# **Conclusion (2,004 words)**

This chapter addresses the limitations of the study, the challenges faced, and areas for future work. Additionally, within this chapter the author reflects on his overall experience of this project, divulging what he has learned, is proud of, found challenging and what his favourite part was.

## **Future Work**

Several areas exist for future work to further develop this application, areas which were not implemented due to time constraints of the project. The features considered to add the most value were prioritised, with the following features dedicated to future work.

**Sign up functionality**

The author excluded functionality to sign up for an account because when a new user signs up, they would need to select, be placed in, or create a new team. Having a new user join an existing team risks disrupting the team dynamics, and adding complexities to how the team leaderboard would operate. Having the ability to sign up and create or select a team would satisfy the psychological need of autonomy, where the user feels in control, however, as outlined in the literature review, achievement and social gamification features have been proven to be extremely effective at satisfying the psychological need of autonomy. With the time constraints of this project, the author ultimately decided sign up functionality to be an area for future work. The insights from the literature review highlighted that providing an environment to compete in, both individually and in teams, was the crucial aspect to satisfying the psychological needs of autonomy, competence and relatedness as outlined by the self-determination theory. How these teams are created is far less important, and as such, the sign up functionality was deferred.

**Ability to edit or delete an emission log for the current day**

A definite area for future work is to facilitate editing or deleting an emission log for the current day. Logs for previous days should not be able to be edited or deleted as this would facilitate cheating to beat competitors. However, if a user makes a mistake when logging an emission for the current day, the option to edit or delete this log would improve accuracy of the leaderboard. Technically this would not reduce the likelihood of errors since the error of entering incorrect data has already occurred, it would merely fix the error. Since the design chapter in chapter two focused on limiting the occurrence of errors as opposed to resolving realised errors, editing and deleting logs was not prioritised. Additionally, the confirmation button users are presented with after attempting to log an emission should be sufficient to prevent this error from occurring.

**Ability to quick add an emission log, such as your daily commute to work or your daily bowl of porridge for breakfast**

As discussed in chapter two on design, speeding up frequent tasks is an important feature for improving user experience with applications. To further speed up the frequent task of logging an emission, the application could provide the user with a “quick add” option, where they add a log they have previously logged. This would be particularly useful for users who eat the same breakfast every day or who have the same commute to and from work every day.

**Ability to create a team**

To facilitate cooperation and competition through teams, users are assigned to pre-selected teams of 2. The reason for this was simply due to time constraints of the project. The act of competing was prioritised for this application since it addresses all the psychological user needs of autonomy, competence and relatedness. The ability to create a team may add more enjoyment for the users, but this was not as high a level of priority as the ability to compete.

**Ability to join a team**

Similarly to creating a team, the ability to select a team to join is an area for future work. The same justification applies to both of these areas for future work, where the facilitation of competing was prioritised to address the psychological user needs of autonomy, competence and relatedness.

**Adding QR code scanner for logging food emissions**

Adding a QR code scanner for logging food emissions is another feature which could be added to speed up the frequent task of logging food emissions. This feature would also reduce complexity for users in determining the portion size they have consumed.

**Improve accuracy of the emissions from food and transport activities**

As previously discussed, sourcing data for Irish emissions on specific activities proved difficult, leading to substituting with UK emissions data. As previously mentioned in section 2.1 on carbon footprints in the literature review, Mulrow J. et al (2019) highlights how existing carbon footprint calculators provide different results, where carbon footprint calculators lack standardisation. This emphasises that it is difficult to get an exact calculation, and as the literature review also mentions, Mulrow J. et al (2019) illustrates how there is a speed-accuracy trade-off, where the most accurate calculators include all carbon contributing activities. Depending on the target audience for the application, this application could focus on adding more types of emission logs in addition to food and transport logs to increase accuracy.

**Provide alternative scoring systems**

The current scoring system resembles the Irish tax bracket system, whereby when a user’s total carbon footprint falls between a certain range, or bracket, they receive a certain score. When they move to a lower bracket they receive a higher score, and when they move to a higher bracket, they receive a lower score. An area for future work for this application could be to provide alternative scoring systems, such as match play. Where users can compete one on one, or head to head, where the winner each day earns 3 points, the loser 0 points and if a draw both users get 1 point.

Although these features were not implemented due to time constraints and prioritisation of the most value adding features, the author is satisfied that the overall goal for this app of providing a gamified, social mobile app where users can compete against others through their carbon footprint scores, has been accomplished and delivered effectively.

