectives for app design and implementation are providing users the ability to track their daily carbon footprint emissions, compete and view position in individual and team leaderboards, view the history of their individual scores over time to analyse progress, view the breakdown of their carbon footprint score and to view suggestions on how to reduce their carbon footprints. Non-functionally speaking, the app should be easy and enjoyable to use.

After collecting data on users' carbon footprint scores over time through the app, the goal of this project is to analyse the potential impact and success gamification can have on reducing individual carbon footprints.

## 2. Literature Review

### 2.1. Introduction

This literature review will discuss the three key areas of this project: carbon footprint, behavioural psychology and finally gamification. After discussing the well-known carbon footprint metric tool and the factors contributing to this metric, behavioural psychological factors will be analysed to account for society's knowledge-action gap towards reducing carbon footprints. Gamification will then be discussed as a promising solution to address this problem, before finally discussing existing solutions to enhance the likelihood of

providing a successful implementation for this project, taking inspiration from their success factors and learning from their mistakes.

## 2.2. Carbon Footprint

As Mulrow, J. et al. (2019) mention, carbon footprints have become the industry norm for calculating individual impact on climate change through greenhouse gas emissions, highlighting the causes of such emissions and providing opportunity to reduce such emissions, where the main factors contributing to carbon footprints are transport (17.7%), agriculture (37.5%) and energy usage (16.7%) (Environmental Protection Agency (EPA) (2022)).

## 2.3. Behavioural Psychology

With the tool of the carbon footprint metric at their disposal, one would wonder why society displays such a large knowledge-action gap. Promising reasons are provided by the inclusion model, social identity and a feeling of a lack of responsibility.

De Dominicis, S., Schultz, P.W. and Bonaiuto, M. (2017) argue that traditional and historic attempts to promote pro-environmental behaviour have failed because of focusing on highlighting the altruistic benefits on nature or the greater good, where they should have focused more on self-interest or self-enhancement. De Dominicis, S., Schultz, P.W. and Bonaiuto, M.'s (2017) work expands that of the Inclusion Model for Environmental Concern (Nolan, J.M. and Schultz, P.W. (2013)) which explains how egoistic or self-interest motivated values and altruistic or self-transcendent values are hierarchically structured, whereby altruism is inclusive of self-interest.

From a social aspect, Bouman, T., Steg, L. and Zawadzki, S.J. (2020) argue that the values individuals perceive their groups to endorse can critically motivate individuals to engage in pro-environmental action. Bouman, T., Steg, L. and Zawadzki, S.J. (2020) expand on the work of the "Social Identity" outlined by Fielding, K.S. and Hornsey, M.J. (2016) and Jans, L., Bouman, T. and Fielding, K. (2018), whereby groups can provide standards that guide individual actions.

With increasing awareness of the proportion of individual impact being negligible compared to large corporations, society feels a lack of responsibility to tackle climate change and argues that no one individual has the capability to make a meaningful change in global emissions (Schwenkenbecher, A. (2014)).

## 2.4. Gamification

Deterding, S. et al. (2011) define gamification as “the use of game design elements in non-game contexts”, with Sailer, M. et al. (2017) expanding on this definition, saying “to foster human motivation and performance in regard to a given activity.” Applying this logic to this project proposes the potential success of applying gamification principles and design to spark pro-environmental behavioural change.

Xi, N. and Hamari, J.’s (2019) research discovers that among the three broad categories of gamification features of immersion, achievement and social features, achievement had the most significant impact on fulfilling the psychological user needs of autonomy, competence and relatedness, followed by social and then immersive features. This research provides great motivation for this project to prioritise implementing achievement features such as leaderboards, points and progress maps, before progressing on to social features such as chatting and teamwork, to create an effective, environmentally gamified app to reduce individual carbon footprints.

## 2.5. Existing Solutions

The potential success of applying gamification to motivate pro-environmental behaviour is evident from the existing application of “Ant Forest”, a gamified environment-friendly app which has reached a carbon emissions reduction equivalent to saving 29.4 billion kwh of electricity, which is equivalent to one full day of China’s electricity consumption (Cao, Y. et al. (2022)).

