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Examining Climate Anxiety and Sustainability Engagement in the Undergraduate Engineering Student Population

Helen Newton
Dr. Lisa Romkey, University of Toronto

Lisa Romkey serves as Associate Professor, Teaching and Associate Director, ISTEP (Institute for Studies in Transdisciplinary Engineering Education and Practice) at the University of Toronto. Her research focuses on the development of sociotechnical thinking and lifelong learning skills in engineering.

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Introduction

It has been previously documented that severe weather events cause a wide range of direct mental health concerns, including depression, PTSD and anxiety in individuals living in the affected community [1]. However, as the urgency around broader climate change has increased, and countries race to meet the 2050 goal of net zero emissions to limit global warming [2], a new phenomenon known as "Climate Anxiety" has emerged [3]. Climate anxiety is a form of anxiety induced by the existence of climate change and concerns about this change, rather than discrete weather events. Simply being aware of climate change and its negative impacts on our natural and social systems can cause a severe anxiety response. The recently developed Climate Change Anxiety Scale (CAS) includes questionnaire items related to both cognitive and emotional impairment as a result of anxiety about climate change, and is designed to enhance our understanding of the anxiety response to this critical global challenge [4].

Although climate anxiety is studied in the general population, and there is some agreement that climate change anxiety has a greater impact on young people [5], very few studies have been conducted with university students, and no studies have been found that focus on the undergraduate engineering student population. Engineers play an important role in the race to meet the critical 2050 goal of net zero emissions to limit global warming, and in supporting societies in adapting to the impacts of climate change, including the adaptation of infrastructure and other systems to handle extreme weather events [6]. This presents opportunity for the profession, but also demands a sense of resilience from those working in engineering, who must devise complex sociotechnical solutions and combat rampant politicization in the space.

This paper describes the process of surveying 200 undergraduate engineering students at a large, public research institution in Canada. The CAS was adapted for this survey, with additional qualitative questions added to understand the student experience with sustainability curriculum and their ideas about pursuing careers in sustainability. In short, we wanted to understand the incidence of climate anxiety in engineering students, and the relationship between climate anxiety, environmental action-taking and an interest in pursuing a career in sustainability. Furthermore, this research can contribute to a gap in the literature on climate anxiety and disciplinary cultures, and contribute to the broader understanding of engineering education and sustainability.

Sustainability has been integrated into the engineering curriculum in various ways; through stand-alone courses and program emphases, as a criterion in the design courses or otherwise through engineering design courses [7-8] and through incidental coverage or the inclusion of a specific module related to sustainability in engineering technical courses [9]. There is a recognition of this work in engineering by the students; those with an interest in sustainability issues do connect engineering careers to sustainability [10]. At the curriculum or program level,

there is movement on the development of programs with a more comprehensive focus on sustainability [11].

Climate Anxiety

The relationship between climate change and mental health is a relatively new area of research, with two forms of anxiety described: anxiety due to the direct experience of climate change, and anxiety produced from the perception of climate change. While research on climate change and mental health more generally is limited, research on acute weather events (floods, wildfires, and earthquakes, for example) and mental health demonstrates higher rates of depression, substance abuse, and anxiety disorders correlated with acute weather events [12, 13]. There is less research on long-term mental health issues from these acute events, but one study found long-term negative effects of floods in people aged 11-20, including increased rates of PTSD [14].

In the last couple decades climate change has become a bigger global issue with more attention and media coverage. In acknowledging climate change as a global threat, anxiety about the uncertainty of the future has proven to be an issue for many [4,15,16,17]. While all citizens can be impacted by anxiety surrounding climate change, children and younger adults are more vulnerable to developing climate anxiety as they are the populations who will feel the negative effects of climate change most strongly if projections come to fruition [4,16-17].

Climate anxiety can be maladaptive or adaptive. It's been demonstrated that people who experience an adaptive response are more likely to respond through behavioral engagement (pro-environmental action). When the anxiety response becomes maladaptive, resulting in challenges with excessive worry and trouble with concentration, it has been observed that this behavioral engagement link weakens. In the context of climate anxiety, this is sometimes referred to as eco-paralysis [3, 18].