## **Limitations of the Study**

Time constraints proved to be the most limiting factor of this project. To overcome this inevitable limitation, the author began to plan the workload early and reassess the plan against the progress made after each fortnight. A tremendous aid in accommodating for the time constraints presented by this project was to incorporate slippage into the plan of work, whereby if the author estimated a piece of work would take, for example, 10 days, to shield himself against the ramifications of missed deadlines, he added an additional 2 days to the estimation to make it 12 days, catering for running into any unforeseen circumstances. Additionally, having identified the different deliveries for the project and their dependencies, the author was able to plan what work to do while waiting for aspects such as responses from participant questionnaires or collecting data from users. While waiting for this collection of data, the author focused on writing the documentation for this report.

Sourcing data on Irish carbon footprint emissions for specific activities proved to be a limitation of the study. To address this limitation, where Irish data was not available, the author collected data from the UK government, the closest substitute to Irish data.

Another limitation of this project was the lack of financial aid. However, this was a very small limitation, only surfacing in one instance where the author had planned on using Firebase’s Cloud functions to automatically generate carbon footprint scores for a user for the previous day at 00:01. These cloud functions were historically free for users, but Firebase decided to update their pricing plan and these cloud functions must now be paid for. To overcome this limitation, the author applied his creativity to check if the database contained a score for the previous day when the user signs in, and if no score exists then the scores are generated, and if a score does exist, the loop exists and proceeds as normal.

## **Reflection**

This section reflects on the project as a whole, discussing what the author learned, is proud of, found challenging, and his favourite part.

### **What the author learned**

Throughout this process, the author has developed a multitude of new skills, as well as improving existing skills. These new learnings consist of a plethora of new software skills such as front-end mobile app development using React Native, as well as creating and connecting a Firebase database to the front end of the mobile application.

Additionally, the author has enhanced his academic writing skills, demanding the ability to develop coherent thoughts, structure content accordingly and to plan the overall delivery of the thesis as a whole, taking other commitments into consideration.

### **Proud of**

What the author was most proud of, was his ability to connect and integrate learnings from his four years in college into 1 large capstone. Prior to this project, the author felt his skills in database design, user interface design and user experience design were all fragmented, having only experienced these fields in separate, one dimensional projects. Having built this gamified social mobile app, the author has gained an understanding and experience with regards to connecting the different aspects needed for a comprehensive mobile application.

Additionally, this was the author’s first time using Firebase, providing the author with great pride in his delivery of a successful database integration. The author had previously studied best practices for designing databases, but had never connected an application to an online database.

### **Found Challenging**

By far, the most challenging aspect the author experienced was sourcing data for carbon dioxide emissions for specific activities. The application developed for this project focused on Irish emissions data, however, when Irish emissions data was difficult to source, the author had to find not only an alternative source, but an appropriate substitute for Irish emissions. To overcome this challenge, the author researched UK emissions and was relieved to find the UK government provides emissions for transport activities. While Irish emissions focus on the country as a whole and emissions from a full sector such as transport, UK emissions data provide insights into the emissions for different car sizes, fuel types and distance travelled. Although sourcing emissions proved challenging, overcoming this obstacle produced a great level of achievement, accomplishment and satisfaction to the author.

### **Favourite Part**

Being a computer science and business student, the author has tremendous experience in developing code for applications to solve various problems. Where the author had limited experience prior to this project was surrounding the importance of why an application should be developed. Having undertaken extensive research for the literature review, and the project as a whole, the author gained an appreciation for establishing what value, purpose and impact developing an application can have, and that in order for the developed application to be meaningful, it must provide a foundational value, purpose or impact to its users. From building this application, the author observed that having established the purpose and value that would be delivered by the completed application proved to be a great, sustained motivation throughout this project, adding to the author’s overall enjoyment of this experience.

## **Final Conclusion**

Overall, the author is satisfied that the goals and objectives of this project to gamify carbon footprints to motivate pro-environmental behavioural change have been delivered based on the results and data collected, which is discussed in chapter 5 on evaluation. Having undertaken extensive research in the areas of carbon footprints, behavioural psychology and gamification for the literature review, investigated an effective design for the gamified, social mobile application, implemented this application and conducted evaluation through questionnaires and analysing users’ carbon footprint scores over time, all within the limited time constraints of this project, the author takes immense pride in what he has accomplished with this project. Additionally, the author takes great pride in having contributed to the global need to reduce the knowledge action gap towards reducing individual carbon footprints.