What impact does online learning have on carbon emissions and mental health compared to classroom learning at the University of Canterbury?

Emma Le Goff, Tomasz Heeney, Lupepe Saofai, Nellie Evison, Roisin Cassidy.

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Executive Summary

The University of Canterbury aims to be carbon neutral by 2030 through the use of biomass and the removal of coal burners by the end of 2022. As revealed in our research, heating is the most consumptive form of energy production. Research conducted post-pandemic also shows a general preference for working from home, proving it to boost productivity and mental health factors.

This research was conducted using the opinions and habits of a GEOG106 class at the University of Canterbury obtained through a survey distributed amongst the class. The survey examined their viewpoints regarding online learning and observed their methods of transport and carbon producing behaviours.

Our research has highlighted that GEOG106 students find their productivity and general sense of wellbeing to increase when on campus, and revealed that the habits of GEOG106 students align with typically environmentally friendly carbon practices. Our recommendations include looking towards blended learning, namely the incorporation of both online learning and on-campus learning, and greater student involvement in consultation and decision-making regarding carbon practices.

1. Introduction

The sudden global Covid-19 crisis which occurred in 2020 forced and imposed many changes on individuals, having significant impact on many areas of our lives including education. The impact of online and in classroom learning on carbon emissions and mental health recognised the need for positive change and promote sustainable practices within the University of Canterbury and wider community. The University of Canterbury is intending on becoming net carbon neutral by 2030, switching to biomass as a heating fuel. Considering the carbon emissions produced from university teaching, our research project looks at reviewing different source of carbon emissions from university operations. These areas include transport, power, and internet.

In addition to this, we also consider mental health as an important part of learning at UC. While seeking to become carbon net neutral by 2030 is important in reducing greenhouse gas emissions, we need to ensure that the changes we implement do not affect students' mental wellbeing. Throughout this research we aimed at calculating various emissions and investigate which form of learning produces fewer emissions; in classroom learning vs online learning. To help deliver UC's sustainability goals, our research project could potentially help in raising awareness on the impact of emissions produced from UC operations, and the mental health status of students. This project was conducted alongside the University of Canterbury's Sustainability Office who is our community partner.

2. Literature Review

2.1. Transport

Literature suggests transport is among the highest contributors to university greenhouse gas (GHG) emissions (Clabeaux et al, 2020; Ozawa-Meida et al, 2011; Talkhestan et al, 2013). However, contrasting opinions exist regarding whether its inclusion to a universities carbon footprint is valid, as it is an indirect emission that is out of the University's control (Garcia-Alaminos et al, 2022). Anthony Sellin (2022), UC's energy manager, explains in an interview that he holds this perspective. In their carbon footprint assessment of Clemson University, South Carolina, Clabeaux et al (2020) found automotive commuting to be the second largest contributor to the universities GHG emissions, following electricity generation. These factors contribute 18% and 36% to the universities carbon footprint respectively. However, the contribution these factors have to UC's carbon footprint will vary due to differences in transport behaviour and use of renewable energy sources.

According to the UC travel survey (UC Sustainability Office, 2020), 55% of students usually use active or public modes of transport. However, a gradual negative trend of cycling has been observed since 2008. Additionally, both walking and bussing have seen their first increases since 2000 and 2008 respectively. As this research is a case study of GEOG106, it was hypothesized that they would show a greater use of active transport than an assessment on the older total UC student population. This is largely due to a higher proportion of participants in this sample living in student accommodation. Observed increases in active and public modes of transport suggest UC transport behaviour is trending in a positive direction. However, the UC Transport Advisory Panel (2016) identify the persistent high use of private motor vehicles as a key issue.

2.2. Devices

According to research on device emissions, carbon emissions produced from laptops is significant (Corless, 2021). From its manufacturing process to transportation, as well as the first four years of the use device, it is estimated that one laptop approximately produces 422.5kg of carbon emissions. Considering the number of students enrolled at the University of Canterbury, 20,919 as of 2021, if every person owned a laptop device, UCs carbon footprint from laptops alone would be around 8,838,277.5kg. Since UC is seeking to become carbon neutral by 2030, it is important to recognise that the resources used for our learning contribute much to UC carbon footprint. In addition to this, energy consumption such as electricity use of device is not included in this estimate, making it a more important factor to consider when looking at UC's overall carbon emissions. Literature review suggests that being more aware of the size of the carbon footprint an individual produces from the use of devices can help promote positive changes in reducing and reversing carbon dioxide. Prototypes including Direct Air Capture (to extract CO2) and Green Algorithms allow users to measure their own computer carbon footprint.