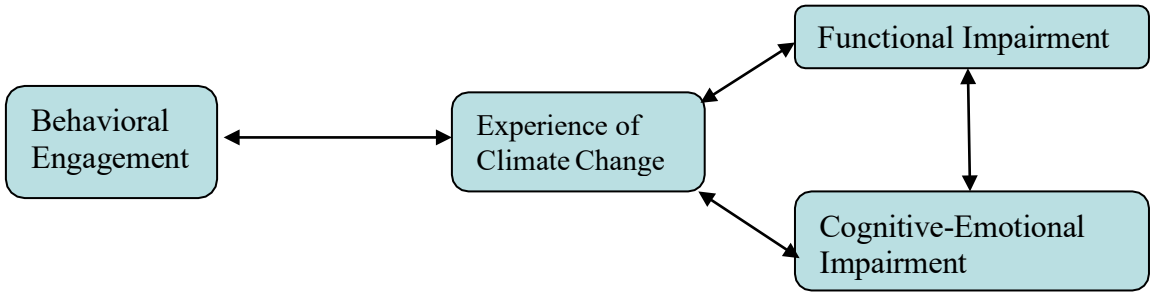
Climate Change Anxiety Scale

Although there is an increasing interest in emotional responses to climate change, the method of measuring this response has differed substantially [14, 19]. In 2020, Susan Clayton and Bryan Karazsia developed and validated a climate change anxiety scale, which consists of items on four different subscales. The first subscale represents items that measure cognitive-emotional impairment. These items examine the effect of climate change on emotions, and a person's ability to concentrate (for example, "I have nightmares about climate change.") The second subscale represents items that measure functional impairment (for example, "My concerns about climate change undermine my ability to work to my potential"). The third measures experience of climate change (for example, "I have been directly affected by climate change"), and the fourth measures behavioral engagement (for example, "I recycle") [4].

In an assessment of the instrument, the subscales of cognitive-emotional impairment and functional impairment were strongly related, and correlated with experience of climate change, but not with behavioral engagement. These relationships can be seen in Figure 1 below. The studies run by the authors to validate the tool used a general population. Other studies have used

the tool to duplicate the results on specific cross sections of populations. However, no expansion studies have been done with undergraduate university students.

Figure 1: Subscale Relations from CAS



Mental Health in Undergraduate Engineering Students

Studies examining mental health in undergraduate engineering students observe that, on average, undergraduate engineering students appear to experience certain mental health issues at a higher rate than undergraduate students in other programs [20-22]. One study suggests the "engineering stress culture" may be partly to blame. The study uses Social Identity Theory to assess the engineering identity of its population. It found a significant correlation between engineering identity and self-reported mental health issues such as anxiety and depression. It also found that women experience engineering culture differently than males, which may have further implications to consider [21].

Another study examined engineering culture in the context of mental health, with participants providing reasons why they thought undergraduate engineers had mental health issues. Most respondents reported that high stress is an expectation for engineering students, and nearly two thirds of the respondents said it's normal for engineering students to skip meals to work on schoolwork. Almost 90% indicated their sleep was impacted by workload and the need to stay up late to complete tasks. The study stopped short of any formal conclusions, but agreed further research was needed on the relationship between mental health issues and engineering culture [22].

The previous two studies looked at respondents from a single institution. A third paper published examined the mental health profile of engineering students at five institutions in the United States. The authors found that respondents were found to experience Panic Syndrome (an anxiety disorder) at 4.5 times the rate as the general population, and PTSD almost 6 times the rate. This study also found that women respondents experienced mental health issues at a higher rate than other respondents, especially women of colour [21].

While there is a lack of studies examining the relationship between climate anxiety and other mental health concerns, research indicates that the engineering population is more vulnerable to mental health concerns, motivating an examination of climate anxiety in this group.

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Engineering and Careers in Sustainability

In this work, we were also interested in the relationship between climate anxiety and sustainability-related career choice, looking to how dimensions of climate anxiety might impact future behavioural engagement. Therefore, we examined research on career choice and more specifically, Social Cognitive Career Theory (SCCT) [23]. Developed in 1994, SCCT is a career theory rooted in general social cognitive theory, and aims to relate three dimensions of career development; how people become interested in a particular academic/career path, how they make decisions about their academic/career path, and how success is (or is not) achieved in their chosen academic/career path.

There are three main variables that SCCT is built upon. The first is self-efficacy beliefs. That is, how a person perceives their ability to do something. These beliefs are dynamic and can change from activity to activity as well as over time. The next variable is outcome expectations. A person is more likely to do something if they believe the outcome will be positive (for them, for society, or in whatever sense they choose). The last one is personal goals, and it relates to both self-efficacy and outcome expectations. Personal goals are often what drives people to pursue a certain academic path and are usually grounded in what they believe they can do (self-efficacy belief) and the intention of a positive outcome (outcome expectations).

Research of the application of SCCT to STEM students, including engineering, has been conducted to see why students do (or do not) pursue a STEM related career. Research looking at multiple studies found that the three main SCCT variables form a good model to predict the career pursuits of engineering students [24]. A 2007 study used SCCT to test whether the general SCCT framework, which has been shown to predict career choice and interests, could also predict the academic satisfaction of engineering students. That is, the extent to which they enjoy pursuing their engineering studies. It was found that the SCCT framework was a good proxy to test this. More specifically, the variables of self-efficacy, academic goal progress (personal goals), and environmental supports were predictive of whether an engineering student was experiencing academic satisfaction [25].

