6F6Z3101 – Geography Dissertation

UNDERSTANDING THE CARBON LITERATE INDIVIDUAL, TO ASSESS THE LONGER-TERM IMPACTS OF CARBON LITERACY TRAINING

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DECLARATION OF ORIGINALITY

This is to certify that the work is entirely my own and not of any other person, unless explicitly acknowledged (including citation of published and unpublished sources). The work has not previously been submitted in any form to the Manchester Metropolitan University or to any other institution for assessment or for any other purposes.

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ABSTRACT

Climate Change is a global issue that must be solved using multiple strategies. Pro-Environmental Behaviour (PEB) is an essential part of tackling the crisis, and Climate Change Education (CCE) can be used as a way to trigger this widely. Behaviour change models, which are studied in multiple psychological fields, can be used in CCE to enhance PEB. This report investigates one such CCE initiative, Carbon Literacy training, to determine how the application of some of these models impacts the likelihood of participants having increased levels of PEB. A survey was conducted on a sample of the population who had received Carbon Literacy training, and on those who had not. They answered questions about their attitudes, beliefs and values surrounding climate change. The responses were analysed using descriptive statistics and non-parametric tests. Significant differences were found between the attitudes and beliefs of the two groups, which suggested that the sample who had completed Carbon Literacy were more likely to engage in PEB. The study provides a strong rationale for further research into the impacts of Carbon Literacy training on longer-term behaviour change, which can be measured through the actions of Carbon Literate individuals.

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1 INTRODUCTION

1.1 Climate change

Climate change (CC) is a complex issue, scientifically agreed to be caused by human activity, that is accelerating the rate at which Greenhouse Gases (GHGs) enter the atmosphere. Some impacts of climate change (IPCC, 2022) include disrupted food systems, more frequent extreme weather such as droughts and floods, and biodiversity loss. These impact human populations, with the most vulnerable being affected disproportionally to those responsible for the majority of carbon emissions (Porter et al, 2020). The International Panel on Climate Change (IPCC) reports that if serious action is not taken to mitigate and adapt to climate change, many parts of the earth will be uninhabitable for humans.

1.2 Pro-environmental behaviour

Pro-environmental behaviour (PEB) is broadly defined as actions that one undertakes, both consciously and unconsciously, to minimise their negative impacts on the natural and built environment (Jensen, 2002). Examples of PEB include reducing food waste (Graham-Rowe et al, 2019), cleaning beaches through litter-picking and reducing the use of a person's personal vehicle. In the context of this study, the PEBs of interest relate to climate action and the reduction of carbon dioxide equivalent (CO2e) emissions, that contribute directly to climate change (Whitmarsh et al, 2021).

Research on the predictors of pro-environmental behaviour is increasingly varied and subjective, due to the complex interacting factors that influence individuals' ability to

change their behaviour, and/or adopt new behaviours to reduce personal environmental impact and carbon footprint (Jensen, 2002).

1.3 Climate change education

Climate change education (CCE) is a method of teaching people about the issue of climate change, and often encourages pro-environmental behaviour change that reduces the negative impacts of climate change. It has been used in many forms as a way to increase awareness, equip people with the knowledge to mitigate and adapt to climate change, and as a way of embedding climate-positive action into people's day-to-day lives and jobs (Cordero et al, 2020).

Monroe et al (2017) conducted a review of different methods of climate change education initiatives which evaluated the increasing wealth of published evidence on the types of CCE being used globally. The main methods found were used in educational institutions, such as schools and universities, highlighting the comparative lack of climate change education beyond the classroom. This must change in order to meet the 13th United Nations Sustainable Development Goal to combat climate change through the sub-goal to 'Improve education, awareness raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning' (United Nations, 2015).

Successful CCE interventions included those that went beyond the science of climate change alone, and into the relevance of climate change to the learners, engaged with scientists and the scientific process, climate 'myth-busting' and the group-led design of practical solutions.

A Climate Change Education intervention that wasn't included in this review, was 'Carbon Literacy' training - a flexible participant-tailored training initiative that is

accredited by the organisational body, ‘The Carbon Literacy Project’ (CLP). Evaluating the effectiveness of this scheme will be the main focus of the report.

1.4 Carbon Literacy

Carbon Literacy (CL) training is designed for ‘those that live, work and study’ (The Carbon Literacy Trust, 2022). This indicates that the training can be adapted to fit a wide range of settings, such as the home, workplace or educational institute, so that everyone theoretically has the opportunity to learn about climate change.

The registered charity, ‘The Carbon Literacy Project’ (CLP), provides a framework, namely the ‘CL Standard’, for the creation of training that comprises a day’s worth of relevant, engaging learning about climate change. The Carbon Literacy Standard is the framework for which all accredited Carbon Literacy courses are based upon. It was developed by a working group to theoretically facilitate the environmental education of every citizen in the UK, aiming to create a ‘low-carbon culture change’ through people's behaviour changes at an individual and organisational level towards carbon-reducing lifestyles. Whatever the context of the training, the course can only be accredited once it meets the requirements of the Standard. The criteria is set out in the ‘criteria-checker form’, which includes (but is not exhaustive to) ‘local/social learning’, ‘delivery by peers’, and the basics of climate science as elements that must be part of the course.

By the end of the training, participants are asked to complete an evidence form where they pledge to an individual action and a group action which reduces carbon emissions, in the context of their training. For example, a course that has been created for staff members at a museum, would result in the creation of actions that could reduce the emissions of both the staff at the museum, as well as empowering the cohort to collaborate to reduce emissions more widely, within their sphere of influence, within that workplace specifically. This helps to embed carbon reduction into the everyday roles and operations of, in this example, the museum. These evidence forms are assessed by

The CLP themselves, and participants are granted a certificate should they meet the requirements of the CL Standard that deems them ‘Carbon Literate’ (CL). The definition of a ‘Carbon Literate’ individual is somebody who has ‘An awareness of the carbon dioxide costs and impacts of everyday activities, and the ability and motivation to reduce emissions, on an individual, community and organisational basis.’ (The Carbon Literacy Trust, 2022). This study will explore the successful-ness of the Project in achieving its aims, particularly the level of ability and motivation of a Carbon Literate individual to reduce emissions.

The Carbon Literacy Project (CLP) is rapidly expanding, and the number of courses being delivered, hence the number of ‘Carbon Literate’ (The Carbon Literacy Trust, 2022) individuals has increased. In order to validate the effectiveness of the CLP as an environmental education framework, it is useful to observe the changes in individuals post-certification. Because the Carbon Literacy Standard shares elements of Behaviour Change Theory (BCT) found in published psychology journals, the theory can be used to understand the extent to which a CL individual is likely to engage in PEB.

2 LITERATURE REVIEW

This chapter will build upon the topics introduced in the previous chapter, synthesising concepts from the fields of (environmental) educational psychology, pro-environmental behaviour and behaviour change theories with Climate Change Education. The Carbon Literacy Project will be the main CCE initiative discussed in relation to this.

2.1 Behavior change theory

There have been many papers in environmental psychology, environmental education research and global change research, which review methods to encourage pro-environmental behaviour (PEB). The findings are vast, but common theories and concepts are often built upon to explain ideas about why humans may or may not engage in PEB. These include the Individual Social Material model, Theory of Planned Behaviour (TPB) and Percieved Behvaioural Control (PBC)

R.A. Howell (2012) suggests that multiple factors lead to PEB, and that behaviour change is not necessarily prompted by environmental concern alone. They suggest many concepts studied in behaviour change theory, which include attitudes, values, beliefs and internal and external factors/barriers (Kollmuss & Agyeman, 2002) can overlap when predicting PEB.

An example of how elevated concern over the environment might lead to PEB could be someone who suffers from ‘eco-anxiety’, a form of chronic worry about climate change. Verplanken et al (2020) finds that eco-anxiety can either lead to constructive pro-environmental action or in other cases, result in self-detriment and inaction.

2.2 Individual Social Material model

Barriers that can impede an individual's likelihood of action are often complex, but can be explained well under the Individual Social Material (ISM) model of behaviour change theory (Darnton and Horne, 2013). This argues that a person's beliefs, habits, willingness and perceived ability to change their behaviour (e.g. cost factors, time constraints etc.), all impact the extent to which a change of behaviour is realised. External barriers to behaviour change include the proximal social influences of family and friends' beliefs and lifestyles, as well as the value they place on those people's opinions (Cordero et al, 2020). For example, if a group of friends are very used to living in a certain way, and have strong shared beliefs, the individual is more likely to trust those friends, care about what they think of them and feel less inclined to change their lifestyle, if it could lead to social exclusion. In addition to these complex interacting factors, if an individual does decide to change their behaviour, the material part of the model proposes that this can be facilitated or hindered depending on the technology available, the policies in place at the time (e.g. the UK government's plan to phase out the sale of new petrol and diesel cars by 2030 (UK gov) may effect a person's choice to purchase one, or a whole company's decision to change their products).

2.3. Theory of Planed Behaviour (TPB)

One of the most well-established behaviour change theories is the Theory of Planned Behaviour (TPB). Early research defines this as the extent to which the actual event of an individual's behaviour being closely dependent on the intention to act (Azjen, 1991).

The TPB model hasn't gone unchallenged (Sniehotta et al, 2014), and research into behaviour change has used, adapted and developed the theory into other concepts, such as the early recognition of the importance of Perceived Behavioural Control (PBC) in the theory, to predict and explain PEB (Terry & O'Leary, 1995).

Perceived Behavorial Control is the idea that an individual's beliefs about their ability to engage in a behaviour, or reach a goal, is closely related to whether the actual event occurs (Azjen and Madden, 1986). Its importance as a variable of TPB has been tested in studies that found it to be a significant factor in both intention and actual PEB (Hansmann et al, 2020).

Whitmarsh (2021) suggests that the combination TPB with other behaviour change models, like the ones discussed here, can further increase intention to act. An action planned with intention is thought more likely to be realised than having not planned to change this behaviour. That is why TPB, although imperfect, remains widely used as a basis for CCE.

2.3.1 Intention-behaviour gap

The limitations in the use of behaviour change models like TPB, when the determiners of PEB are vast and subjective for each individual circumstance (Howell, 2012), have been recognized in psychological and environmental fields, especially when predicting ethical consumption (Carrington et al, 2010). Carrington et al first conceptualised the 'intention-behaviour gap' to explain why the intention to behave pro-environmentally might not always lead to the action expected in the TPB model. Barriers outside of the model can both increase and decrease expected behaviour-change, as found in a large study by Grimmer and Miles (2017).

2.4 Value Belief-Norm Model

Another behaviour-change theory that can be studied alone, or in conjunction with other models like TPB, to understand pro-environmental behaviour change, is the Value-Belief-Norm (VBN) model (Ates, 2020). This shares elements of the ISM model, and is rooted in the individual context, placing importance and likelihood of behaviours being

heavily dependent on personal values, e.g. how much the individual values the environment, beliefs, e.g. the extent to which they believe that this behaviour can make a difference and have a meaningful contribution to the reduction of emissions. Existing norms for the individual can shape how these values and beliefs manifest in reality, contributing to the psychological ease of action. For example, if an individual believes a certain behaviour will positively impact the environment, and it is close to their existing ways of behaving, they are more likely to adopt that behaviour. This model is often associated with more low-impact, but frequent pro-environmental behaviours (Whitmarsh et al, 2021). Therefore, if the person were to be educated about climate change in a way that encourages them to reconsider their values and beliefs, the change may increase their likelihood of considering more effortful behaviour changes as a 'normal' and necessary action to align with these values (Howell, 2012).

2.4.1 Value-orientations

The widely used Schwartz value survey (1992) has been the base of studies evaluating the impact of value-orientations on pro-environmental behaviour. De Groot & Steg (2007) used the scale to develop a model that grouped values into three categories: biospheric, altruistic and egoistic. Biospheric values related to protecting the environment, closeness with nature; altruistically orientated values related to caring about people, equality and serving others; egoistic values related to valuing the self and serving the individual as a priority. The de Groot and Steg paper indicated that biospheric values were associated with more likelihood of adopting pro-environmental behaviour.

