

Optimizing Aerospace Sustainability Outputs*

Understanding How Negative Emotions from Barriers to Personal Achievement Affect Researchers, Product Developers, Trainers, and Recruiters

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ABSTRACT The future of sustainable aviation and aerospace depends not only on technological advances and policy but also on the motivation and well-being of the workforce. This study examined how meaningful work, organizational support, and mental health shape sustainability engagement in the sector. An explanatory sequential mixed methods design was employed. 386 students and professionals completed an online survey assessing meaningfulness of work, commitment, stress, distress, resilience, and sleep quality. This was followed by focus groups with student participants to examine lived experiences in greater depth. Quantitative findings indicated moderate levels of meaningful work and commitment across groups, with students reporting higher scores than professionals. Common barriers included limited team or employer support and inadequate funding. A lack of belief they were making a difference was associated with reduced efficacy, while funding constraints were paradoxically linked to greater positive meaning. Focus group participants conceptualized sustainability across environmental, social, and economic dimensions but described barriers such as high costs, limited infrastructure, and few institutional incentives. They also reported misalignment between passion and recognition, stigmatization of career pathways, and a culture of comparison that undermined motivation. Mental health concerns—including distress, poor sleep, and stigma around disclosure—were prevalent, particularly among international students, who emphasized the need for mentorship, transparency, and organizational support.

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1 Introduction

The creation of a thriving and sustainable aviation and aerospace future depends not only on technological innovation and policy, but also on the people behind the work: researchers, engineers, product developers, educators, trainers, and recruiters. These professionals must be deeply invested in the sustainability mission and believe in the transformational potential of their work. At the heart of that investment lies the concept of meaningful work (1,2).

“Meaningful work” has become a widely studied topic across diverse disciplines, recognized as central to individual well-being and organizational performance (1). It is closely linked to job satisfaction and work engagement, often regarded as its most immediate outcomes (2–4). Belief in the value of one’s work can foster positive attitudes, which in turn can promote positive behaviours (2). Across disciplines, a consistent understanding has emerged that meaningful work involves work perceived as significant and positively valued (5,6). While typically regarded as a positive experience, it can also emerge from difficult or emotionally complex situations involving sacrifice or tension (7).

Research has identified several contextual antecedents of meaningful work. Organizational factors like corporate social responsibility (8), developmental human resources practices (9), and social-moral climates (10) can foster it, while incivility may hinder it unless framed for reflection and autonomy (11,12). Work culture and training programs have also been shown to positively affect performance (13). Social context plays a key role: supportive coworkers, belonging, and ethical or servant leadership enhance meaningfulness, whereas abusive leadership undermines it (14). Job design factors like autonomy, task significance, and relationships contribute positively (2,15), while repetitive or devalued tasks diminish it (16). Employment conditions further shape these experiences: job insecurity (17), underemployment (18,19), and precarious forms of work (20) undermine meaningfulness, whereas fair compensation and balanced workloads promote it (21).

The outcomes of meaningful work benefit both employees and organizations. For individuals, it is linked to job satisfaction, engagement, commitment, psychological flourishing, and reduced turnover intentions and absenteeism (17,19). For organizations, it supports in-role and extra-role performance, creativity, and innovation (22). A meta-analysis found positive correlations across these outcomes (2). Collectively, these findings underscore the continued relevance of meaningful work, while also highlighting conceptual ambiguities and limited diversity in the literature.

Sustainable aeronautics is an emerging and dynamic interdisciplinary field that spans aviation, aerospace, and space transportation. The Waterloo Institute for Sustainable Aeronautics (WISA) defines three equally important pillars of sustainability (23): (1) social sustainability, building equitable, diverse, and inclusive workforces, communities, and access to mobility; (2) environmental sustainability, reducing and eliminating the harmful environmental impacts of aeronautics; and (3) economic sustainability, supporting a future-ready workforce and long-term economic growth (23). Making progress toward sustainability in these three key areas depends not only on technical solutions and regulatory frameworks but also on the ability to attract, retain, and empower a high-performing workforce. Meaningful work plays a critical role in this effort. Employees who believe their work aligns with sustainability goals are more likely to stay engaged, innovate, and contribute to organizational transformation. Conversely, if sustainability initiatives are poorly

communicated, disconnected from daily work, or perceived as tokenistic, they may fail to generate the employee buy-in needed for long-term success (24).

Developing an industry baseline for psychological and motivational risk is essential to protecting the human capital required for a sustainable aviation and aerospace sector. This study aims to offer evidence-informed guidance and targeted mitigation strategies to reduce performance degradation and promote workforce sustainability within this community.