Another important consideration when applying SCCT to engineering students, is the differing experiences between men and women. A Spanish study showed that while the SCCT framework could be applied across genders and still produce a good data fit, there was a difference in the self-efficacy beliefs and interests. Women usually have less self-efficacy beliefs and interest than men. However, no differences were seen in expectation outcomes or goal setting [26].

In considering a relationship with climate anxiety, we were curious to know whether career goals – and in particular, drawing from SCCT, self-efficacy, outcome expectations and personal goals – might interact with climate anxiety in some way, whether to encourage or discourse pursuit of sustainability-related careers.

Methods – Survey

A survey was created for distribution to undergraduate engineering students at a large research-intensive university in Canada. The survey was comprised of four sections: Demographics, a

modification of the CAS, questions grounded in SCCT, and open-ended questions about sustainability, particularly in the context of the curricular experience. Demographics in this survey were kept to a minimum. Participants were asked for their engineering discipline and year of program. Participants were also asked whether they are a domestic student or international student. Literature has demonstrated that international engineering students are more susceptible to mental health issues than domestic students [20], motivating an interest in looking at this group. These demographic items can be seen below in Table 1, with their possible responses.

Table 1: Demographic Items

What year are you in?	Year 1, Year 2, Year 3, Year 4, Work Experience Year, Year 5+
What program are you in?	Programs specific to the institution were listed; for example, electrical engineering, civil engineering, etc.
Are you an International or Domestic Student?	International, Domestic

Of the original 22 items on the CAS, 20 were retained. The items “I recycle” and “I turn off lights”, both measures of behavioral engagement, were discarded. Given the nature of potential engineering engagement in sustainability work [6], we wanted to include focus on future/career engagement rather than only measures of personal behavioural engagement, and these items in particular are the low-hanging fruit of behavioural engagement. One new item was created for our survey: “Climate change is so overwhelming; I feel that there is nothing to be done about it”. This item was added to see if climate anxiety in engineering students is maladaptive or adaptive in nature. The scale for all questions on the survey were kept the same as the original research (5-point Likert scale: Never, Rarely, Sometimes, Often, Almost Always). Table 2 below summarizes the items from the CAS used in the questionnaire, plus our singular addition.

Table 2: CAS (Climate Anxiety Scale) Survey Items

Thinking about climate change makes it difficult for me to concentrate
Thinking about climate change makes it difficult for me to sleep
I have nightmares about climate change
I find myself crying about climate change
I think, “Why can’t I handle climate change better?”
I go away by myself and think about why I feel this way about climate change
I write down my thoughts about climate change and analyze them
I think, “Why do I react to climate change this way?”
My concerns about climate change make it hard for me to have fun with my family and friends
I have problems balancing my concerns about sustainability with the needs of my family
My concerns about climate change interfere with my ability to get work or school assignments done
My concerns about climate change undermine my ability to work to my potential
My friends say I think about climate change too much
I have been directly affected by climate change
I know someone who has been directly affected by climate change
I have noticed a change in a place that is important to me due to climate change
I wish I behaved more sustainably
I try to reduce my behaviors that contribute to climate change
I feel guilty if I waste energy
I believe I can do something to help address the problem of climate change
Climate change is so overwhelming, I feel like there is nothing to be done about it

The second part of the survey draws from a study done about the application of SCCT in the context of sustainable careers [27]. This study was originally written in another language, and then translated to English. When translated, only a subset of survey items was translated. The authors of the paper were contacted to see if the full set could be obtained. Unfortunately, the authors were unable to provide this. From the subset of items provided in the English version, six were selected. The wording was modified where necessary (i.e., to make the items more relevant to an engineering context). The scale for these items was the same as the original study (5-point Likert scale: Strongly Disagree, Disagree, Neutral, Agree, Strongly Agree) [27]. Table 3 below summarizes these items.

Table 3: Career-Related Items

I plan to choose a career in sustainability
I believe I would be successful in occupations working on sustainability issues
I am certain that my professional engagement could contribute to the reduction of climate change
Compared to other professions, engineering students are well-suited to address sustainability concerns
Friends support me in my desire to work in sustainability
It will be difficult to find a job in the field of sustainability

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The third and final part of the survey is a set of three open-ended questions. The purpose of these questions is two-fold. One, to ask questions that further expand on the ideas expressed in the CAS and SCCT without limiting participants to a Likert-scale response. And two, there is a question included specifically about whether students perceive their engineering education sufficiently covers climate change. The purpose of this inclusion is to determine whether relationships exist between climate anxiety, action-taking, and perception of education. Table 4 below summarizes these items as they appear in the survey.

Table 4: Open-ended Survey Items

Does the engineer have a role in climate change solutions? If so, what is it?
Do you feel that your engineering classes adequately cover climate change? If not, what do you feel is missing?
Is there anything stopping you from pursuing a career in sustainability?

The survey was distributed to most undergraduate engineering students at a large research-intensive institution through departmental newsletters, course websites and in-class announcements.