Contrastingly, “Green Life” is a gamified environmental app which targets financial incentives but has lacklustre performance with an underwhelming user base of 700,000

users in total so far, with a concerning app store rating of only 2.3 out of 5 ((Xi, N. and Hamari, J.'s (2019)). "Green Life" is the perfect illustration of the danger of assuming any form of gamification will result in effective behavioural change, and that, as Gartner (2012) warns, 80% of current gamified applications were estimated to fail to meet their objectives due to poor design.

## 2.6. Conclusion

After identifying the knowledge-action gap problem (the central motivation for this project), the inclusion model, social identity and lack of responsibility put into perspective why such infrequent action is taken. By connecting the ability of gamification to tackle these psychological barriers to pro-environmental behaviour change, and analysing this in practice through existing solutions of "Ant Forest" and "Green Life", motivations and direction will be taken forward to aid in the design of this project.

### 3. Plan of Work

#### 3.1. Gantt Chart

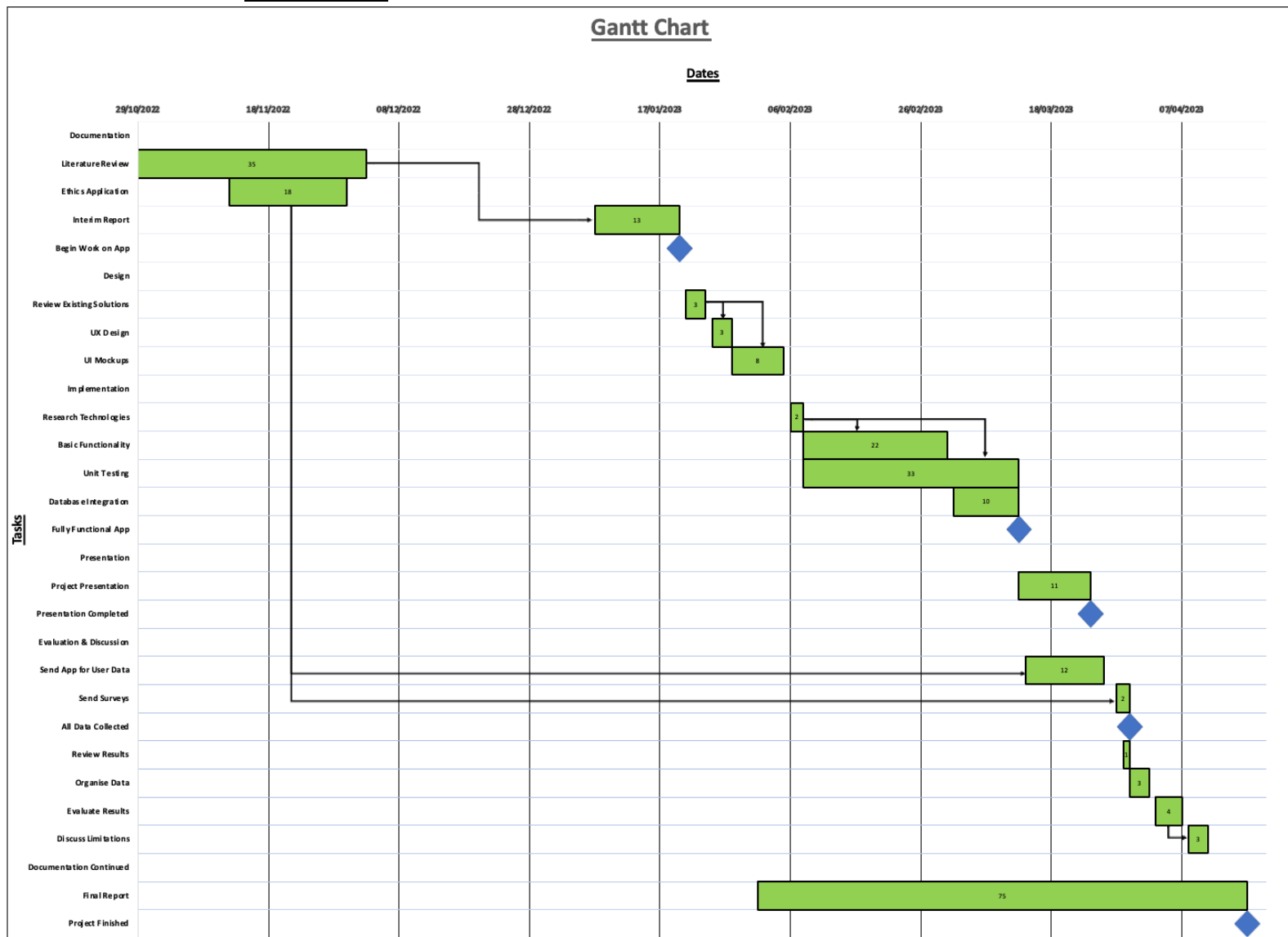


Figure 1: Gantt chart illustrating the plan of work for the project. Task stages, tasks themselves and milestones are labelled on the left hand side corresponding to the rows, and the dates are labelled on the vertical axis along the columns. Milestones are represented by diamonds and dependencies are represented by connected arrows, which means one task cannot start until the connected task is finished. The number of days for each task is labelled in each bar.

### 3.2. Tasks, Schedule and Milestones

#### **Tasks, Schedule and Milestones**

Task	Start Date	End Date	Duration
<b>Documentation</b>			
Literature Review	29/10/2022	03/12/2022	35
Ethics Application	12/11/2022	30/11/2022	18
Interim Report	07/01/2023	20/01/2023	13
<b>Begin Work on App</b>	20/01/2023		
<b>Design</b>			
Review Existing Solutions	21/01/2023	24/01/2023	3
UX Design	25/01/2023	28/01/2023	3
UI Mockups	28/01/2023	05/02/2023	8
<b>Implementation</b>			
Research Technologies	06/02/2023	08/02/2023	2
Basic Functionality	08/02/2023	02/03/2023	22
Unit Testing	08/02/2023	13/03/2023	33
Database Integration	03/03/2023	13/03/2023	10
<b>Fully Functional App</b>	13/03/2023		
<b>Presentation</b>			
Project Presentation	13/03/2023	24/03/2023	11