2.3. Power

Literature illustrates how energy consumption including electricity, heating and gas contribute the most to worldwide university carbon footprints, with more than 70% of contributions originating from Ireland, Australia and the USA. When translated to CO2 emissions per capita, the USA and Australia are still the two largest contributors (Helmers et al, 2021). These statistics also demonstrate little correlation between geographical location and total power consumption, alluding to the fact that carbon emissions produced by the usage of power, particularly heating, are down to processes and strategies tertiary institutions have in place to reduce their own carbon footprints.

The University of Canterbury's strategic objective to become carbon net neutral by 2030 is largely reliant on the switch from coal to biomass as a heating source. This biomass, inclusive of woodchips and pellets will reduce the amount of carbon dioxide as a greenhouse gas by approximately 80%, and will eventually run off an entirely renewable recourse scheme. A tree planting programme owned and operated by UC will support the new heating approach (University of Canterbury, n.d.). Tony Sellin (2022) remarks how UC is the most advanced university in the Southern Hemisphere in terms of its trailblazing carbon emission offsets, and will continue to lead significant processes for years to come.

2.4. Learning efficiency and stress

Studying at home is strongly correlated with higher levels of stress in students, according to a review of the literature on learning effectiveness and stress. The literature review was based on earlier research conducted during the pandemic, which may have also been a factor contributing to the students' elevated levels of stress (Rajab et al., 2020). Further examination of literature on learning effectiveness revealed that students who were enrolled in an online university retained 20% less of the lecture on average than those students who took it in a classroom context (James et al., 2016). However, there appeared to be no difference in grades between the students who took online courses and those who took them in a traditional classroom, making this factor of overall final grades insignificant in attempts to evaluate the learning effectiveness of online learning (Alghazo, 2015).

2.5. Separation of Work and Home

Recent studies have shown that a blurring of boundaries between work and one's life impacts their ability to work effectively (Galanti et al. 2021). Additionally, it was found that work hours significantly increased where boundaries were not clearly in place (Baudot & Kelly, 2020). A subjective measurement of productivity was used by Baudot & Kelly (2020), which will be employed as a form of measurement in the survey of the GEOG106 class. In the form of perceived productivity, the GEOG106 survey will gain an understanding of how effective students perceive themselves to be when studying at home. A university-based study relates the use of remote learning and study within scientific disciplines at universities with lower quality work due to the lack of close supervision and mentoring (Hunter, 2019).

3. Methods

Data contributing to the carbon emissions and education related wellbeing assessment of GEOG106 was collected using a survey distributed to class participants through their course LEARN page. Insights into student power use and transport behaviour were gathered as literature suggests these factors tend to contribute the most to carbon emissions. This report *additionally* assesses the effect online learning has on student wellbeing and learning efficiency compared to classroom learning. With consideration of both emissions and student wellbeing factors, suitable climate mitigation strategies can be recommended.

Closed ended questions were used in this report to provide easily interpretable data that could be exported to Microsoft Excel to aid with calculations and analysis. Two question formats, multiple choice and Likert scale, were implemented for questions relating to carbon emissions, and wellbeing and learning efficiency respectively. Likert scale questions were represented from 1-5, with strongly disagree and strongly agree at either end. All primary data used in this report was collected from GEOG106 with secondary sources then being used to compliment these findings.

3.1. Analysis – Transport Calculations

Students who selected driving as their main mode of transport *additionally* provided details of their vehicle class: Small, Medium, Large, Diesel, Hybrid, or Electric. From this information, an average fuel economy *for each class* was calculated from five common vehicles within each class sold in New Zealand (EPA, n.d.). Data was gathered from vehicles produced near 2008 as this is the average age New Zealand's car fleet (Ministry of Transport, 2021). Using the fuel economy data, a carbon emissions factor of 2.3 Kg Co2/L of unleaded petrol was than applied to each vehicle class, and subsequently student travel, per kilometre (NTC, 2019). A carbon emissions factor of 0.122kg/km, as used by Davison et al (2015), was applied to students who selected bussing as their main mode of transport.