Values have been studied further, establishing links to self-identity perception, with some academics suggesting that values and identity have a stronger influence on PEB than attitudes alone (Gatersleben et al, 2014). Having a 'green identity', has been associated with a biospheric value-orientation, as well as increased engagement in pro-environmental behaviour (Hansmann et al, 2020). Having a 'green' or 'pro-environmental' identity is thought to increase ones intent

to act, as well as perceived behavioural control, within the TPB model (Carfora et al, 2017), which may increase the likelihood of PEB. Another study supported this point too, suggesting that this orientation affected their level of, e.g. recycling, but also strengthened their self-perceived 'green identity', pre-disposing them to make unconscious decisions that were environmentally-constructive (Ates, 2020).

2.4.2 Moving beyond the singular value-orientation view

Climate change education has been studied to assess the effectiveness of the above theories in an educational context. These will be discussed in more detail in section 2.6, but it should be noted that in addition to findings that effective CCE can harness and develop values linked to biospheric orientations, the same has been found for attributes of altruistic values (Franco et al, 2018). For example, Howell has had two published papers, one which concluded that a surveyed sample's motivations for pro-environmental behaviour were linked to helping others and achieving justice, which are both related to altruistic orientations (Howell, 2012).. Interestingly, the second article, which explores the motivations and values of climate change educators, finds that a combination of biospheric and altruistic values supported an individual's motivations to educate others about climate change (Howell and Allen, 2016). This is significant, because it suggests that CCE may strengthen motivations to adopt new pro-environmental behaviours, through appealing to all of these values. In the context of the 2016 study, this evidence is significant because of the content of the Carbon Literacy Standard (The Carbon Literacy Trust, 2018), which ensures it's criteria includes teaching participants how to communicate climate change effectively, so that others can be educated, hence sharing skills with educators like those studied in Howell and Allen's 2016 paper.

2.5 Studies on Carbon Literacy

Thus far, studies into the longer-term impacts of CL training have been conducted in the context of where training initiatives have taken place. For example, on the 'Coronation Street' team (Chapple et al, 2019) and the MMU Carbon Literacy Living lab (Dunk et al, 2017). These studies provide an in-depth review of the low carbon culture change seen on a specific organisational level, and found positive results of large CL initiatives, including:

- Transformational organisational change.
- Greater sense of responsibility of the collective as well as the individual to take action to reduce their carbon footprint.
- Enhanced communication of issues
- Increased overall confidence

The positive outcomes of CL in these settings encourage further investigation into the attitudes towards climate change that could incite PEB after completing the training. Because the training framework can be used in so many contexts, there is so much opportunity to assess the validity and success of the framework across multiple training environments.

2.6 Significance of behaviour change theory in CL

Upon investigation into the literature surrounding environmental education and the psychology of behaviour change, themes and concepts were drawn and related to the elements of the CL Standard.

A paper written by L. Whitmarsh et al (2021) critically evaluates applications of behaviour change theories to mitigation responses. Potential limitations were found in some common models applied to mitigation approaches, such as the Theory of Planned Behaviour (TPB) and the Value-Belief-Norm (VBN). These were found to falter to some

extent because of the focus on one aspect of the individual. Hence, it was suggested that a combined approach that targeted individual-decision-making/action planning (TPB), as well as models that targeted deeper values and beliefs (VBN) had the potential to activate more areas of psychology which together, would directly and indirectly encourage PEB.

The Carbon Literacy Standard (The Carbon Literacy Trust, 2018) has five elements core to the educational framework:

1. Learning Method
2. Knowledge
3. Values
4. Action
5. Process

The first four elements can be related to the literature surrounding behaviour change and evidence of effective environmental education initiatives. Cross-referencing the literature with the CL Standard will allow for a critique of, as well as the break-down of the framework, to link with easily identifiable themes (lettered “a” through “d”) emerging from examples of successful applications of behaviour change theory in CCE.

Common themes found across the reviewed literature, present in climate change education, include (a) holding space for discussion and interaction and (b) including information relevant to the participants (Molthan Hill et al, 2019) (Monroe et al, 2017).

The Carbon Literacy Standard addresses theme (a) through the inclusion of ‘social learning’ as an essential part of the criteria, ensuring learners are engaged throughout training initiatives.

Howell (2012) discusses how a sense of community may increase the chances of climate action among populations, which feeds into themes (a) and (b). The connection to theme (a) has been made based on the assumption that discussion and interaction

are social activities that promote a feeling of “togetherness”, hence community. The connection with theme (b) has been made based on feelings of community being facilitated through learning that is relevant to the participants themselves, which is another feature of the CL Standard.

Howell also found that individuals who are aware that climate change is an issue that intersects with other issues like human rights and health, were more motivated to act pro-environmentally, because they had more reason to. This was classed into theme (c), found in other papers which commend the use of multiple benefits/co-benefits to promote action on climate change (Brick et al, 2021). Based on this, it could be assumed that CL has the potential to increase levels of PEB, because the CL Standard also specifies that co-benefits of climate action should be included in courses, to illustrate the widely-reaching impacts of climate change action/pro-environmental behaviour (The Carbon Literacy Trust, 2022:Documents).

The CL Standard ensures course-creators make the learning ‘local’ to the participants. Topics such as CC impacts and solutions are tailored towards the audience so that they become equipped with relevant knowledge, and tools they can use to reduce their own and collective carbon footprint, which aligns with theme (b) found in the literature. What’s more, relevance to the learner is shown to increase motivation to act in the case of CL training (Astbury and Tate, 2012), as well as, in the wider CCE sphere (Monroe et al, 2017). Verplanken and Whitmarsh (2021) suggest that the likelihood of tangible behaviour change rests on another theme drawn from the literature review – (d) a combination of belief, positivity and motivation, which is also embedded into the ‘values’ section of the CL standard.

This synthesis suggests Carbon Literacy training includes elements essential to an effective education initiative. Because the Carbon Literacy Standard includes criteria to ensure the course targets learner psychology that links to multiple behaviour change theories found in the academic literature, the attitudes, motivations, values and beliefs of past participants can be explored to see whether they are likely to lead to an elevated

level of pro-environmental and carbon reduction behaviours. Hence, the rationale for a survey conducted to compare Carbon Literate and Non-Carbon Literate individuals is presented below. The below Figure (1) briefly illustrates how the concepts found in both the literature and the CL Standard have been used to inform the selection of variables for which to base survey questions around.

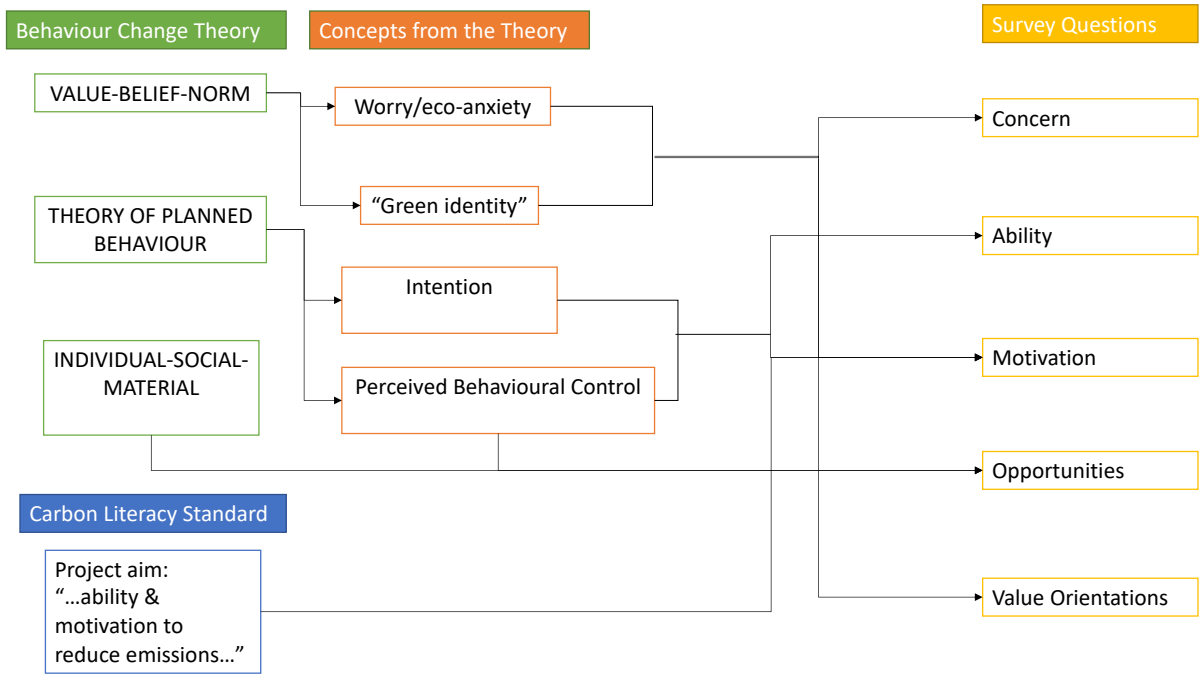

Figure 1: Flow diagram for research rationale and decisions on survey questions

3 AIMS & OBJECTIVES

3.1 Key

Aim = AX
Objective = AXOX

(Where ‘X’ represents a number)

3.2 Aims and objectives

A1: Determine if a significant difference exists between a Carbon Literate (CL) individual’s ability and motivations around reducing one’s carbon footprint compared to a Non-Carbon Literate (NCL) individual.

> A1O1: Create a survey that asks respondents questions about their overall concern about climate change; their ability to identify carbon reduction actions; their motivation to reduce their own carbon footprint and; their perceived opportunity to act.
>
> A1O2: Perform analysis on the CL and NCL populations’ responses to determine if any significant differences exist between them.

A2: Find the extent to which the values of Carbon Literate individuals differ from Non-Carbon Literate individuals.

> A2O1: Ask survey respondents to place numerical importance on their values, using a value-orientation scale template, to group the values of CL and NCL samples.

A2O2: Perform analysis on both samples to determine if differences exist between the two populations. This includes comparing the ranks of the value orientations within each population sample.

4 METHODOLOGY

This methodology for data collection and analysis summarises the process undertaken to facilitate the aims and objectives of the research project.

4.1 Survey development

A survey, approximately 20 minutes long, was designed in collaboration with the Carbon Literacy Department at Manchester Metropolitan University (MMU) and The Carbon Literacy Project. The survey was responded to by those certified as 'Carbon Literate' (CL) in the last 6-18 months, as well as those Non-Carbon Literate (NCL), to gather information about their thoughts, feelings and actions about climate change. This time-frame was chosen for the CL group because it was a significant amount of time since the training, so longer-term impacts could be explored.

Choosing to ask the same questions to both CL and NCL samples enabled a 'control' group of people who had not undergone any form of CCE to be asked the exact same questions as the CL group, so responses could be compared from those who had completed CL training, with intent to use this comparison to interpret impacts of CL training. It also allowed the survey to be shared across more channels of communication such as social media, in addition to the CLP research mailing list, creating ease of data collection and potentially increasing the number of respondents.

The survey was piloted within the Carbon Literacy Department at MMU, and to the team at CLP, on 17/01/23. Piloting the survey meant that it could be tested for any technical issues, and opened up opportunities for feedback and improvement, e.g. about its user-friendliness or question style.

The survey was completely anonymous.

4.2 Sampling method

The survey was sent out via a 'SurveyMonkey' link through various media platforms, mainly shared by students and their spheres of influence, as well as The Carbon Literacy Project via their communication streams, such as the Monthly Newsletter and LinkedIn. There was also a chance to win a £200 shopping voucher, a strategy used to incentivize people to complete it.

The 'Convenience sampling' technique was used to acquire survey respondents. This method has strengths in that data collection is uncomplicated, low-cost and can reap fast and large levels of response (Rahi, 2017).

Limitations of the method include the possibility that the sample of the non-CL population may not be reflective of the true demographics of the whole population. This will be discussed in more detail in the discussion (section 6).

4.3 Final outline of survey

Questions were mainly closed, 'tick box' style (Graham-Rowe et al, 2019). This allows results to be analysed using quantitative methods. Because the project was time-bound, using mostly quantitative data helped to maximise the amount of data that could be analysed in a smaller timeframe, compared to qualitative data. Please refer to figure 1 (section 2) throughout this section, to aid in the understanding of the survey question selection.