<b>Presentation Completed</b>	24/03/2023		
<b>Evaluation &amp; Discussion</b>			
Send App for User Data	14/03/2023	26/03/2023	12
Send Surveys	28/03/2023	30/03/2023	2
<b>All Data Collected</b>	30/03/2023		
Review Results	31/03/2023	01/04/2023	1
Organise Data	01/04/2023	04/04/2023	3
Evaluate Results	05/04/2023	09/04/2023	4
Discuss Limitations	10/04/2023	13/04/2023	3
<b>Documentation Continued</b>			
Final Report	01/02/2023	17/04/2023	75
<b>Project Finished</b>	17/04/2023		

Figure 2: Tasks, schedule and milestones of the project, illustrating the start date, end date and the duration of the task. Yellow indicates stages of the project and blue indicates milestones.

### 3.3. Dependencies

#### **Dependencies**

Task	Dependent On
UI Design	Review Existing Solutions
UI Mockups	Review Existing Solutions
Basic functionality	Research Technologies
Database Integration	Research Technologies
Send App for User Data	Ethics Application
Send Surveys	Ethics Application
Send App for User Data	Unit Testing
Send Surveys	Unit Testing
Discuss Limitations	Evaluate results

Figure 3: Dependencies of the project with dependent tasks in the 1st column and the tasks they are dependent on in the 2nd column.



## 4. Ethical Issues

### 4.1. Handling Participants' Data

Since this project involves users inputting data to calculate their carbon footprint, ethical concerns of anonymity, security and transparency arise. To provide transparency, participants will be informed of how their data will be handled prior to beginning their involvement in this study through the informed consent form and the participation information sheet. This information is repeated at the beginning of the questionnaire where participants are reminded of how their data will be anonymised before publication, that only the researcher and supervisor will have access to this data providing security and that the data will be kept for 10 years for research integrity purposes, after which point it will be deleted.

Users will be informed that their participation is entirely voluntary and they can withdraw at any time without penalty, up to before the data is anonymised, and that they cannot participate in the study unless they agree with and sign the consent form. To facilitate any desire to withdraw from the study, and to address any other participant(s)'s concerns, participants will be provided with the researcher's contact details.