In this analysis, students who selected active modes of transport, including walking or cycling, were carbon neutral. Although some literature suggests there is an associated carbon cost with these transport modes, the impact is minimal, and it requires many assumptions regarding the participants lifestyle choices (Walsh et al, 2008). Thus, its exclusion from this report is justified.

The final transport related carbon emissions figure was calculated by multiplying the following variables: Vehicle carbon emissions factor, frequency of travel to UC per week, distance travelled to UC x2 (accounting for a return trip), and x24 which considers each week of the University year. As the survey received 42 responses from a total class population of 245, the transport emissions figure of 1,879.05 calculated from the sample has a weight of 5.83. This results in a final figure of 10,955.29 kilograms of carbon dioxide produced from GEOG106 students' yearly university related travel.

3.2. Analysis – Device Calculations

To calculate emissions associated with the use of devices, participants were questioned on the frequency at which they replaced university related devices, the number of students who bring devices to university for lecture notes, and the time spent on computers at UC. We then calculated the average carbon foot-print of a laptop at 422.5kgs, using circular computing, by the number of the students who responded to our survey from Geog106 who said yes to owning a device. 35x 422.5=14,787.5kgs.

To calculate the final emissions for the whole class we multiplied the average carbon foot-print of a laptop by the number of people that own devices which gave us 14,787.5. We then calculated this by 5.833 which is the proportion that have laptops out of the whole class. This then gave us a final figure of 86,190kgs for Geog106 (14,787.5 x 83.3% = 204 x245 =86,190kg). This number will most likely remain for the next 3 years.

4. Results

4.1. Power

Students of the GEOG106 class were given a question regarding their at home heating behaviours during winter months. We chose to distribute five answer options to accurately assess each participants' heating uses without causing survey fatigue or focusing on unnecessary areas of research. Our options were as follows; never, up to 2 hours, up to 4 hours, up to 6 hours and over 6 hours. We have collectively decided that answers over 6 hours can indicate any amount of time between 6 and 12 hours of heating use per day in winter months. When calculating emissions based on answers given for over 6 hours, we will output a range representative of 6 to 12 hours.

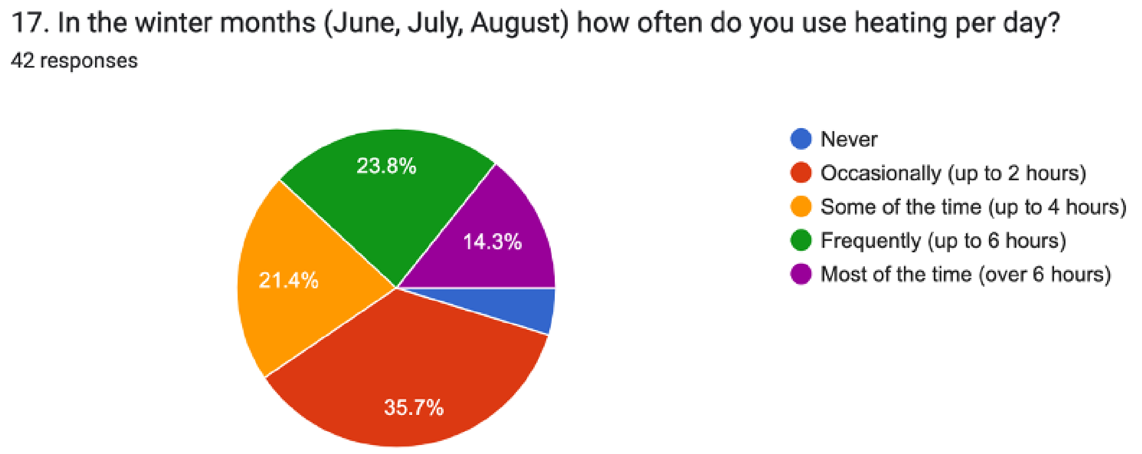


Figure 1. Proportion of Students Using Heating in Winter Months

Of the 245 students enrolled in GEOG106, 17% took part in our class survey. Data pertaining to the calculations of students' heating behaviours have been collected through 42 individual student participants. As illustrated by *Figure 1* only two participants never use heating at home in winter months (4.8%). When generalized towards the entire class of 245, only 11-12 students never use heating at home (11.6).