4.3.1 Thoughts, feelings and attitudes questions

The parts of the survey from which the responses were analysed include the Likert-type responses surrounding thoughts, feelings and attitudes towards climate change and climate action (See Appendix A for link to full survey). The

questions (QX, where X is the question number) and answer choices (numbered directly below the Qs) were as follows:

Q1: “How concerned are you about climate change, overall?” (Concern)
Answer options to Q1:

1. “Not at all concerned”
2. “Slightly concerned”
3. “Moderately concerned”
4. “Very concerned”
5. “Extremely concerned”

To what extent do you agree with the following statements…
Q2: “I am able to identify actions to reduce my carbon footprint” (Ability)
Q3: “I am motivated to reduce my carbon footprint” (Motivations)
Q4: “I have sufficient opportunities to reduce my carbon footprint” (Opportunities)
Answer options to Q2, Q3 and Q4:

1. “Strongly disagree”
2. “Somewhat disagree”
3. “Neither agree nor disagree”
4. “Somewhat agree”
5. “Strongly agree”

Q1 was used to gain an over-arching idea of the psychological distance of climate change to the two sample populations (Portinga et al, 2011), as well as potentially using Verplanken et al’s 2020 article to indicate some likelihood of action, as a basis.

Q2 and Q3 were analysed to gain insight into the extent to which CL training has achieved its aims of giving people the “ability and motivation to reduce emissions” (The Carbon Literacy Project, 2022). For this study, this aim was

limited to the ‘individual’ part of the definition of what it means to be ‘Carbon Literate’ because of the questions being asked about the individual only.

Responses to Q4 were analysed to find out the level of perceived behavioural control (PBC), relating to the TPB model, impacting the likelihood of action due to perceived ease of performing it (Terry and O’Leary, 1995). It may also provide some context about the impact of perceived barriers, e.g. those discussed in the ISM model, on motivations/likelihood of action.

To analyse this data, Likert scales were used to collect answers so that the data could be converted into numerical interval data, for analysis through Excel and SPSS software. Likert scales have proved effective ways in many studies to assess behaviour change and attitudes (Vagias, 2006) for quantitative data analysis. The tests that were run on the above data include descriptive statistics, to find the frequencies, median and spread of the data in the two sample populations. Using SPSS statistics software v28, Mann-Whitney U tests were run to test for any significant differences in the distributions of the answers to the survey between the two populations samples, because the data is not normally distributed, and ordinal. This analysis method has been used in similar studies in environmental education that use likert-type questions in a survey (Goulgoti et al, 2019).

4.3.2 Value-Orientation questions

To allow the relation of the behavior change theory models discussed in the literature review in the context of respondents’ values, a Schwartz value-orientation scale was included in the survey, based on the de Groot and Steg evaluation (2007) of the effect of altruistic, biospheric and egoistic value orientations on environmental beliefs of sample populations from different countries.

13 values were listed, and survey respondents were asked to attribute a number to each value, and encouraged to avoid placing the same number for multiple values, based on the importance of that value. The highest score could be 7, corresponding to “extremely important to me” descending to 0, “not important to me” and -1, “opposed to my values”. From this part of the survey, values could be scored for the two populations and compared between the two sample populations, to determine if there are any differences in the value-orientations, looking at descriptive statistics such as variance and distribution. Descriptive statistics provided a mean value for the scores for each value-orientation, so that a value-orientation rank for each population sample could be established and compared. Using SPSS statistics software v28, Spearman’s rho was run to test for relationships/strength of correlations between the means of the value-scores. This was because the data was not normal and scale, and the analytical method was supported in previous studies that tested for correlations between belief norms in the context of CCE impacts on PEB in high school students (de Leeuw et al, 2015). The variables from section 4.4.1 were also analysed using the spearman’s rho test, so that relationships between all data variables (e.g. values and attitudes) can be analysed to find any relationships.

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5 SURVEY RESULTS AND STATISTICAL ANALYSIS

This chapter will present a description of the results from the survey, including the statistical analysis results from tests ran on the survey data.

5.1 General survey results

5.1.1 Composition of sample respondents

Table 2: Composition of survey respondent population samples

Population Code	Description	Number of complete responses
Non-CL	Respondents had neither completed CL training *nor* any other CCE	57
CL	Respondents have completed CL training 6-18 months prior; can include other CCE completion as well	89

Table 1 shows the composition of survey respondents. The sample of people who hadn't completed any formal CCE was smaller than the population sample of people who had completed CL training 6-18 months prior. Below are pie charts displaying the proportion of responses for both population samples combined for the questions described in section 4.3.1.

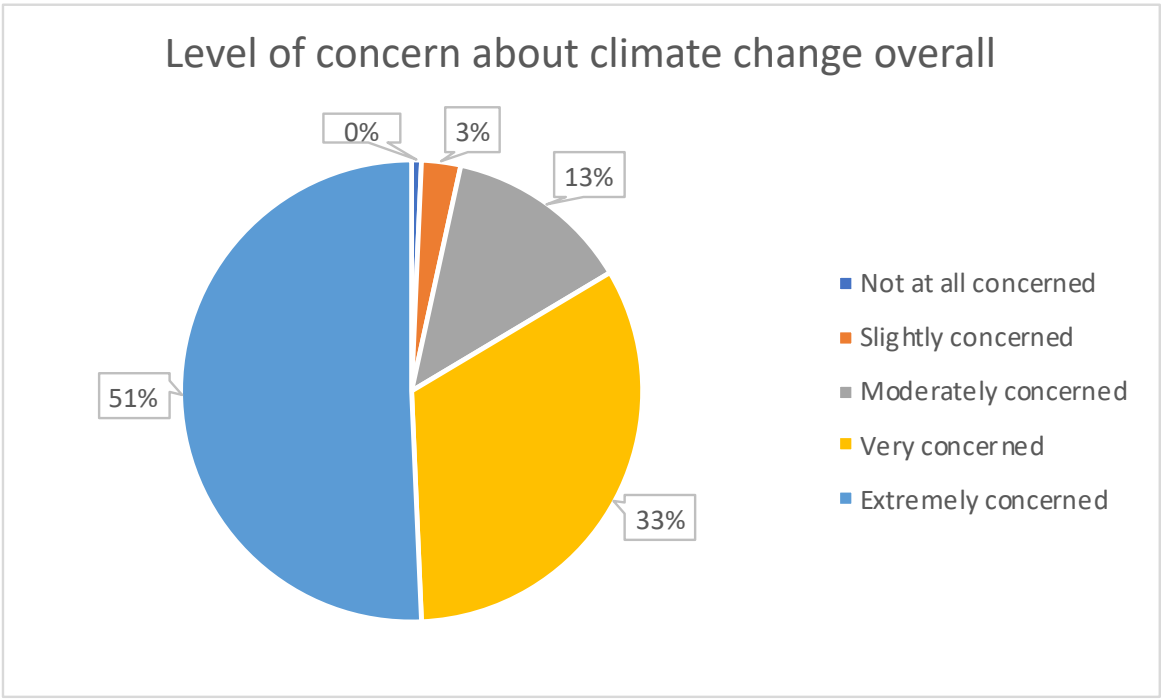


Figure 2: Distribution of level of concern for all survey respondents

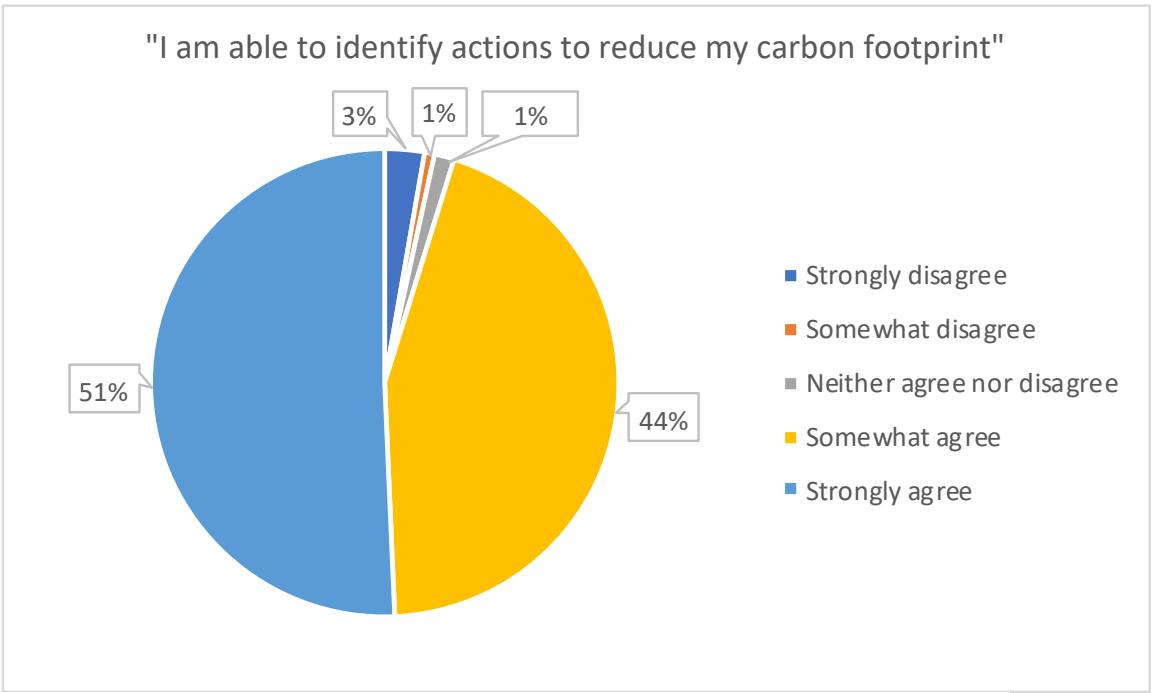


Figure 3: Distribution of level of ability for all survey respondents

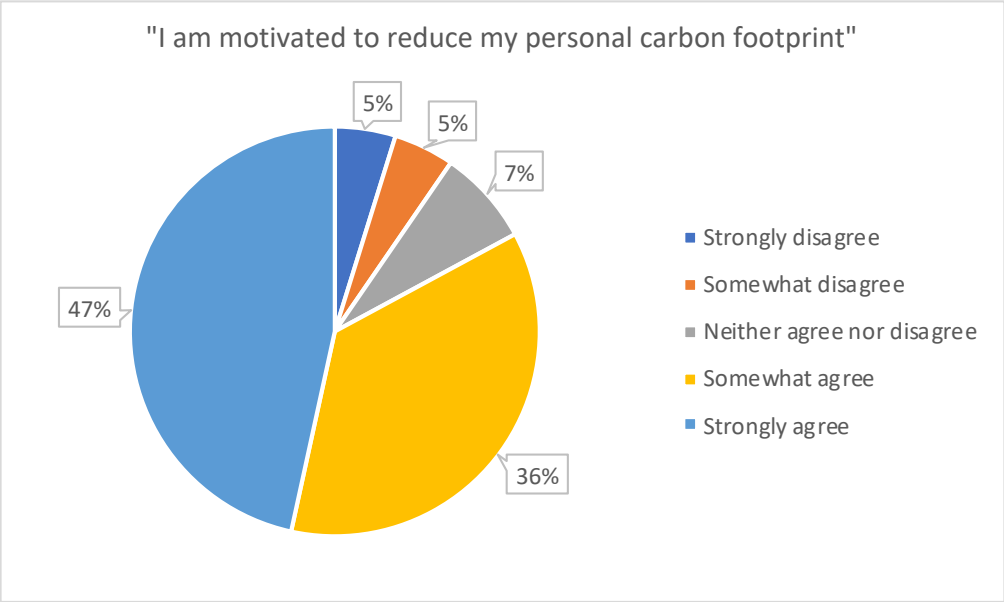


Figure 4: Distribution of level of motivation for all survey respondents

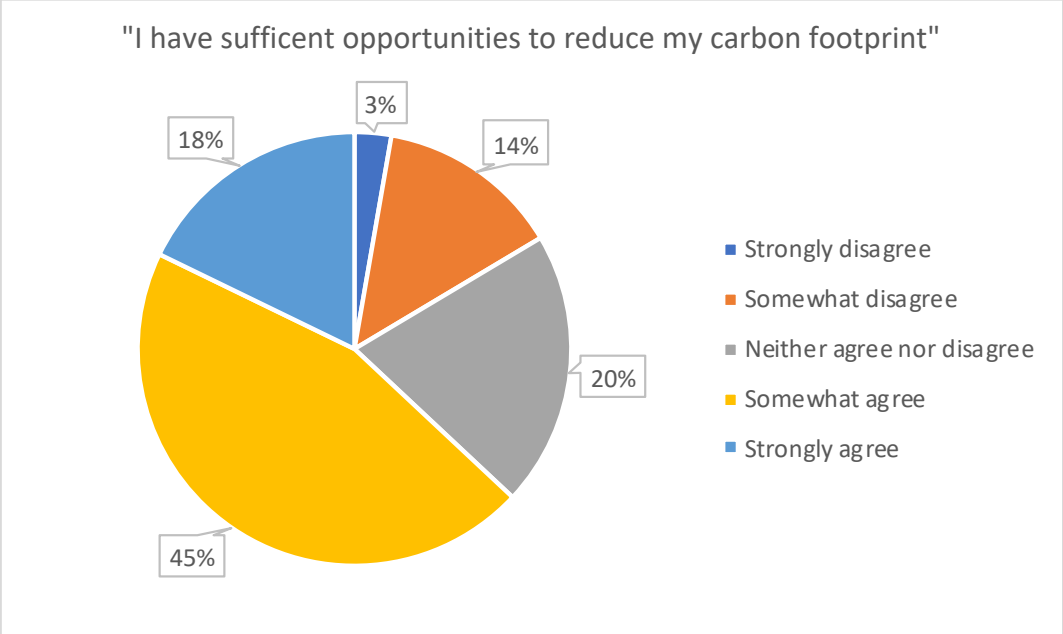


Figure 5: Distribution of level of opportunity for all survey respondents

The percentages of responses for level of opportunity (figure 5) were higher in the 3 central agreement levels compared to the other variables. The highest frequency of "strongly disagree" was for the motivation (figure 4) variable, and the highest frequency of "strongly agree"/"Extremely concerned" was joint between concern (figure 2) and

ability (figure 3). The results for the whole survey respondent population can be used to make some general inferences about the population later.