Methods – Working with Likert Scale Data

Likert-scale data, which comprises the majority of the survey results, is ordinal and therefore non-linear. In general, the assumption cannot be made that the difference between “Never” and “Rarely” is the same as the difference between “Rarely” and “Sometimes” [28]. However, research suggests that Likert-data pertaining to moods, feelings, or attitudes can be treated as continuous data in particular data analysis techniques, like factor analysis [29]. For this project, the Likert scale data is treated as continuous. Furthermore, ordinal data with five or more categories, as is the case here, can generally be used as continuous without harm to the analysis. Data was converted to continuous by assigning each Likert-scale a range of numbers, as summarized in Table 5.

Table 5: Converting Ordinal Data to Continuous

CAS	SCCT	Number
Never	Strongly Disagree	1
Rarely	Disagree	2
Sometimes	Neutral	3
Often	Agree	4
Almost Always	Strongly Agree	5

For the question “It will be difficult to find a job in the field of sustainability”, the scale was flipped. That is, “Strongly Disagree” was assigned as 5, while “Strongly Agree” was assigned as

1. This is because the wording is flipped compared to the other questions in the set. The rest have "Strongly Agree" as a positive connotation, while this question had "Strongly Disagree" as a negative connotation.

Methods - Exploratory Factor Analysis

There are 27 survey items, and thus 27 observed variables in the quantitative section of the survey. Factor analysis is a methodology that enables the identification of a set of underlying factors (or latent variables) to reduce the dimensionality of the observed data, or to find patterns between the variables under study [30]. In other words, factor analysis can help us understand which questionnaire items have a stronger relationships, and therefore may represent a single variable, reducing the complexity of the data. Similar items are grouped together, and then the average scores of those items can be used for further analysis. Factor analysis was used in the development of the CAS, to understand the key dimensions at play – this analysis lead to the identification of the four subscales as described in the section on the CAS.

Exploratory factor analysis was chosen over confirmatory analysis because of the modifications made to the survey items compared to the original CAS. Using factor analysis in this research allows a determination of whether relationships between variables is the same in the general population/original survey and engineering student population/modified survey.

Methods - Qualitative Data Analysis

For qualitative analysis, the three-open ended questions were coded and then sorted into thematic categories based on this coding. This was done in two general steps following procedures described by Saldaña [31]. The first pass of coding was to analyze the data. In this pass, codes were assigned to the data. Based on this coding, themes were determined. The second pass was to look specifically for any signs of anxiety within the written responses. While some qualitative data is presented in this paper, full analysis is ongoing and will be presented in future work.

Results and Discussion

188 undergraduate engineering students participated in the survey. Of these students, 160 are domestic students, and 28 are international students. Second years participated the most with 74 responses, followed by first years at 38, fourth years at 32, and third years at 31. Students who have been studying for 5+ years had 8 responses, and there were only 5 responses from those currently participating in a work term. A variety of disciplines were represented; although not representative of the institution's undergraduate engineering population by discipline and year, it is a large enough sample size to be representative of undergraduate engineering students without considering year or discipline (confidence level 95%, margin of error 7%).

The results of the climate anxiety survey (CAS) questions are first presented, followed by the career-oriented questions, then an examination of the relationships between CAS and career plans, and finally the open-ended questions.

Results – Modified Climate Anxiety Scales

Table 6: Frequency, Means and Standard Deviation for Modified CAS

	Never	Rarely	Sometimes	Often	Almost Always	Mean Response	Standard Deviation
Thinking about climate change makes it difficult for me to concentrate	71	66	37	14	0	1.97	0.94
Thinking about climate change makes it difficult for me to sleep	110	51	19	7	1	1.61	0.86
I have nightmares about climate change	145	26	11	4	2	1.36	0.78
I find myself crying about climate change	153	22	10	3	0	1.27	0.63
I think, “Why can’t I handle climate change better?”	90	33	41	22	2	2.00	1.13
I go away by myself and think about why I feel this way about climate change	120	39	22	7	0	1.55	0.84
I write down my thoughts about climate change and analyze them	152	23	11	1	1	1.28	0.64
I think, “Why do I react to climate change this way?”	112	35	26	12	3	1.72	1.03
My concerns about climate change make it hard for me to have fun with my family and friends	124	46	14	4	0	1.46	0.73
I have problems balancing my concerns about sustainability with the needs of my family	95	36	31	19	7	1.97	1.19
My concerns about climate change interfere with my ability to get work or school assignments done	149	30	8	1	0	1.26	0.56
My concerns about climate change undermine my ability to work to my potential	142	38	8	0	0	1.29	0.54
My friends say I think about climate change too much	155	19	11	3	0	1.27	0.64