The largest proportion of students who participated in the survey use up to 2 hours of heating/day during the winter months (35.7%). These 15 students would represent 87-88 students in a representation of the entire class. Interestingly, the second largest proportion of time spent heating houses each day in the winter was represented by almost one quarter of participants (23.8%). Being up to 6 hours of heating, 10 students answered with this option. This translates to roughly 58 students within the entire GEOG106 cohort (58.3). Following closely are students who use up to 4 hours of heating each day (21.4%) and we estimate this time frame to be heating usage between 2 and 4 hours. 14.3% of participants claim to use over 6 hours of heating each day, which when applied to the entire class would indicate a total of 35 students (35.035). Each of these results show that students opt to using heating in their homes more than they would choose not to.

4.2. Learning efficiency and stress

The results obtained from the GEOG106 class based on mental wellbeing and stress showed that a strong majority of students felt a higher level of stress doing online university. The mental wellbeing of students also showed to be lower when studying online. This is shown by 66.7% of students that felt a strong sense of well-being studying on campus over online learning, with 23.8% of students feeling neutral about the question. This finding demonstrates that students prefer to study on campus.

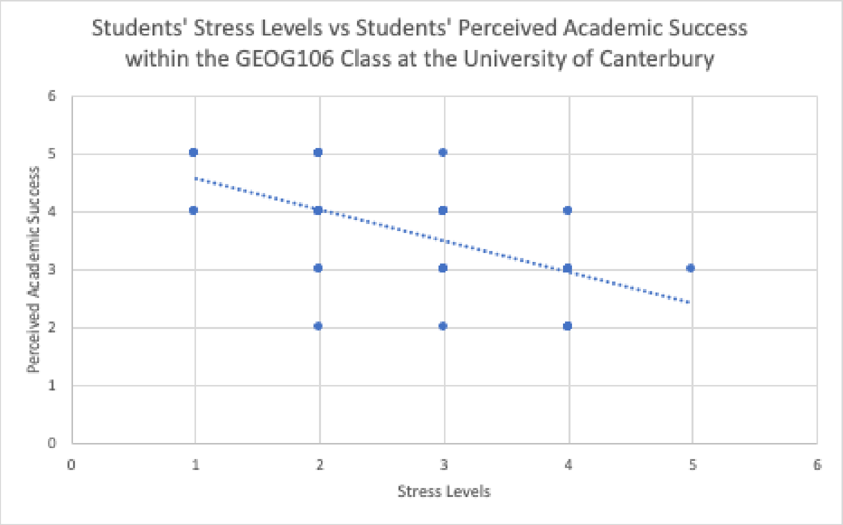


Figure 2. Students Stress Levels vs Students Perceived Academic Success

61.9% of students achieve greater success doing university on campus compared to online, and, as shown in *Figure 2,* there appears to be a negative correlation between stress and perceived academic success. This demonstrates that when students experience high levels of stress of stress, their perceived academic stress decreases.

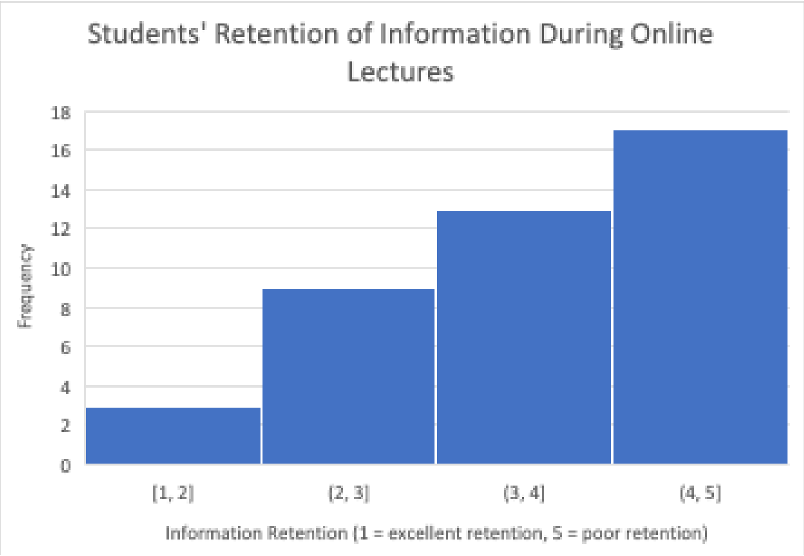


Figure 3. Students Retention of Information During Online Lectures

From the bar graph shown in *Figure 3* , the responses of the students are negatively skewed, which shows that 71.5% in GEOG106 strongly believe that they retain more of a lecture when in person in comparison to watching it online.