5.2 Mann-Whitney U Tests

Below are the results from the Mann-Whitney U tests ran on the variables relating to A1 (thoughts, attitudes and beliefs).The “Groups” that were compared refer to the Carbon Literate (CL) and Non-CL (NCL) population samples. The aim of the Man-Whitney U tests is to determine if there are any statistically significant differences between the two groups. The decision to use Man-Whitney U Tests for this analysis was made because the data is not normally distributed and ordinal.

Table 2: Mann-Whitney U Test results for attitudes between the Non-CL and CL population samples

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.[a,b]	Decision
1	The distribution of Concern is the same across categories of Groups.	Independent-Samples Mann-Whitney U Test	<.001	Reject the null hypothesis.
2	The distribution of Ability is the same across categories of Groups.	Independent-Samples Mann-Whitney U Test	<.001	Reject the null hypothesis.
3	The distribution of Motivation is the same across categories of Groups.	Independent-Samples Mann-Whitney U Test	<.001	Reject the null hypothesis.
4	The distribution of Opportunity is the same across categories of Groups.	Independent-Samples Mann-Whitney U Test	.037	Reject the null hypothesis.

a. The significance level is .050.

b. Asymptotic significance is displayed.

The Mann-Whitney U Tests ran on the variables relating to A1 all resulted in decisions to reject the null hypothesis that ‘The distribution of [variable] is the same across categories of groups’, meaning that it can be suggested that there is a difference in the distribution of ‘level of concern about climate change’, ‘ability to identify actions to reduce carbon footprint’, ‘motivation to reduce carbon footprint’ and ‘level of perceived opportunity to reduce carbon footprint’ between Non-CL and CL groups at the 0.050 significance level. How the distributions differ for each variable can be seen in the charts beside the actual values produced from the tests below (figure 6, 7, 8 and 9), as well as a table for each variable with actual response breakdown (table 4, 5, 6 and 7). The medians (Table 3) for the NCL group were lower in the concern, ability, and

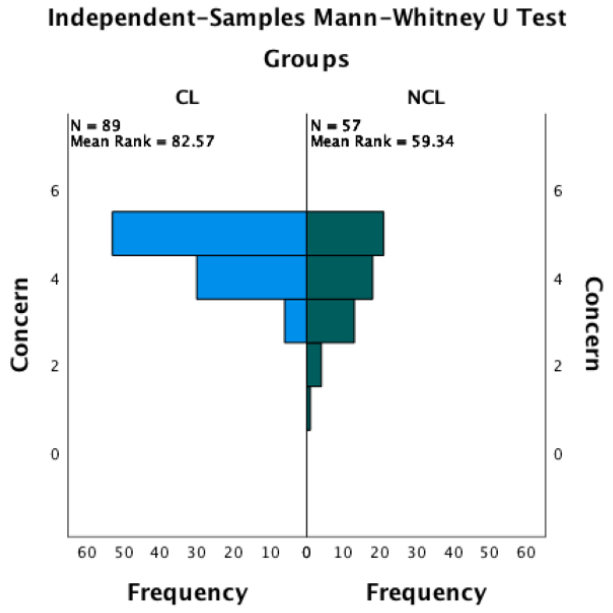
motivation categories, with values of 4. 4 corresponds with the responses “very concerned” for concern and “somewhat agree” for the other variables. The CL group median values were the highest for the same variables, with a value of 5, corresponding with “extremely concerned” for concern and “strongly agree” for the other variables. Both groups had the same median value for the “opportunity” category, which also happens to be the test result of lower significance.

Table 3: Report on attitude medians across the Non-CL and CL population samples

Report

Median

Groups	Concern	Ability	Motivation	Opportunity
NCL	4.00	4.00	4.00	4.00
CL	5.00	5.00	5.00	4.00
Total	5.00	5.00	4.00	4.00



Independent-Samples Mann-Whitney U Test

Concern across Groups

Independent-Samples Mann-Whitney U Test Summary

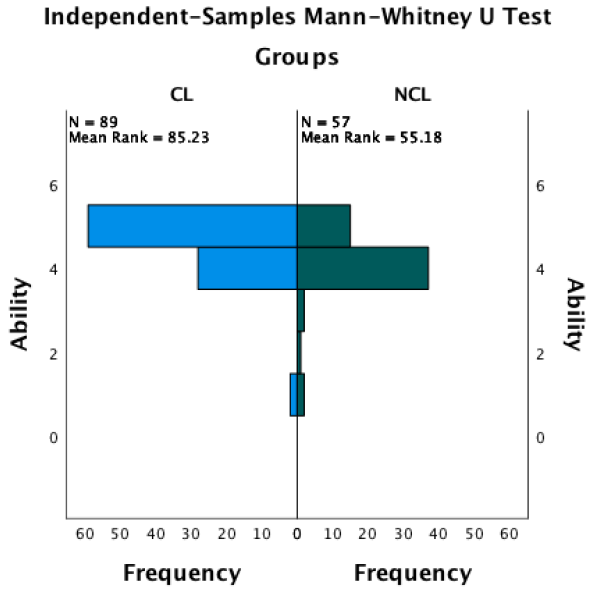
Total N	146
Mann-Whitney U	3343.500
Wilcoxon W	7348.500
Test Statistic	3343.500
Standard Error	227.395
Standardized Test Statistic	3.549
Asymptotic Sig.(2-sided test)	<.001

Figure 6: Butterfly chart displaying distributions for NCL and CL groups, beside a table for the Mann-Whitney U Test results (Concern)

Table 4: Actual response breakdown for concern level across CL and NCL population samples

	Level of overall concern about climate change					
	Not at all concerned	Slightly concerned	Moderately concerned	Very concerned	Extremely concerned	Total
NCL	1	4	13	18	21	57
CL	0	0	6	30	53	89
Total	1	4	19	48	74	146

For concern, there was sufficient evidence to reject the null hypothesis at the 0.001 significance level. From the butterfly chart, it is visible that the distribution of concern level for the NCL group about climate change overall follows a similar shape to the CL group, but has a wider spread, with more respondents indicating lower levels of concern about climate change. The CL group had a distribution that was more narrowly skewed towards the higher levels of overall concern about climate change.



Independent-Samples Mann-Whitney U Test

Ability across Groups

Independent-Samples Mann-Whitney U Test Summary

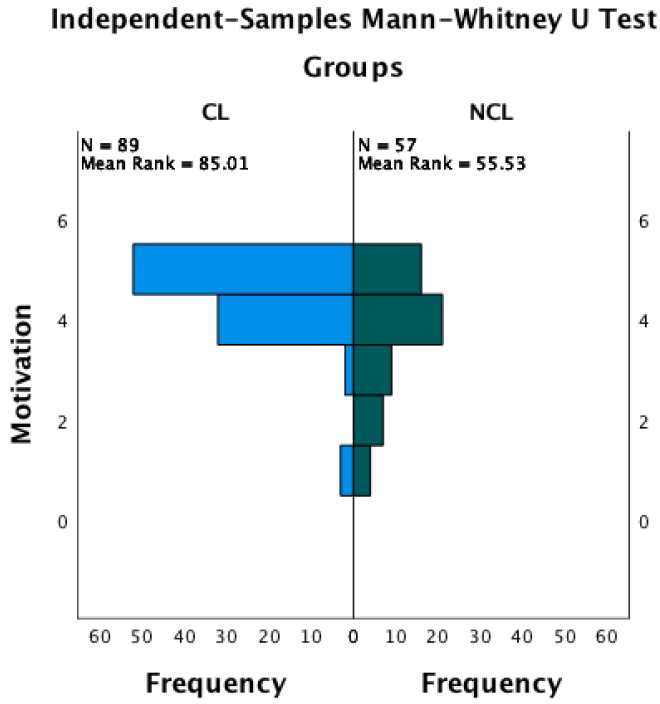
Total N	146
Mann-Whitney U	3580.500
Wilcoxon W	7585.500
Test Statistic	3580.500
Standard Error	220.385
Standardized Test Statistic	4.737
Asymptotic Sig.(2-sided test)	<.001

Figure 7: Butterfly chart displaying distributions for NCL and CL groups, beside a table for the Mann-Whitney U Test results (Ability)

Table 5: Actual response breakdown for ability level across CL and NCL population samples

	"I am able to identify actions to reduce my personal carbon footprint"					
	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree	Total
NCL	2	1	2	37	15	57
CL	2	0	0	28	59	89
Total	4	1	2	65	74	146

For perceived level of ability to reduce personal carbon footprint, there was sufficient evidence to reject the null hypothesis at the 0.001 significance level. From the butterfly chart, it is more visible than the concern variable (figure 6) that the distribution of abilty for the NCL group is different to the CL group. The CL group had responses that were more clustered in the highest level of ability (See table 5), whereas the distribution of ability in the NCL group had the highest number of responses in the “somewhat agree” category. Unlike the CL group, there was a more even spread of responses, with responses for all levels of ability. Interestingly, the only other response category for which participants responded other than the two highest levels (strongly agree and somewhat agree), for the CL group, was the lowest level of agreement for perceived ability, a polar response to the in comparison to the majority of the population sample.



Independent-Samples Mann-Whitney U Test

Motivation across Groups

Independent-Samples Mann-Whitney U Test Summary

Total N	146
Mann-Whitney U	3561.000
Wilcoxon W	7566.000
Test Statistic	3561.000
Standard Error	229.902
Standardized Test Statistic	4.456
Asymptotic Sig.(2-sided test)	<.001

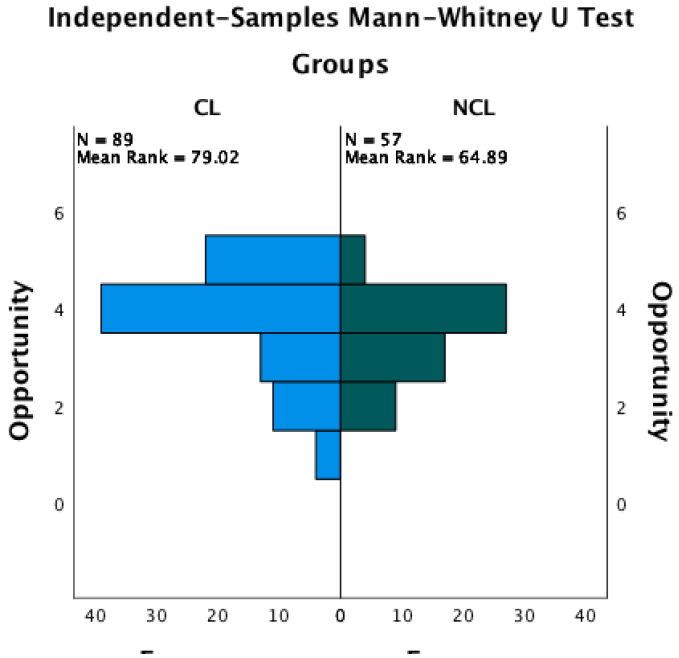
Figure 8: Butterfly chart displaying distributions for NCL and CL groups, beside a table for the Mann-Whitney U Test results (Motivation)

Table 6: Actual response breakdown for motivation level across CL and NCL population samples

	"I am motivated to reduce my personal carbon footprint"					
	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree	Total
NCL	4	7	9	21	16	57
CL	3	0	2	32	52	89
Total	7	7	11	53	68	146

For level of motivation to reduce personal carbon footprint, there was sufficient evidence to reject the null hypothesis at the 0.001 significance level, indicating that there was a statistically significant difference between the NCL and CL group for this variable. From the butterfly chart, it is clear that there is a higher proportion of respondents who strongly agreed they were motivated to reduce their carbon footprint in the CL group, and a higher proportion of respondents who chose the “somewhat agree” level of

motivation. The distribution of the NCL group was also more varied, with a higher proportion of the sample with levels of agreement across all points.