### 4.2. Selecting Participants

Participants will be recruited using opportunistic sampling through personal connections. The gamified team aspect of the app will involve grouping members into teams which will be conducted using a random number generator to prevent bias and consequently potentially inaccurate results.

### 4.3. Gender, Race and Inclusivity

There are no ethical concerns with regards to gender, race and inclusivity for this project.

## 5. References

Bouman, T., Steg, L. and Zawadzki, S.J. (2020) "The value of what others value: When perceived biospheric group values influence individuals' pro-environmental engagement," *Journal of Environmental Psychology*, 71. Available at:

<https://doi.org/10.1016/j.jenvp.2020.101470>.

Cao, Y. et al. (2022) "How gamified cooperation and competition motivate low-carbon actions: An investigation of gamification in a popular online payment platform in China," *Journal of Environmental Management*, 324. Available at:

<https://doi.org/10.1016/j.jenvman.2022.116259>.

De Dominicis, S., Schultz, P.W. and Bonaiuto, M. (2017) "Protecting the environment for self-interested reasons: Altruism is not the only pathway to sustainability," *Frontiers in Psychology*, 8. Available at: <https://doi.org/10.3389/fpsyg.2017.01065>.

Deterding, S. et al. (2011) "From game design elements to gamefulness," *Proceedings of the 15th International Academic MindTrek Conference: Envisioning Future Media Environments [Preprint]*. Available at: <https://doi.org/10.1145/2181037.2181040>.

Environmental Protection Agency (EPA) (2022) Ireland's Provisional Greenhouse Gas Emissions 1990-2021. Available at: [https://www.epa.ie/publications/monitoring--assessment/climate-change/air-emissions/EPA-Ireland's-Provisional-GHG-Emissions-1990-2021\\_July-2022v3.pdf](https://www.epa.ie/publications/monitoring--assessment/climate-change/air-emissions/EPA-Ireland's-Provisional-GHG-Emissions-1990-2021_July-2022v3.pdf) (Accessed: January 6, 2023).

Fielding, K.S. and Hornsey, M.J. (2016) "A social identity analysis of climate change and environmental attitudes and behaviors: Insights and opportunities," *Frontiers in Psychology*, 7. Available at: <https://doi.org/10.3389/fpsyg.2016.00121>.

Gartner (2012) Gartner says by 2014, 80 percent of current gamified applications will fail to meet business objectives primarily due to poor design., Gartner. Available at: <http://www.gartner.com/it/page.jsp?id=2251015>.

Jans, L., Bouman, T. and Fielding, K. (2018) "A part of the energy \in crowd\": Changing People's Energy Behavior via group-based approaches," IEEE Power and Energy Magazine, 16(1), pp. 35–41. Available at: <https://doi.org/10.1109/mpe.2017.2759883>.

Mulrow, J. et al. (2019) "The state of carbon footprint calculators: An evaluation of calculator design and user interaction features," Sustainable Production and Consumption, 18, pp. 33–40. Available at: <https://doi.org/10.1016/j.spc.2018.12.001>.

Nolan, J.M. and Schultz, P.W. (2013) "Prosocial behavior and environmental action," Oxford Handbooks Online [Preprint]. Available at: <https://doi.org/10.1093/oxfordhb/9780195399813.013.011>.

Sailer, M. et al. (2017) "How gamification motivates: An experimental study of the effects of specific game design elements on psychological need satisfaction," Computers in Human Behavior, 69, pp. 371–380. Available at: <https://doi.org/10.1016/j.chb.2016.12.033>.

Schwenkenbecher, A. (2014) "Is there an obligation to reduce one's individual carbon footprint?," Critical Review of International Social and Political Philosophy, 17(2), pp. 168–188. Available at: <https://doi.org/10.1080/13698230.2012.692984>.

Xi, N. and Hamari, J. (2019) "Does gamification satisfy needs? A study on the relationship between gamification features and intrinsic need satisfaction," International Journal of Information Management, 46, pp. 210–221. Available at: <https://doi.org/10.1016/j.ijinfomgt.2018.12.002>.