5. Discussion

5.1. Transport

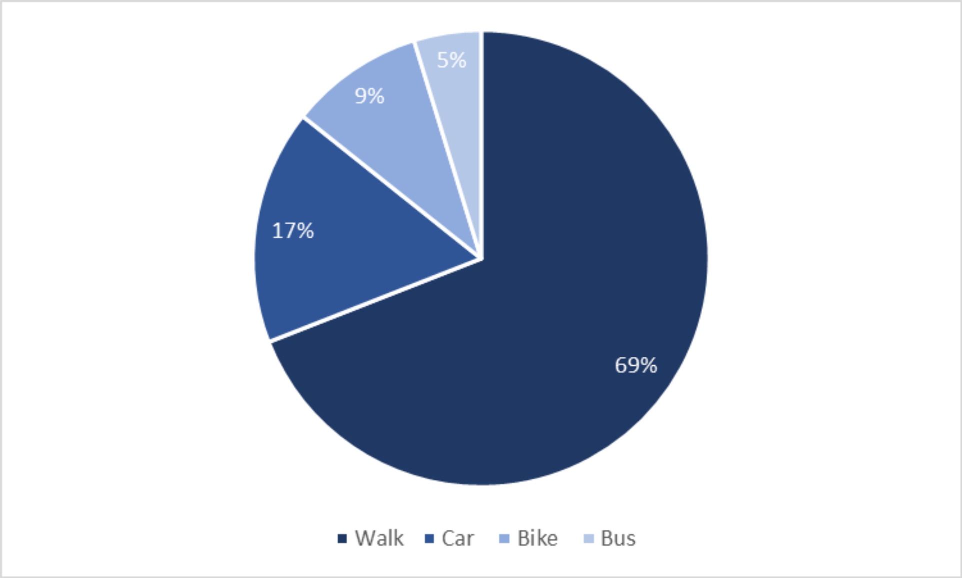
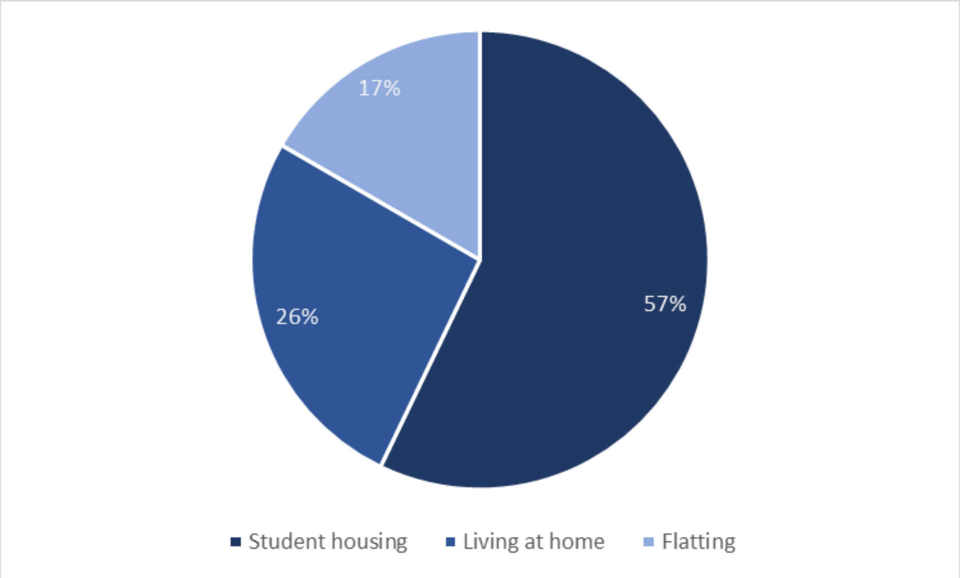


***Figure 4.* Pie Chart of GEOG106 Student's Mode of Transport**

A recurring theme observed in the literature is that transport related emissions are among the highest contributors to a university's carbon footprint. Our results show this may still be true for GEOG106, but to a smaller degree. *Figure 4* shows 78% of students use active transport as their primary mode to UC campus. This is significantly higher than the 45.53% figure found by the 2020 UC travel survey (UC Sustainability Office, 2020) which assessed the total UC student population. The high use of active transport in GEOG106 can be largely attributed to the proximity of student accommodation, where 57.1% of students have identified they live, as shown in Figure 2. Most of these students will move into flats for the following years of their tuition which has a high likelihood of reducing active transport use as many students travel further to UC. Therefore, on a wider scale the data gathered for this report is best used to understand the transport trends of 100 level courses only.