Independent-Samples Mann-Whitney U Test

Opportunity across Groups

Independent-Samples Mann-Whitney U Test Summary

Total N	146
Mann-Whitney U	3027.500
Wilcoxon W	7032.500
Test Statistic	3027.500
Standard Error	235.276
Standardized Test Statistic	2.087
Asymptotic Sig.(2-sided test)	.037

Figure 9: Butterfly chart displaying distributions for NCL and CL groups, beside a table for the Mann-Whitney U Test results (opportunity)

Table 7: Actual response breakdown for level of opportunity across CL and NCL population samples

	"I have sufficient opportunities to reduce my carbon footprint"					
	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree	Total
NCL	0	9	17	27	4	57
CL	4	11	13	39	22	89
Total	4	20	30	66	26	146

For perceived level of sufficient opportunities to reduce personal carbon footprint, there was sufficient evidence to reject the null hypothesis at the 0.050 significance level. This is a lower level of significance than the previous variables, suggesting that the shape of

the distribution of responses between the NCL and CL groups are closer in similarity, when compared to the other variables. From the butterfly chart, this is reflected visually. Interestingly, the spread of responses was wider in the CL group, with all 5 levels of the Likert-type answers being answered. There was a smaller proportion of responses for the highest level of agreement in the NCL group in comparison to the CL group, and both group's mode response was "somewhat agree".

5.3 Value-orientation results

This section presents the descriptive statistics and preliminary analysis of the data collected regarding the value-score results.

Table 8: CL Population value scores

Value	N	Min	Max	Mean Score	Standard Deviation	Rank
Protecting the environment (preserving nature)	89	4	7	6.426966292	0.86454981	1
Respecting the earth (harmony with other species)	89	3	7	6.325842697	0.836324221	2
Preventing pollution (protecting natural resources)	89	2	7	6.303370787	0.934253401	3
Equality (equal opportunity for all)	89	2	7	6.02247191	1.252066729	4
A world at peace (free of war and conflict)	89	0	7	6	1.215431087	5
Unity with nature (fitting into nature)	89	3	7	5.921348315	1.198718246	6
Social justice (correcting injustice, care for the weak)	89	0	7	5.831460674	1.501786474	7
Helpful (working for the welfare of others)	89	0	7	5.449438202	1.47718433	8
Ambitious (hard-working)	89	0	7	5.033707865	1.668215147	9
Influential (having an impact on people and events)	89	0	7	4.370786517	1.854858623	10
Wealth (material possessions, money)	89	-1	7	2.617977528	1.933588386	11
Authority (the right to lead or command)	89	-1	7	2.550561798	2.30124095	12
Social power (control over others, dominance)	89	-1	7	1.460674157	2.407640205	13

Table 9: Non-CL value scores

Value	N	Min	Max	Mean Score	Standard Deviation	Rank
Equality (equal opportunity for all)	57	0	7	6.122807018	1.268719482	1
A world at peace (free of war and conflict)	57	3	7	6.105263158	1.144618004	2
Protecting the environment (preserving nature)	57	3	7	5.789473684	1.26401913	3
Social justice (correcting injustice, care for the weak)	57	0	7	5.771929825	1.43946349	4
Helpful (working for the welfare of others)	57	0	7	5.631578947	1.422166091	5
Preventing pollution (protecting natural resources)	57	1	7	5.561403509	1.603762806	6
Respecting the earth (harmony with other species)	57	1	7	5.315789474	1.548707926	7
Ambitious (hard-working)	57	0	7	4.789473684	1.829684224	8
Unity with nature (fitting into nature)	57	0	7	4.631578947	1.876847461	9
Influential (having an impact on people and events)	57	0	7	3.807017544	1.777222919	10
Wealth (material possessions, money)	57	-1	7	3.035087719	1.990736693	11
Authority (the right to lead or command)	57	-1	7	2.789473684	2.144235146	12
Social power (control over others, dominance)	57	-1	7	1.894736842	2.395562941	13

5.3.1 Distribution

The tables were formatted to give a visualisation of the value orientation groups through the colours: green, for values attributed to a biospheric orientation; pink, for values attributed to an altruistic orientation; and yellow, for an egoistic orientation. The tables were also ranked in order of mean descending from highest mean value score to lowest. This makes it easy to see the differences and similarities in distribution for the mean value scores, as well as the orientations of the sample populations.

For the Carbon Literate population sample, 3 of the 4 values regarded as biospheric were ranked the highest by mean score, with ‘Protecting the environment’ ranking the highest. Although this was not the highest for the Non-CL group, it was the highest-scoring value belonging to the biospheric orientation. All 5 egoistic values ranked the lowest. The 4 mean value scores for the altruistic orientation ranked in the same order as the Non-CL group, despite having different ranks overall. I.e., ‘Equality’ had the highest mean score for that orientation category and ‘Helpful’ was the lowest.

For the Non-Carbon Literate sample, 4 out of the top-scoring values belong to the altruistic orientation, with ‘Equality’ ranking highest. ‘Social Power’ ranked the lowest mean value score and 4 out of the 5 lowest-ranked values belong to the egoistic value-orientation.

It should also be noted that the last 4 ranked values with the lowest mean scores, are identical between the two populations.

From the descriptive statistics ran in SPSS, box plots showing the variance in values between the two populations were created. The following have been selected for presentation either due to them being the highest-ranked values for each group, or because they stand out in comparison to the other value score descriptors. The rest of the box plots can be found in Appendix B.

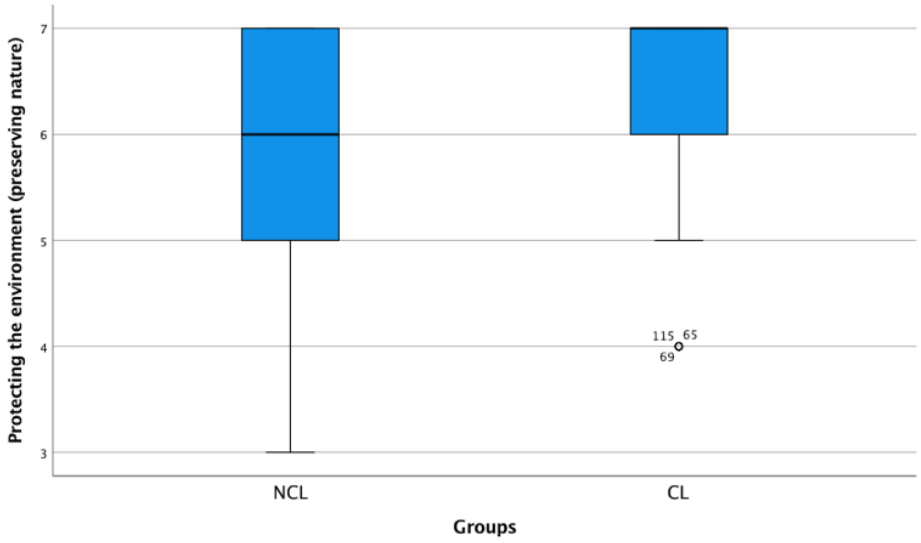


Figure 10: Boxplot displaying the distributions of scores for one value within the population samples

The distributions for the highest-ranking value for the CL group, ‘Protecting the environment’, has a narrow distribution for the CL group, with an interquartile range (IQR) of 1, between the highest and second-highest value score that could be chosen by the participant. This includes a median value of 7, meaning that at least half of the population chose the highest possible score for this value. The NCL group had a wider distribution of scores attributed to this value, with an IQR of 2. The IQR is still narrow in general, but compared with the CL group, has a wider range overall.

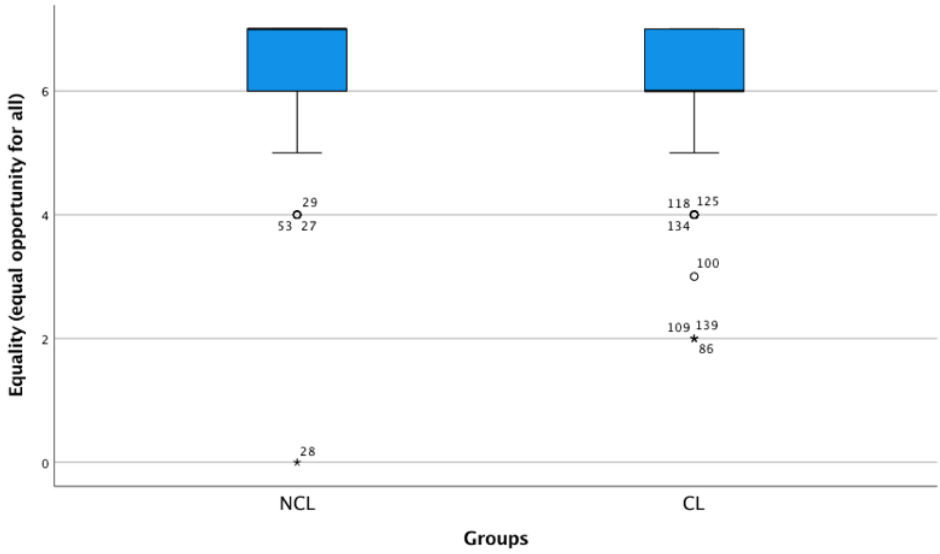


Figure 11: Boxplot displaying the distributions of scores for one value within the population samples

The distributions for the highest-ranking value for the NCL group, 'Equality', has a narrow distribution for both groups, with an interquartile range (IQR) of 1, between the highest and second-highest value score that could be chosen by the participant. This includes a median value of 7 for the NCL group, meaning that at least half of the population chose the highest possible score for this value. The CL group had a median of 6, meaning at least half of the CL population attributed the second-highest value score to this variable. In the CL group, there are more outliers than the NCL group. Ignoring these, the distributions are quite similar for this value.

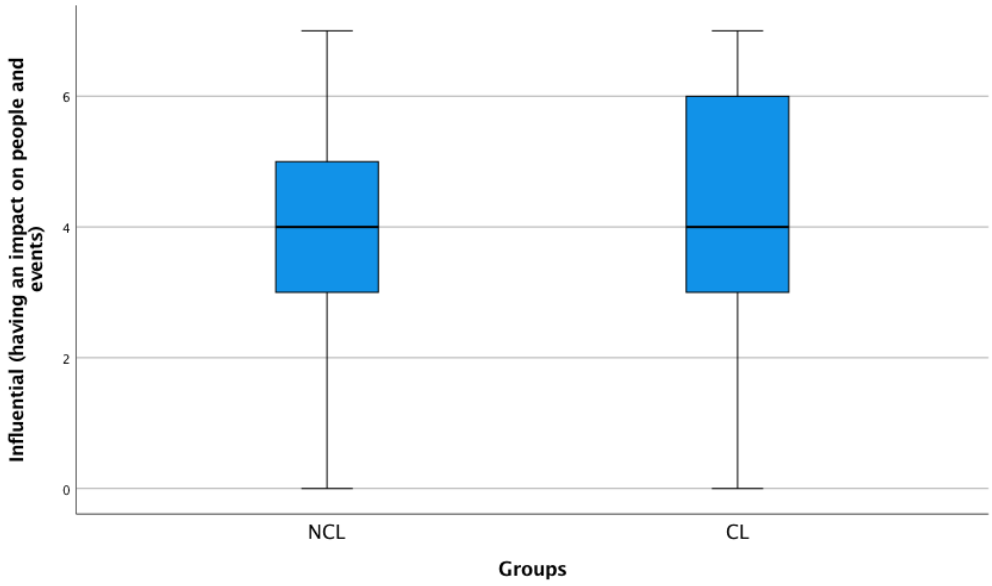


Figure 12: Boxplot displaying the distributions of scores for one value within the population samples

The spread of responses in the CL group for the 'influential' value was wider in the upper quartile in comparison to the Non-CL group. Consequently, the IQR is larger for the CL group. The median value is the same, at 4, which is approximately the centre of the value-score ranking system. The ranges are the same, ranging from 0 to 7, indicating that none of the respondents thought that the value was opposed to their values. This value visually appeared to have the largest differences in distribution between the two sample populations.