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I have been directly affected by climate change	66	42	40	25	15	2.37	1.30
I know someone who has been directly affected by climate change	59	28	40	33	28	2.70	1.45
I have noticed a change in a place that is important to me due to climate change	38	27	44	40	39	3.08	1.41
I wish I behaved more sustainably	23	20	45	57	43	3.41	1.29
I try to reduce my behaviors that contribute to climate change	13	22	61	65	27	3.38	1.09
I feel guilty if I waste energy	16	18	47	63	44	3.54	1.19
I believe I can do something to help address the problem of climate change	23	34	52	46	33	3.17	1.26
Climate change is so overwhelming, I feel like there is nothing to be done about it	39	42	56	39	12	2.70	1.20

Table 6 demonstrates the frequency of each response, as well as the mean response, and the standard deviation for each item within the CAS section of the survey. The anxiety-type questions, (those of functional impairment and cognitive impairment) generally have low standard deviations and low mean responses. This indicates lower levels of climate anxiety in the engineering population. The questions related to behavioral engagement or experience of climate change have higher standard deviations and higher mean responses. This indicates there is a grouping of students that are engaging in actions to combat climate change, and who have experienced/know someone who has experienced effects of climate change. However, there are some exceptions. For example, the question, “I think, “Why can’t I handle climate change better?” is a cognitive impairment question but has a much higher standard deviation than the other cognitive questions. This is explained by the 22 survey respondents who answered “often”, indicating there may be a small but notable group of students impacted by climate anxiety.

Based on exploratory factor analysis, a five-factor solution emerged as outlined in Table 7. The factors load similarly, but not precisely the same as those in the original CAS.

Table 7: Modified CAS Factor Analysis

Survey Item	Factor Loadings				
	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
Thinking about climate change makes it difficult for me to concentrate	**0.50**	0.14	0.25	0.41	0.48
Thinking about climate change makes it difficult for me to sleep	**0.53**	0.31	0.10	0.27	0.48
I have nightmares about climate change	**0.52**	0.19	0.09	0.20	0.40
I find myself crying about climate change	0.30	0.20	0.15	0.22	**0.43**
I think, “Why can’t I handle climate change better?”	0.27	0.00	0.52	0.21	**0.32**
I go away by myself and think about why I feel this way about climate change	0.37	0.15	0.22	-0.01	**0.53**
I write down my thoughts about climate change and analyze them	0.04	0.06	0.04	-0.08	**0.79**
I think, “Why do I react to climate change this way?”	0.10	0.01	0.28	-0.07	**0.69**
My concerns about climate change make it hard for me to have fun with my family and friends	**0.67**	0.24	0.12	0.13	0.20
I have problems balancing my concerns about sustainability with the needs of my family	**0.57**	0.04	0.36	0.14	0.00
My concerns about climate change interfere with my ability to get work or school assignments done	**0.75**	0.10	0.09	-0.30	0.28
My concerns about climate change undermine my ability to work to my potential	**0.75**	0.07	0.16	-0.08	0.05
My friends say I think about climate change too much	**0.62**	0.13	0.16	0.04	0.18
I have been directly affected by climate change	0.18	**0.87**	0.11	0.04	0.08
I know someone who has been directly affected by climate change	0.17	**0.91**	0.13	0.05	0.10
I have noticed a change in a place that is important to me due to climate change	0.17	**0.68**	0.36	0.17	0.15
I wish I behaved more sustainably	0.10	0.26	**0.77**	0.21	0.04

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I try to reduce my behaviors that contribute to climate change	0.22	0.22	**0.66**	0.02	0.16
I feel guilty if I waste energy	0.10	0.04	**0.79**	0.09	0.14
I believe I can do something to help address the problem of climate change	0.16	0.25	**0.61**	-0.44	0.23
Climate change is so overwhelming, I feel like there is nothing to be done about it	0.03	0.18	0.22	**0.77**	0.02

The bolded entries indicate the highest loading factor for each survey item. From these, the five subscales were identified, and internal reliability was validated with Cronbach Alpha. Because the factor loadings and Cronbach Alphas are acceptable, it was determined that the scores for each subscale can be averaged; i.e. questionnaire items can be "collapsed" into a smaller set of underlying variables that describe climate anxiety.

In the original CAS, the four factors identified were cognitive-emotional impairment, functional impairment, experience of climate change and behavioural engagement. In our modified survey, these four factors are still present, however, there is also an additional fifth factor: Climate Dispair. Table 8 below summarizes the correlation between these five factors.