Figure 5. Pie Chart of GEOG106 Students' Housing Situation



Interestingly, 86% of the students who drive to UC travel a distance of at least 5km each way. Beyond this distance, driving is a valid option as many would perceive this to be too far to use active transport. Bussing would be a suitable alternative at this distance; however, the 2020 UC travel survey identifies lack of connections to UC as a key barrier preventing the use of this service. Mitigation strategies that promote a change in transport mode would therefore be of very low impact as there is an existing high penetration of a climate positive behaviour in GEOG106. This suggests the yearly transport carbon emissions figure of 10,955.29 kg of CO_2 is relatively low considering the class population of 245 students.

5.2. Devices

Device emissions from both online learning and in classroom learning contribute much of UC's emissions. To calculate the GEOG106 devices carbon footprint, the sample of 42 people who responded to our survey produce approximately 14,787.5kg. To get a representation of the whole class we divided the number of students in class by the number of survey responses. Applying this to the total population of the class, carbon emissions from GEOG106 came to 86,190 kg. Although this was an overall estimation of GEOG106 device carbon footprint we need to ensure that we spread out the time students use their devices for to get more of an accurate number. In addition to this, more questions needed to be asked on the type of device used. We assumed that every GEOG106 student uses a laptop. However, this might not be the case as some may choose to use iPads, tablets, and other forms of device to take notes for lectures. We also recognised that out of the 42 responses received, almost 75% of them only tend to change devices when required to with most of them using their laptops for 3 plus years. This indicates the carbon foot-print for GEOG106 will remain the same for the next 3 years. Taking this into consideration, it is important to recognise that this current estimate will change after this period.

5.3. Power

When calculating total energy/power consumption for each answer given, we have determined the median number of hours for each answer, and used this for our calculations.

This is to account for each answers' two-hour variance, and allows us to address the most accurate power summary for each time period. For students who gauged their daily heating time as 6 hours or more, we have calculated both a figure for 6 hours of use and 12 hours of use to account for participants who may use home heating for up to 12 hours (or all typical daylight hours). The total CO2e emissions for the following calculations will therefore range between 1 hour and 6-12 hours for consistency.

Considering our survey did not specify a particular heating source (eg, heat pump, oil heater, heating fan etc), our calculations have been based off an average emission estimate from New Zealand's most common type of space heating, the high wall unit heat pump (Ltd, 2022). Using a heat pump kW output calculator ("Calculator," n.d.) for both average living room heat pump emissions and average university hall/dorm bedrooms, we have calculated a range of CO2e emissions for at home heating. Excluding those who opted for never using at home heating, average living room CO2e emissions found students use between 8.6kW (1 hour) and 51.5kW-103.2kW (6-12 hours) each day. These power outputs translate to an expenditure between 412.8g (1 hour) and 2476.8g - 4953.6g (6-12 hours) of CO2e per day. Figures were calculated using the average 48g of CO2 produced per kWh in NZ (*NZ Electricity Emissions*, n.d.).

We also created a more specific calculation based on the fact 57.1% of survey participants reside in university halls, therefore having their own bedroom with individual heat sources. Producing between 1.4kW and 8.4kW-16.8kW of power for our survey answer options, the total CO2e emission production is thought to be between 67.2g and 403.2g - 806.4g (based on a smaller 1.4kW heat pump appropriate for a smaller room ("Calculator," n.d.)).

Based on our survey results, it's found that majority of participants generate either 67.2g of CO2e or 412.8g (dependant on room and heat pump size) each day. Considering over half of our participants are in halls with access to their own heating source, the at home statistic for total CO2e emissions produced by heat pumps is likely to resemble a number much closer to 67.2g.

This results to much less than the daily CO2e emissions produced per student using UC heating, which equates to 1.47kg each day (1470g) (*Energy | Life at UC*, n.d.). This figure is a daily breakdown based on 2021 figures, which illustrate UC's CO2e coal heating production of 11,250 Tonnes with 20,919 enrolled students (11250/20919).