5.4 Spearman's rho results

Below are the results of the Spearman's rho tests conducted to see if there are any significant relationships between any of the variables.

Table 10: Codes representing the variable combinations ran through Spearman's rho testing

Variable	Overall concern about climate change	Ability to identify actions to reduce personal carbon footprint	Motivation to reduce personal carbon footprint	Percieved level of opportunity to reduce personal carbon footprint	Biospheric value orientation	Altruistic value orientation	Egoistic value orientation
Overall concern about climate change		Cab	CM	CO	CB	Cal	CE
Ability to identify actions to reduce personal carbon footprint			AbM	ABO	AbB	AbAl	AbE
Motivation to reduce personal carbon footprint				MO	MB	Mal	ME
Percieved level of opportunity to reduce personal carbon footprint					OB	Oal	OE

Correlations

			Concern	Motivation
Spearman's rho	Concern	Correlation Coefficient	1.000	.667**
		Sig. (2-tailed)	.	<.001
		N	57	57
	Motivation	Correlation Coefficient	.667**	1.000
		Sig. (2-tailed)	<.001	.
		N	57	57

**. Correlation is significant at the 0.01 level (2-tailed).

Correlations

			Concern	Biospheric
Spearman's rho	Concern	Correlation Coefficient	1.000	.666**
		Sig. (2-tailed)	.	<.001
		N	57	57
	Biospheric	Correlation Coefficient	.666**	1.000
		Sig. (2-tailed)	<.001	.
		N	57	57

**. Correlation is significant at the 0.01 level (2-tailed).

			Motivation	Biospheric
Spearman's rho	Motivation	Correlation Coefficient	1.000	.658**
		Sig. (2-tailed)	.	<.001
		N	57	57
	Biospheric	Correlation Coefficient	.658**	1.000
		Sig. (2-tailed)	<.001	.
		N	57	57

**. Correlation is significant at the 0.01 level (2-tailed).

			Ability	Motivation
Spearman's rho	Ability	Correlation Coefficient	1.000	.576**
		Sig. (2-tailed)	.	<.001
		N	89	89
	Motivation	Correlation Coefficient	.576**	1.000
		Sig. (2-tailed)	<.001	.
		N	89	89

**. Correlation is significant at the 0.01 level (2-tailed).

Figure 13: SPSS Spearman's rho outputs for the 4 combinations of variables with the most significant correlation coefficients

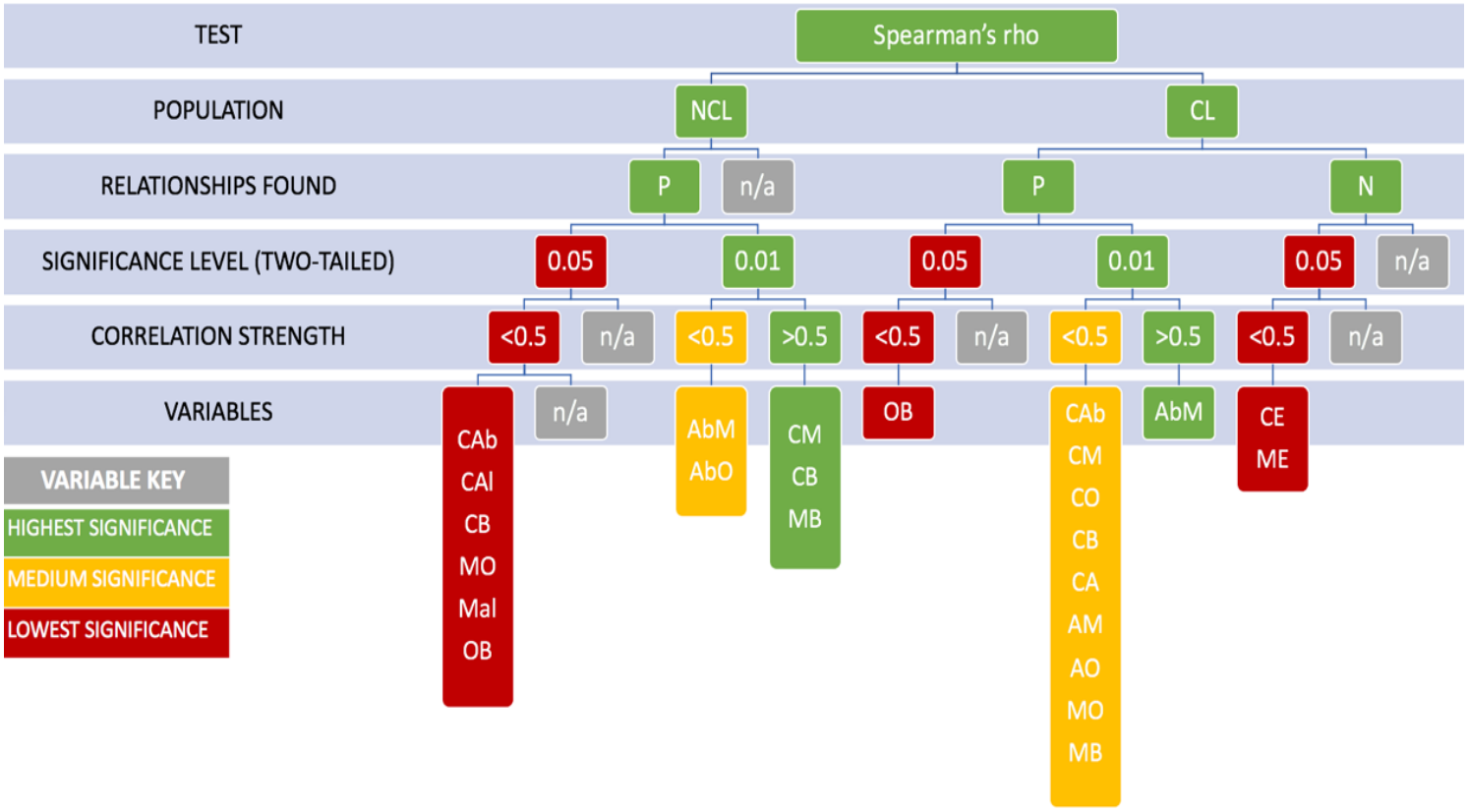


Figure 14: Tree diagram representing the process for grouping variables by significance level

Please refer to figure 14 throughout this results section, which explains the process that led to determining the significance of relationships found between all of the data variables for the CL and Non-CL population samples. Please also refer to table 10 for definitions of the codes used for each variable combination.

5.4.1 Highest Significance

The relationships of highest significance indicated from running the Spearman's rho tests (see figure 14) include:

1. Overall concern about climate change/motivation to reduce personal carbon footprint

2. Overall concern about climate change/biospheric value orientation

3. Motivation to reduce personal carbon footprint/biospheric value orientation

4. Ability to identify actions to reduce personal carbon footprint/motivation to reduce personal carbon footprint

Relationships 1-3 are strongest in the Non-CL group, with positive correlation coefficients of .667, .666 and .658 respectively at the 0.01 level of significance. The corresponding coefficients for the CL group were .421, .396 and .297 respectively at the 0.01 level of significance. All results suggest that as one variable increases, so does the other, but the likelihood of this happening is higher when the coefficient is closest to a value of 1 for positive relationships.

Relationship 4 is strongest in the CL group, with a positive correlation coefficient of .576. the corresponding coefficient for the Non-CL group is smaller, with a value of .37.

5.4.2 Medium Significance

For this dataset, relationships in the medium category include those with a correlation coefficient of less than 0.5, at the 0.01 significance level. These relationships include:

1. Ability/Motivation
2. Ability/Opportunities
3. Concern/Ability
4. Concern/Motivation
5. Concern/Opportunities
6. Concern/Biospheric
7. Concern/Altruistic

8. Ability/Opportunities
9. Motivation/Opportunities
10. Motivation/Biospheric

Relationships 1-8 were found in the CL population sample and included all of the relationships with the highest significance for the Non-CL group. Relationships 9 and 10 were found in the Non-CL group.

5.4.3 Lowest Significance

Excluding the tests run on two variables that did not display a relationship (see figure 13), the relationships of lowest significance were characterised as having a significance of <0.5 at the 0.05 level. There were no relationships found that were >0.5 at the 0.05 level, hence the grouping criteria did not consider this characteristic. They were, as follows:

1. Concern/Ability
2. Concern/Altruistic
3. Concern/Biospheric
4. Motivation/Opportunities
5. Motivation/Altruistic
6. Opportunities/Biospheric
7. Concern/Egoistic
8. Motivation/Egoistic

Relationships 1-5 were found in the Non-CL group, relationship 6 was found in both populations, and relationships 7 and 8 were negative in the CL population alone. Because the strength of the significance is close to zero at a lower significance level than the previous two sets of results, they will not be discussed in great detail.

6 DISCUSSION/INTERPRETATIONS

During this chapter, the results and statistical analyses of the survey will be interpreted together in the context of the research aims. The main findings will be critically evaluated in the context of the wider literature and The Carbon Literacy Project itself, including limitations.

6.1 Attitudes and beliefs across the whole population

The results of the whole population who responded to the survey showed that over half of the population answered that they were “extremely concerned about climate change overall” and the exact same proportion strongly agreed that they were “able to identify actions to reduce their carbon footprint”. This could indicate that at least 1 in 2 of the general population are informed to some extent on the climate crisis, and are able to identify at least some actions to reduce their carbon footprint, perhaps suggesting the base level of knowledge is increasing, which supports findings from a CCE review paper suggesting that effective CCE should still move away from just teaching the basics of climate change in order to maximise action (Monroe et al, 2017).

6.2 Differences in attitudes and beliefs

The statistical analysis in section 5.2 showed that there were statistically significant differences in the distribution of attitudes for all 4 variables tested in the Non-CL and CL populations, which answers A1: Determine if a significant difference exists between a CL individual’s ability and motivations around reducing one’s carbon footprint compared to a non-CL individual.

The CL sample group’s responses tended towards the highest levels of concern, highest level of ability to identify carbon reduction actions, highest levels of motivation to reduce carbon footprint and highest levels of belief that they opportunity to reduce

carbon footprint. The differences in distribution could indicate that Carbon Literate individuals are generally more concerned about climate change overall, are more competent to act and more motivated to act, than those who haven't undergone any formal CCE (i.e. the NCL group).

Higher levels of concern about climate change have been associated with increased motivations to act in a pro-environmental way (Verplanken & Whitmarsh, 2021), and the higher levels of concern in the CL group could suggest that this population are more likely to have eco-anxiety as a result (see section 2.1), another indicator of action (Verplanken et al, 2020). Concern has also shown to lead to increased motivation to act in a pro-environmental way, supported to some extent by the results from the Spearman's' rho analysis in section 5.4. This has been tested in the wider literature, finding correlations of higher significance than this study, supporting this inference (De Leeuw et al, 2015). Therefore, it is suggestable that the higher levels of concern, paired with higher levels of motivations (see section 5.2) in the CL, may lead to the CL group being more likely to engage in pro-environmental behaviour.

The lower significance level of the differences in perceived level of sufficient opportunity to reduce carbon footprint between both groups could be explained by the way in which Carbon Literacy training is designed to educate individuals in how they can make the most significant action within their personal control (The Carbon Literacy Project, 2022). The argument that the Carbon Literate individual is more aware of how to reduce emissions - supported by the higher proportion of respondents able to identify carbon reduction actions (see section 5.4) – could be proposed through this lens: That higher levels of competency in the identification of *significant levels* of action, Carbon Literate individuals may be more aware of more opportunities available to everyone to reduce their carbon footprint, hence are able to identify more easily where they do not have the opportunity to. Therefore, this could suggest Carbon Literacy training is effective in achieving its aims to raise the awareness of an individual's opportunities to act in their *control*.