Table 8: Subscales of CAS with Correlations
*Internal reliability not applicable in this case because only one survey item loaded onto factor

Measure	Factor 1: Functional Impairment	Factor 2: Experience of Climate Change	Factor 3: Behavioral Engagement	Factor 4: Climate Despair	Factor 5: Cognitive-Emotional Impairment
Functional Impairment	1	0.48	0.48	0.22	0.64
Experience of Climate Change	0.48	1	0.47	0.29	0.38
Behavioral Engagement	0.48	0.47	1	0.22	0.54
Climate Despair	0.22	0.29	0.22	1	0.16
Cognitive Impairment	0.64	0.38	0.54	0.16	1
Cronbach Alpha	0.84	0.87	0.78	N/A*	0.70
Mean Score	1.52	2.72	3.38	2.70	1.56

It is noted that there is a strong positive correlation ($\rho > 0.5$) between Cognitive Impairment and Functional Impairment and between Behavioral Engagement and Cognitive Impairment. Moderate positive correlations ($0.3 \leq \rho \leq 0.5$) exist for Experience of Climate Change with Cognitive Impairment, Functional Impairment, and Behavioral Engagement. Further, there is a

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moderate positive correlation between Behavioral Engagement and Functional Impairment. The remaining correlations are weakly positive ($\rho < 0.3$)

The most notable difference between this study and those performed in the literature is that climate anxiety (and in particular, cognitive impairment) is strongly correlated with Behavioral engagement. In the original two CAS studies, ρ was between 0 and -0.1 for correlations of Behavioral Engagement with Functional Impairment and Cognitive Impairment, indicating a practically non-existent correlation. Granted, as outlined in the methods section, this study did not utilize the exact same survey items as the original studies. The removal of two of the behavioral items, without the addition of new engineering-specific equivalent items may have affected this and needs to be considered a limitation.

Another notable finding in comparison to the literature, is the introduction of a new factor. While the original studies found a 4-factor solution, this study found a 5-factor solution. This new factor, which has been called Climate Despair, is the result of a new survey item being added for this study. This suggests there may be another dimension of more intense climate anxiety not yet explored. However, a further study with additional items would need to be run to confirm this.

Results – SCCT (Career)-Related Scales

Table 9 below includes the frequency of each response on the career oriented (SCCT) questions, as well as the mean response, and the standard deviation for each question. The table demonstrates variability in views on sustainability-related careers, perception of potential for success and the relevance of engineering.

Table 9: Frequency of SCCT-Related Questionnaire Items

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Mean Response	Standard Deviation
I plan to choose a career in sustainability	28	41	60	37	22	2.91	1.22
I believe I would be successful in occupations working on sustainability issues	11	25	46	79	27	3.46	1.08
I am certain that my professional engagement could contribute to the reduction of climate change	15	37	57	58	21	3.18	1.12

Compared to other professions, engineering students are well-suited to address sustainability concerns	8	17	30	74	59	3.85	1.10
Friends support me in my desire to work in sustainability	15	13	97	41	22	3.22	1.01
It will be difficult to find a job in the field of sustainability	24	43	59	42	20	3.05	1.18

Based on exploratory factor analysis, a two-factor solution emerged as outlined in Table 10 below.

Table 10: SCCT Factor Analysis

Survey Item	Factor Loadings	
	Factor 1	Factor 2
I plan to choose a career in sustainability	**0.82**	0.14
I believe I would be successful in occupations working on sustainability issues	**0.82**	0.15
I am certain that my professional engagement could contribute to the reduction of climate change	**0.78**	-0.07
Compared to other professions, engineering students are well-suited to address sustainability concerns	**0.56**	-0.31
Friends support me in my desire to work in sustainability	**0.80**	0.01
It will be difficult to find a job in the field of sustainability	0.07	**0.94**

The bolded entries indicate the highest loading factor for each survey item. From these, two subscales were created – Suitability of Engineers (for Sustainability Careers) and Perception of Ability to Find a Job (in sustainability), and internal reliability was tested using Cronbach Alpha. Because the factor loadings and Cronbach Alphas are acceptable, the scores for each subscale can be averaged. Table 11 below summarizes the Cronbach Alphas, mean scores, and the Pearson coefficient correlation, ρ.

Table 11: Subscales and Correlations of SCCT Items

Measure	Suitability of Engineers	Perception of Ability to Find Job
Suitability of Engineers	1	0.07

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Perception of Ability to Find Job	0.07	1
Cronbach Alpha	0.81	N/A*
Mean Score	3.32	3.05

Internal reliability is not applicable in this case because only one survey item loaded onto factor 2. Notably, there is no significant correlation (negative or positive) between views on the suitability of engineers and their perception of their ability to find a job.

Interactions of CAS and SCCT results

This section examines the relationships between the CAS and SCCT results. More specifically, the subscales for each tool, devised using exploratory factor analysis, are compared using Pearson's coefficient.