5.4 Student academic success and mental health

Literature suggests that where there is a physical separation between one's workspace and their living area boosts productivity. However, one point to recognise is that the majority of the literature collected on this issue pertains to research undertaken during and directly following the period of isolation associated with the COVID-19 pandemic. This may have a direct influence on one's perception of working from home, due to a shift in normalised workspaces and habits.

The GEOG106 class recorded that stress levels were greater when undertaking remote learning practices. Thereafter, if the university decided to move primarily online, then stress reduction methods would be a paramount area of research. The primary sources of stress identified in the literature reviews included feelings of isolation and loneliness among classmates as well as an increased workload brought on by navigating new technologies. These factors were the main causes of why online learning was perceived as being more stressful (Destinations, 2020). By giving the GEOG106 class an accessible platform to connect with other students, and providing the tools they need to complete their university work online, this transition to online university can be managed and stress levels won't rise.

Retention rates of GEOG106 were also perceived to be much lower when watching lectures online, with many students finding that coming into class allowed them to retain a lot more of the lecture content. Lower retention rates are largely due to the increased levels of distraction that come with watching lectures, where social media, texting, and other environmental factors can divert attention. However, all these factors can be reduced through the creation of better study environments, such as switching off devices, when watching a lecture online.

A factor that is emulated in our study is the difference between productivity impacts in relation to working from home compared to studying from home. Most studies in relation to remote work found there to be an increase in productivity upon the introduction of more flexible working conditions, while the integral study in relation to remote learning found there to be a significant decrease in the quality of student's grades (Hunter, 2019). Where students are remotely learning, especially those in more practical degrees such as Geography, there is a significant disconnect between the student's learning and the ability to gain individual assistance from tutors or lecturers. This may, in fact, be an outcome of blended learning, due to resources being shared between those opting to learn in person and those choosing to study remotely. It may be the case that where one form of learning is prioritised, the resources are shifted to accommodate. Therefore, if it is decided that the GEOG106 class be moved entirely online, the resources for communication between tutors, lecturers and students will be focused in one area, potentially increasing the effectiveness and quality of communication and academic assistance for students.

The GEOG106 class lives primarily in halls. Many of the University of Canterbury's student housing contain study centres that are entirely separate from the students' bedrooms (Accommodation Services, n.d.). The ability to create a mental barrier between one's study and living spaces can result in increased productivity. However, contrary to this fact, the general consensus among the GEOG106 students was that they felt as though they were more productive on campus. This trend may indicate a shift in attitudes toward remote learning, where students are understanding the value of in person learning following a period of forced isolation, where resources weren't readily available.

6. Conclusions

Overall, GEOG106 students exhibit travel and electricity consumption behaviours in line with practices that would be considered 'environmentally conscious' behaviours. Additionally, despite persistent research stating that productivity increased with remote work, the sample found the students perceived their work ethic to improve, along with their mental health state, while on campus

A central recommendation given the findings of the GEOG106 survey is an investigation into the prospects of formalised blended learning. The formalisation of blending learning would attribute itself to the investment of funds into resources that can directly benefit those choosing to learn online, such as accessible lab programs. As mentioned previously, a potential risk with this recommendation is the uneven distribution of resources between online and on-campus learning, as to not provide adequate funding and resources for either option. Alternatively, where funding is prioritised for one form of learning, some students may be disadvantaged by a lack of resources in their chosen method of learning.

An advantage of the formalisation of blended learning is providing for flexible learning arrangements for students with other commitments such as work, family commitments and extra-curricular activities. Where students are able to choose when and how they work, they can make time for other commitments, as well as activities that benefit their mental and physical health.

Another recommendation is to further the incorporation of student voices into decision-making spaces. Currently, the University of Canterbury Sustainability Office has two UCSA representatives on their Sustainability Committee and a single student representative on their Sustainability Programme Board (Sustainability Officer, n.d.). A central concern is that a single student is unlikely to be entirely representative of the student population and may not give the insights required to make holistic decisions regarding sustainability practices and how it impacts all students. A remedy for this could be a student-run sustainability committee, within which a student representative corresponds with the sustainability office on behalf of the student body. This recommendation may help to incorporate more inclusive decision making through increased consultation and discussion with students regarding their needs.

7. Acknowledgments

We would like to acknowledge the help of our two community partners Deirdre Hart and Emily Arthur, as well as our tutor Koen Faber.

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