Alternatively, the slightly closer similarity in distribution of perceived opportunities could be related to the nature of the CL sample having completed the training 6-18 months ago. Perhaps the level of perceived opportunity is relative to when they completed the training, were by the end of the training, they would have had to fill a form with 2 action plans to reduce personal and collective carbon footprints in the context of their training (see section 1). Relating back to the TPB-based models for behaviour change, which centred around planning, intention and Perceived Behavioural Control (Hansmann et al, 2020), this end activity, where the training is still fresh and the learner is planning an action, is very much related to TPB (see section 2.3). Therefore, it could be suggested that this part of the training is where learners feel they have the most opportunity to make change, and have allotted time, outside of any environments where they may experience barriers, such as time constraints, work responsibilities, other personal obligations etc to planning (Cordero et al, 2020). This argument could be used to suggest the training is still effective, as the proportion of CL individuals who display high concern, motivation and ability is still significantly larger than the NCL Group, even 6-18 months post-certification.

The higher levels of ability and motivation to reduce carbon footprint relates directly to the aims of the CLP (see section 2, figure 1). Furthermore, previous reports on Carbon Literacy training effectiveness have also indicated that the training increases the ability to identify carbon reduction actions (Shaw, 2017) and pro-environmental behaviour change (Astbury and Tate, 2012) which can now be supported by this research and vice versa, regarding the longer-term impacts of Carbon literacy training.

6.3 Differences in values

In response to Aim 2: ‘Find the extent to which the values of Carbon Literate individuals differ from those not’ (see section 3), there is a difference indicated in the relative value-orientations of each populations, though not analysed using a test to confirm a statistically significant difference, which suggests the CL group are more biospherically-orientated than the NCL group surveyed (see tables 8 and 9). The elevated importance of such values to the CL group could be interpreted as being resultant of Carbon

Literacy training. This is supported further by evidence that the order of ranking of the altruistic values alone is the same for both sample populations, but at different levels in relation to the environmental values. Hence, it could be suggested that the 'test group', i.e. CL group, could have had similar value ranks to the 'control group', i.e. NCL group, prior to the training. On the other hand, the difference in values could simply indicate that people with a biospheric value-orientation are more inclined to take part in Carbon Literacy training. This would need further investigation into the context of *how* the sample did Carbon Literacy training, because the training might not necessarily be undertaken voluntarily. For example, the *voluntary* completion of the training could support the suggestion that people who have a more biospheric value-orientation are more inclined to take part in CCE, and Carbon Literacy. However, if the training was completed on a mandatory basis, then the suggestion would be less strongly-supported.

Because biospheric values are closely linked to engagement in pro-environmental behaviours (Ates, 2020), this finding further suggests that Carbon Literate individuals are more likely to engage in PEB. The fact that the values of the CL group are orientated in this way, up to 18 months post-training completion, could be indicative of the effect that CL has had on the individuals in the long-term.

Following these results and interpretations, the relationship between CL and value orientation could be studied in more depth, as there is not as much (if any) literature or reports published that study the impact of CL on value-orientations (The Carbon Literacy Trust, 2023: Research). As there is an increasingly sufficient body of research into the relationship between value-orientations and pro-environmental behaviour (PEB) in the context of CCE (Hansmann et al, 2020), this would complement and support new findings to inform the power that CCE has on individual values, and of values on the uptake of PEB.

6.4 Relationships between attitudes and values

The results of the Spearman's rho tests ran to test for relationships between all of the variables used in this study are indicative of how complex the factors affecting PEB can be.

The most significant relationship found in the CL population was between level of ability and motivation, which could suggest that the aim of The CLP to increase ability and motivation to reduce carbon emissions could be a strong outcome in its participants, even after a significant amount of time. The largest number of bivariate relationships overall were found to be of medium significance in the CL group, which could suggest that the relationships that relate to pro-environmental behaviour and the main models of behaviour change theory, are all enhanced by CL training, and individuals are impacted by intersecting values, beliefs and motivations in the months post-certification. The multiple interactions could be linked to the literature that suggests PEB is more likely when multiple elements from several behaviour change models are applied (Whitmarsh, 2021). Hence, this could strongly support the indication that CL individuals are more likely to engage in PEB.

For the sample of the Non-Carbon Literate (NCL) population, the strongest relationships matched observations and findings surrounding the attitudes, values and behaviours in the wider environmental/behaviour psychology research field (Howell, 2012). The relationships were also similar to those found in the literature surrounding 'Green identity', which could indicate that these relationships were more significant in the NCL group due to a wider polarity and distribution (see section 5.2) of respondent's attitudes and beliefs. Perhaps there were respondents in the NCL sample who, although hadn't done any formal CCE, already identified with values and beliefs associated with a 'green identity', therefore correspondent of the relationships found in the literature (Verplanken et al, 2020). Additionally, this point could be supported by the possibility of the sample of the NCL population to be slightly skewed towards having more people with attributes of a "green identity", hence these correlations were more defined in the sample analysis.

The above consideration should be noted as a limitation of the study, because it could have introduced unintentional biases, and therefore skewed results that may not truly

reflect the NCL population. For example, if the NCL sample was more representative of the attitudes and values of the general population, the differences between the samples may have been more varied, significant, or not significant, as well as there being potentially different relationships between variables in the sample itself. This is based on the fact that the survey was distributed to people who had close proximity to The Carbon Literacy Project, the Carbon Literacy team at MMU and MMU students, due to the convenience sampling method. Hence, the NCL sample may have had a larger number of respondents who may be more informed, involved and aware of the climate crisis. This could be assumed because the afore-mentioned organisations are involved in issues around sustainability and climate change, so the people with whom the survey link was directly shared with (before then sharing with their wider spheres of influence) could likely have more exposure to the issue through proximity to the organisation. Perhaps a truer reflection of the NCL population would introduce more varied responses, due to the wide range of people who may not have been reached through the communication streams used to distribute the survey. Therefore, it would be advisable to repeat the study on a larger sample with a sampling method that best ensured a reflective representation of the NCL population.

Being such a small sample size, these interpretations still have limitations, despite being supported by the literature. The most significant relationships were still quite weak in terms of Spearman's rho results, so larger samples would need to be studied to further validate the findings in this context, although the interpretations are indicative of a research area that is complex, diverse and therefore should be invested in, so that the research can be further synthesised to create stronger linkages between behaviour change theory in the context of CCE.

7 CONCLUSION

7.1 Strongly-supported conclusions about the longer-term impacts of Carbon Literacy training

For the sample studied, there is a statistical difference between the perceived ability and motivations of a CL individuals and Non-Carbon Literate individuals to a 0.001 significance level. From this analysis, it can be concluded that an impact of Carbon Literacy training includes increasing an individual's capability to identify things they can do to reduce their personal carbon footprint. It can also be concluded that Carbon Literacy training increases an individual's motivation to reduce their carbon footprint.

The combination of ability, motivation and opportunity increases the likelihood of individuals engaging in pro-environmental behaviour. Therefore, it can be concluded that another impact of Carbon Literacy training is the increased likelihood of an individual to behave in ways that benefit the environment. It cannot be concluded with certainty that these behaviours will reduce carbon, due to the way the supporting literature links these attitudes to 'pro-environmental behaviour', which encompasses all behaviour that benefits the environment, rather than carbon reduction specifically (Jensen, 2002). However, it can be speculated that Carbon Literacy increases an individual's likelihood of behaving in ways that reduce carbon, due to survey questions posed to the sample being based specifically around their 'carbon footprint'.

7.2 More speculative conclusions drawn from this study, including recommendations for further research

This study found that Carbon Literate individuals were more likely to have a biospheric value-orientation. This finding could prompt a number of conclusions, such as an impact of CL being that it has a long-term influence on the values of Carbon Literate individuals. Another conclusion could be made, that people with biospheric values are more likely to do CL – implications of these inconclusive findings, discussed in section 6.3, could prompt larger studies that compare the values of people who have done

Carbon Literacy training and people who haven't done formal Climate Change Education could be done to see if this trend is true on a larger scale. This could inform stakeholders in the CCE field (and more specifically The CLP) as to the characteristics of their typical audience, in comparison to their target audience.

It can also be concluded that CL has the potential to affect an individual's sense of identity, as the attitudes of Carbon Literate individuals become more centred around concern about climate change, and motivations to reduce personal carbon footprint since completing the training. Concern about climate change and engagement in PEB are linked to a "green identity", hence a longer-term impact of CL could be that it causes a shift in self-perception. In order to be a stronger conclusion, this would need to be validated by further research into Carbon Literate individuals, perhaps through studying themes of identity using a pre and post-course survey, like that of MMU.

7.3 Final note

Finally, this report suggests that Carbon Literacy training has a lasting impact on the attitudes, capabilities and beliefs of individuals who undertake it. Based on the literature review of behaviour change theories in the context of Climate Change Education and pro-environmental behaviour, it can be suggested that part of the impacts discussed above can be attributed to the design of the CL Standard, because it includes approaches to CCE that are deemed effective, as well as using approaches that are supported by behaviour change theory to increase likelihood of actual pro-environmental behaviour change.

The main limitation to consider for the whole study and the basis for making the above conclusions, would be the intention-behaviour gap that creates uncertainties in the confidence of predicting actual PEB (Carrington et al, 2010). This report has assessed the impacts of the training on individuals' attitudes, values and perceptions that can indicate increased likelihood of pro-environmental behaviour, but it has not measured the real, tangible PEB of Carbon Literate individuals.

Reporting on the actual PEB of a sample of the CL population could compliment this work, to further validate CL training as effective CCE, and as a tool for tackling the crisis of climate change.

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10 APPENDICES

Appendix A: Link to Survey used to collect data for this dissertation: https://www.surveymonkey.co.uk/r/Climate_Act

Appendix B: Boxplots for all value score distributions:

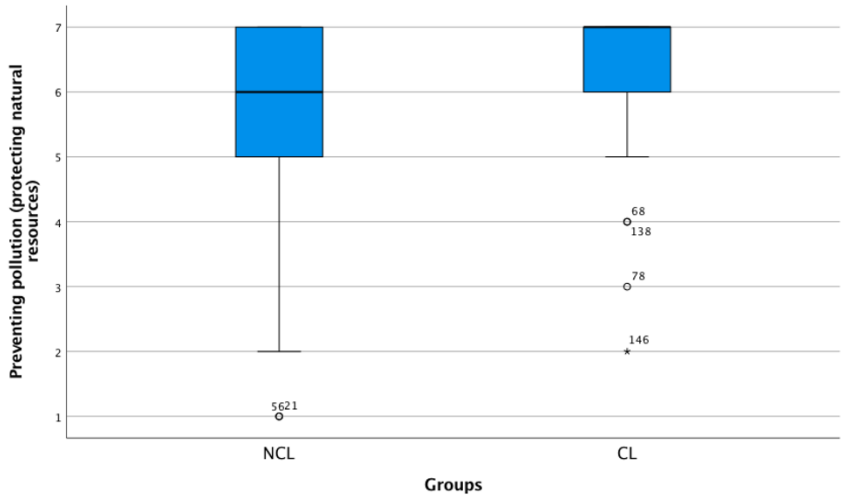

Figure 1: Boxplot displaying the distributions of scores for one value within the population samples

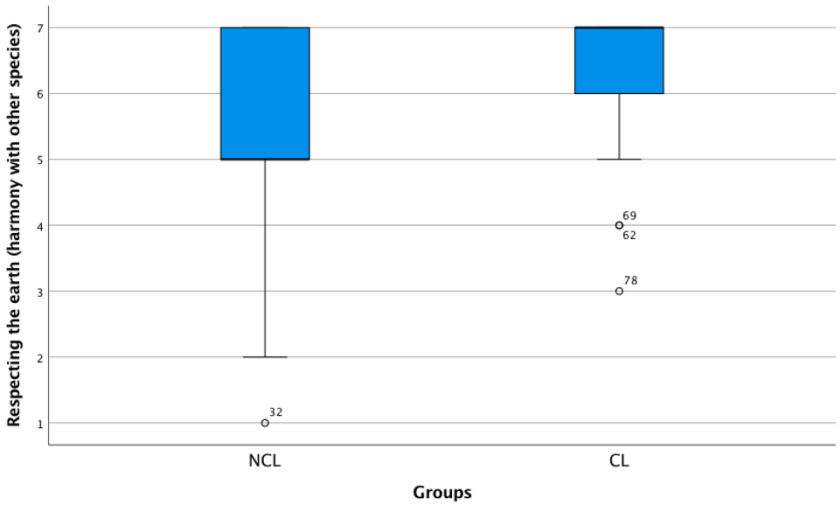

Figure 2: Boxplot displaying the distributions of scores for one value within the population samples