Table 12: Correlations Between CAS and SCCT Items

Measure	Functional Impairment	Experience of Climate Change	Behavioral Engagement	Climate Despair	Cognitive Impairment	Suitability of Engineers	Perception of Ability to Find Job
Functional Impairment	1	0.48	0.48	0.22	0.64	0.38	-0.07
Experience of Climate Change	0.48	1	0.47	0.29	0.38	0.30	-0.05
Behavioral Engagement	0.48	0.47	1	0.22	0.54	0.56	-.015
Climate Despair	0.22	0.29	0.22	1	0.16	0.01	-0.11
Cognitive Impairment	0.64	0.38	0.54	0.16	1	0.43	-0.09
Suitability of Engineers	0.38	0.30	0.56	0.01	0.43	1	0.07
Perception of Ability to Find Job	-0.07	-0.05	-0.15	-0.11	-0.09	0.07	1
Cronbach Alpha	0.84	0.87	0.78	N/A*	0.70	0.81	N/A*
Mean Score	1.52	2.72	3.38	2.70	1.56	3.32	3.05

*Internal reliability not applicable in this case because only one survey item loaded onto factor 2

The results demonstrate a strong correlation between Behavioral Engagement and views on the "Suitability of Engineers", indicating that students who engage in sustainability-related behaviours believe that engineers are well-suited to careers in sustainability. There are also moderate correlations between Functional Impairment and Cognitive Impairment, and views on the Suitability of Engineers for work in sustainability. That is, engineering students who believe

engineers are well-suited for a role in sustainability, tend to be more climate anxious. These students are also more likely to be participating in behavioral engagement related to sustainability. While we want students to engage in sustainable behaviours and climate justice action-taking, these results emphasize the need for further tools and understanding of climate anxiety to help support those students, who, as engineering students, may also be prone to additional mental health challenges.

Qualitative Data Analysis

As noted above, the survey included three qualitative questions. This section provides key thematic analysis based on the responses to these questions, noting that analysis of the qualitative data is preliminary and ongoing.

Question 1: Do you feel that your engineering classes adequately cover climate change? If not, what do you feel is missing?

The overwhelming response to this question was that students do not feel that climate change is adequately covered in their courses. Of the 48 participants who do believe it is covered sufficiently, 14 said it was because they didn't see extensive climate change coverage being needed in their courses or that they viewed sustainability as something separate from engineering. For example, one participant said, "Haven't taken a climate change class yet, so I don't know". Another one said, "No. Climate change is a different area of study and should be kept separate from engineering classes."

Of the people that said no, a small group thought that students should not be forced into learning about climate change. One participant said, "No they don't. But I don't believe that is a problem. I believe engineers are smart enough to see climate change and be proactive without being forced into through course work.". Four more students believed even though it wasn't covered in class, that isn't an issue, as the responsibility of climate change shouldn't fall on engineering students, but rather on big companies or government.

The remaining students who said no, said that climate change is either brushed over, not brought up at all, or that coverage is not sufficient. One recurring theme is the lack of substantiality in design courses. For example, "Especially in introductory design classes, the importance of design for the environment is lost. Ethics already has some sustainability components, but these failed to strongly emphasize the climate crisis as a central problem, and one engineers need to be active in solving (or at least in avoiding making worse)." Another participant said that technical courses lack connections to sustainability and climate change, "Many technical courses miss opportunities to highlight interesting, useful and/or important connections to climate change and sustainability."

Question 2: Is there anything stopping you from pursuing a career in sustainability?

This question was coded first by yes/no due to its binary nature. Many students just answered no without further elaboration. Other students who answered no, provided a more detailed response. Some students indicated they felt there was good future job availability in sustainability, the

industry they are interested in is already heavily focused on sustainability, the program they are pursuing within engineering sets them up well for a job in sustainability, or that in addition to pursuing a career in sustainability they have other goals and areas of interest.

Four students indicated they were passionate about a career in sustainability, while one student indicated their desire to pursue a career but that they were overwhelmed, “I'm highly motivated to do whatever I can to best combat climate change. However, sometimes I feel overwhelmed by the complexity of the problem and don't know what the best choice of career in sustainability is, so I'm less enthusiastic about any one approach/role/job/path.” Another student shared they wanted to pursue a career in sustainability because they feel it is their responsibility. Finally, another student indicated that the feeling of success and accomplishment is critical in a sustainability-related job. This group of students was identified as potentially climate anxious based on questionnaire results.

For those who indicated that there were barriers stopping them from pursuing a career in sustainability, most said it was due to lack of interest or lack of money available. Three people held personal beliefs that contrasted with working in sustainability. For example, one participant said, “Yes!! Sometimes to me, sustainability feels like an abstract discipline or a fad with no legit career work (maybe like working in cryptocurrency or being an inventor or a social media influencer). That's why I don’t see myself doing it?” However, six students indicated a lack of understanding and/or education in the field. For example, one participant said, “Lack of research availability for undergrads. I've been trying to find a way to get into the field but have been unsuccessful.” Four participants suggested that sustainability isn’t a career, but rather a set of principles that apply to all careers. Finally, a group of students indicated that they didn’t believe they would make a difference working in a sustainability related job, and that it’s the role of government and/or big corporations to move the needle on climate change.

Question 3: Does the engineer have a role in climate change solutions? If so, what is it?

Most participants agreed that engineers have a role to play in climate change solutions. 18 participants said they don’t, with most agreeing that while they’re technically capable, bigger changes need to happen at the policy and government level. For example, one participant said, “Yes, the reversal of climate change will require new technology to make renewable sources more accessible. However, climate change is a battle that will be fought in politics as public funding and international policy is necessary.”

Of the students who said engineers do have a role to play, most students said that sustainability is a principle that can be applied to any type of engineering, for example, “Yes, the engineer must have a global perspective. They must consider the impact of their work on various parties, including the environment.” However, a smaller subset of participants say that engineers must be the ones to create novel solutions and technologies. For example, one participant said, “Engineers have the power to implement a solution to help slow climate change.”

Discussion and Key Conclusions

Like the general population [3], climate anxiety in undergraduate engineering students is generally low. This is demonstrated in both the frequency counts in Table 7, and in the quantitative questions. Qualitative question 2 ("Is there anything stopping you from pursuing a career in sustainability?") responses offered signs of climate anxiety outside of the quantitative data. Further, in general, the participants coded with potential climate anxiety from question 3 had high scores on the CAS questionnaire items. Although these students demonstrated passion for a career in sustainability, they also mentioned feelings of responsibility to do so, feeling overwhelmed about where to start, and the need to feel success/achievement in such a role, further demonstrating the relevance of SCCT.

The survey demonstrated a positive relationship between behavioural engagement in sustainability-related activities and climate anxiety, which is in contrast to the studies conducted with a general population [3]. These results have important implications for considering how to best support students engaged in sustainability and climate-change related activism, and those considering careers in this space. Despite the generally low rate of climate anxiety, given the existing concerns around mental health and engineering programs noted earlier in the paper, it is worth considering how to support these students in mitigating feelings of climate anxiety, and channeling concern into action.

Another interesting finding was that most students did not feel that climate change was adequately covered in their engineering courses. Although difficult to correlate this with any of the quantitative data, it is notable that there was a set of students in the second qualitative question who said lack of knowledge/training was holding them back from pursuing a career in sustainability. Further research on what students expect/want to learn about climate change in their engineering courses could be useful.

Many students also viewed sustainability as a separate discipline or subject, as opposed to a set of principles for application in engineering. For example, in the second qualitative question, students indicated that they had a stronger interest in something else (i.e., Aerospace), implying the independence of sustainability from their interest. In the first qualitative question, many students said that their discipline is not related to the environment/sustainability, and therefore climate change discussions are not relevant in their classes. This is despite most students agreeing (both in the SCCT quantitative section and in the qualitative section) that engineers are well-suited to tackle problems related to sustainability and climate change.

Future Work

For this study, the data was converted to be linear/continous based on previous studies finding studies with Likert items related to emotions, attitudes, and feelings more likely to be linear. However, a more rigorous way to run the data analysis would be to use statical analysis methods appropriate for ordinal data. There are a few exploratory factor analysis procedures that can do this. One for example, is using polychoric correlations instead of a regular correlation matrix. This approach assumes that although the observed variables may not follow a normal distribution, the latent variables (i.e., the factors) do. The observed data can then be binned into

different ranges, giving correlations between the (assumed) linear latent variables. For ordinal data, this approach has been shown to provide a more accurate model [31].

Based on responses, further modification of certain dimensions of the survey may be valuable. For example, in the case of the Behavioral Engagement questions, there is an opportunity to create further examples of engineering student-relevant examples of engagement. Given the correlation found between climate anxiety and behavioral engagement, it would be worth checking if that correlation remains with specific engineering-related action items. From literature, the consensus is that engineers can act in two ways: one, create new technologies specific to climate change and two, modify existing processes within all types of engineering to be less carbon intensive. The first is already well covered by the SCCT by checking if students are interested in working in specific sustainability roles. Some behavioral items could be developed to assess the second. For example, “I consider sustainability in my design work even if it is not mandatory” may assess a student’s engagement on an engineering level.

Finally, engaging in follow-up interviews with participants who rate high on the CAS and have climate anxious thoughts in their qualitative responses could provide richer understanding of how to support climate anxious students. Although a small subset, these students could provide valuable insights, both in understanding how climate anxiety looks in engineering students, but also for educators who are teaching these students.

The survey demonstrated a positive relationship between behavioural engagement in sustainability-related activities and climate anxiety, which is in contrast to the studies conducted with a general population. These results have important implications for considering how to best support students engaged in sustainability and climate-change related activism, and those considering careers in this space. Despite agreement that engineers have a role to play in climate change, many of the students surveyed view sustainability and climate change studies as a discipline distinct from their own engineering work, which may be impacted by relatively low coverage in their curriculum. This is also significant, as students indicated a barrier for pursuing a career in sustainability is a lack of knowledge/training.

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