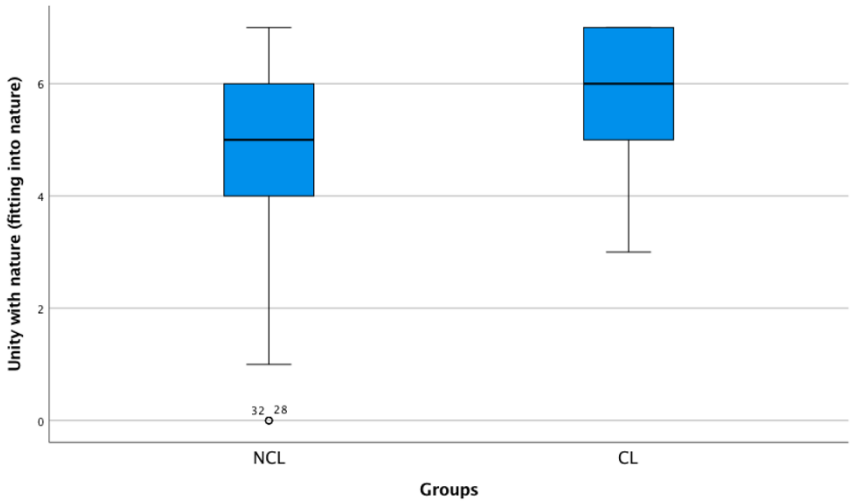

Figure 3: Boxplot displaying the distributions of scores for one value within the population samples

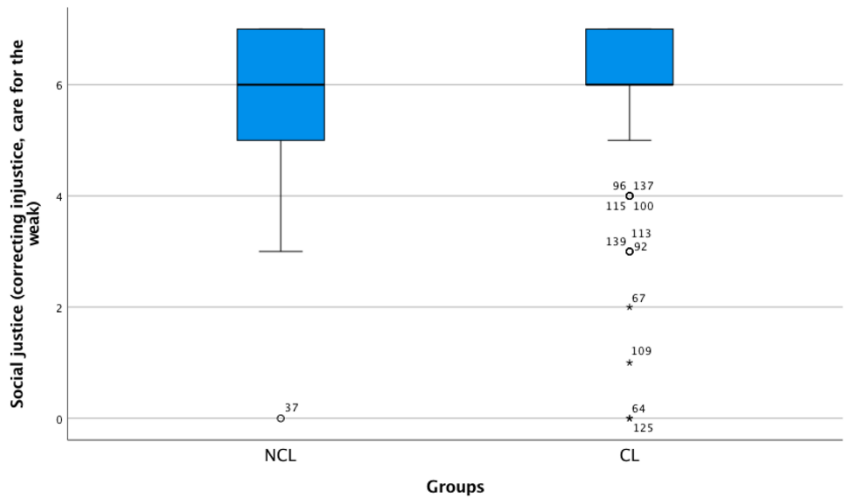

Figure 4: Boxplot displaying the distributions of scores for one value within the population samples

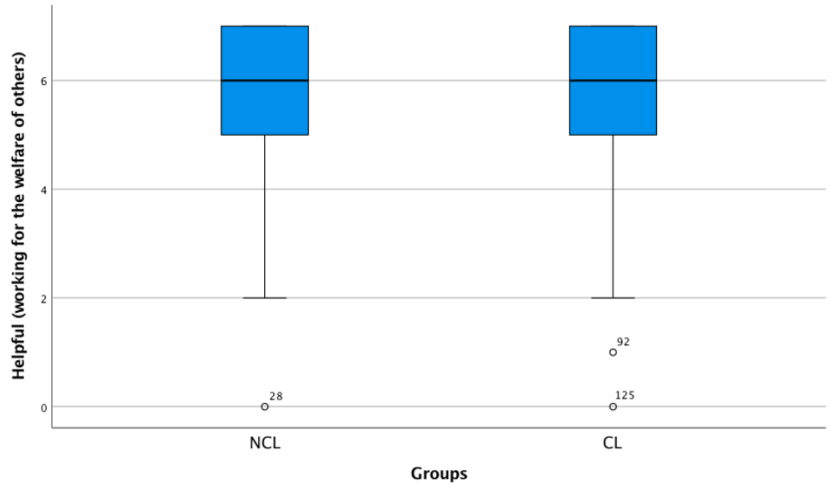

Figure 5: Boxplot displaying the distributions of scores for one value within the population samples

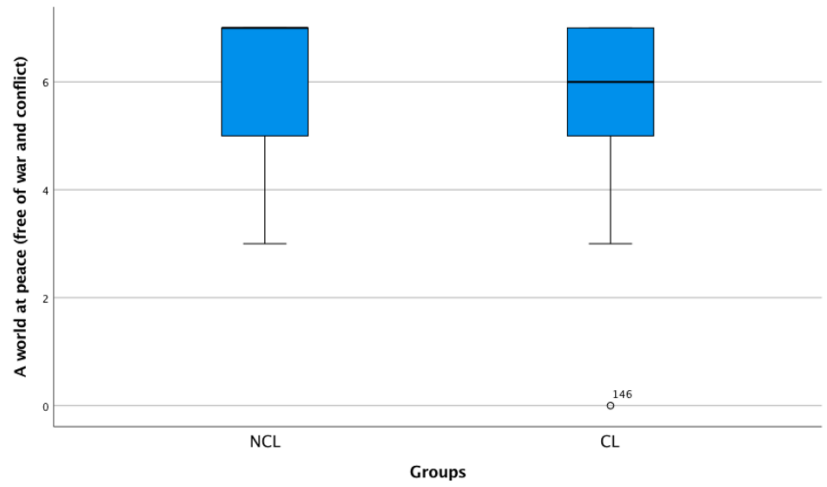

Figure 6: Boxplot displaying the distributions of scores for one value within the population samples

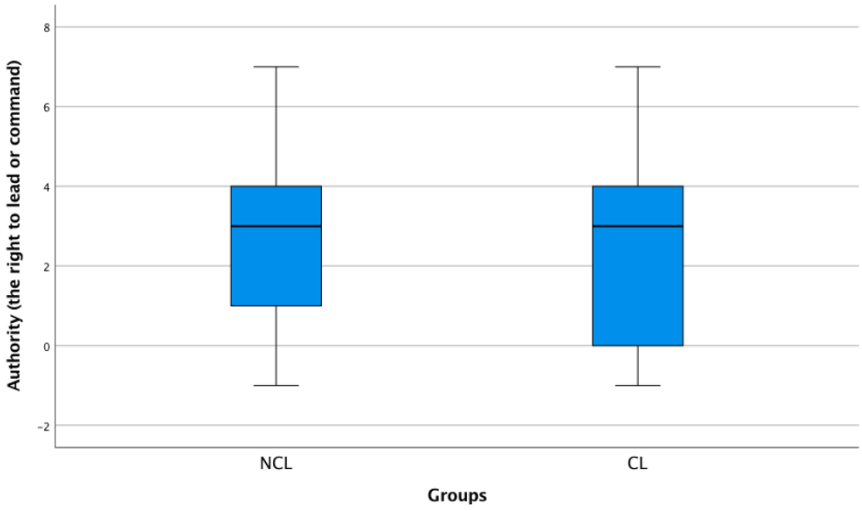

Figure 7: Boxplot displaying the distributions of scores for one value within the population samples

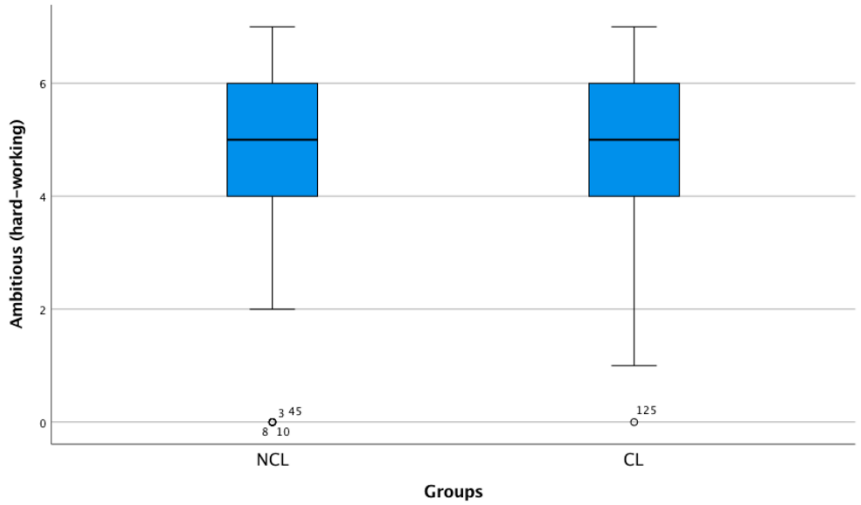

Figure 8: Boxplot displaying the distributions of scores for one value within the population samples

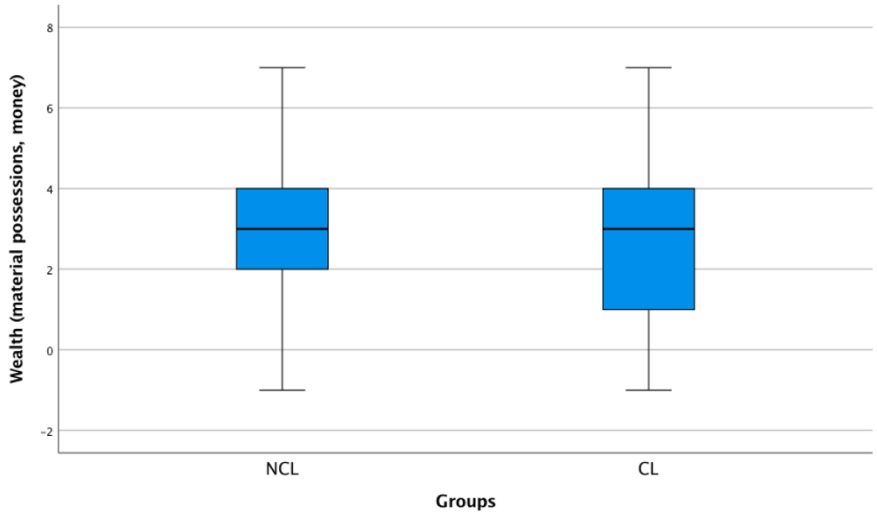

Figure 9: Boxplot displaying the distributions of scores for one value within the population samples

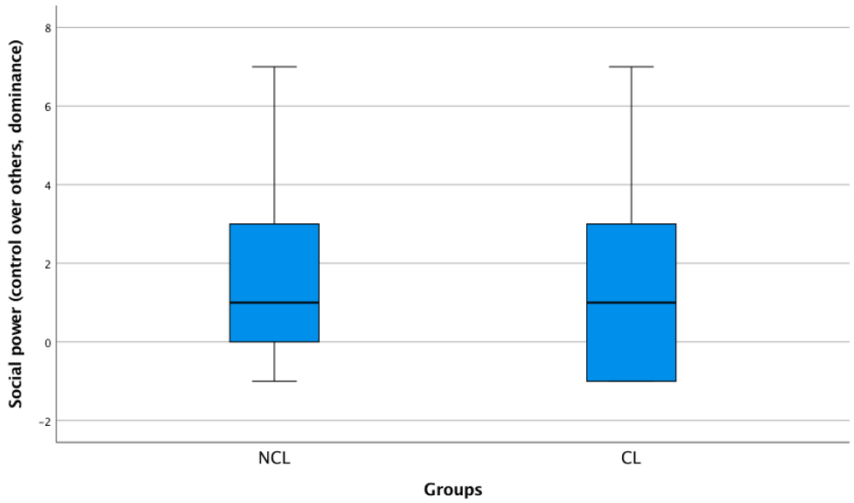

Figure 10: Boxplot displaying the distributions of scores for one value within the population samples