2 Methods

2.1 Study Purpose

This study aimed to improve our understanding of how to best protect the emotional and cognitive well-being of individuals in the aviation and aerospace industry by identifying and addressing barriers to personal achievement and meaningful work. We explored including perceived meaningfulness of work, organizational support, and emotional well-being, with the goal of informing strategies to enhance motivation and safeguard mental health within the aviation/aerospace sustainability sector.

Two objectives guided this study: (1) to explore the lived experiences of individuals engaged in work or study related to sustainable aviation and aerospace, with attention to the types and meanings of barriers to personal achievement they encounter; and (2) to evaluate the relationships between experiencing these barriers and perceptions of commitment to work and work output, while accounting for the effects of mental health status and demographic characteristics.

2.2 Study Design

An explanatory sequential mixed methods study design was applied, consisting of two distinct phases. In the first phase, participants completed an online survey that captured quantitative data including demographic characteristics and validated instruments designed to assess respondents' perceived meaningfulness in work, contributions to sustainability and mental health and well being.

The second phase of data collection was comprised of focus group interviews conducted among a subset of survey respondents. Interviews were designed to explore in greater depth the patterns and themes that emerged from the first phase of data collection. Participants shared their lived experiences, perceptions of barriers to personal achievement, and the emotional challenges associated with their roles. The collection of qualitative data in addition to the quantitative survey data facilitated a more comprehensive understanding of the findings. ## Participants and Recruitment

Participants were recruited from two primary groups: (1) university students at the University of Waterloo, Canada whose studies focused on aviation and aerospace sustainability, and (2) aviation and aerospace professionals, including researchers, engineers, faculty members, corporate representatives, manufacturers, airline personnel, and individuals involved in the aviation supply chain. Participants were eligible to participate if they were actively engaged in academic or professional work related to sustainable aviation or aerospace. No exclusion criteria were applied.

Recruitment was achieved through targeted outreach leveraging institutional networks, email invitations, and professional and academic channels associated with the University of Waterloo. Participants who completed the initial survey were invited to volunteer for follow-up focus group interviews, allowing for purposeful sampling in the qualitative phase based on survey responses and areas of interest. Survey respondents were offered the opportunity to enter into a draw for a chance to win one of 15 100 dollar e-gift cards to Amazon. Focus group participants were also compensated with a 100 dollar e-gift card to Amazon.

2.3 Measures

Data collected through online surveys included: demographic characteristics; perceived mental health and emotional well-being; perceptions of meaningfulness in one's work; perceived institutional and corporate support; and individual psychosocial factors such as motivation, self-efficacy, and perceived loss of control. Several demographic characteristics were asked in the survey, including year of birth, gender (male, female, non-binary or other), role (undergraduate student, graduate student, aerospace/aviation professional), years of experience in current role, and estimated personal income.

Participants were asked about both the barriers to and the impacts on sustainability across social, economic, and environmental dimensions. They were asked to rate the extent of their impact in each area compared to peers with similar experience, and to indicate which barriers to sustainability they had encountered from a predefined list.

The **Work as Meaning Inventory (WAMI)** has been adapted in different cultural contexts, showing good psychometric properties (25). It has been validated in multiple languages and contexts, including Turkey (26), Brazil (27), Italy (28), Poland (29), and Israel (30). The scale has 10 items on a 6-point agreement scale, ranging from Strongly Disagree to Strongly Agree. The scale is also composed of three subscales: Positive Meaning, Meaning-Making through Work, and Greater Good Motivations (25). These subscales assess different dimensions of meaningful work: how much individuals find their work personally significant, how work helps them make sense of life, and the extent to which they believe their work contributes to the greater good (25). Similarly, indicators of

Commitment to Work (CTW) was assessed using 10 survey items adapted from prior literature on work commitment and motivation (6,31). Items were rated on a 6-point Likert-type scale ranging from Strongly Disagree (1) to Strongly Agree (6). The measure encompassed three sub-dimensions: Locus of Control (the extent to which individuals perceive control over their work outcomes), Motivation (intrinsic drive and engagement with work tasks), and Efficacy (confidence in one's ability to achieve work goals). Responses across these sub-dimensions were used to capture a multidimensional view of participants' commitment to work.

The **Perceived Stress Scale (PSS-10)** assesses the degree to which individuals find their lives unpredictable, uncontrollable, and overloaded, using 10 self-report items rated on a 5-point Likert scale ranging from 0 (never) to 4 (very often) (32,33). Four items are positively stated and reverse scored (Items 4, 5, 7, and 8), with total scores ranging from 0 to 40; higher scores indicate greater

perceived stress. The scale has demonstrated good internal consistency and validity across diverse populations and is widely used in health and psychological research (32,33).

The **Kessler Psychological Distress Scale (K10)** is a widely used 10-item self-report questionnaire designed to measure a person's level of psychological distress, particularly symptoms of anxiety and depression experienced over the past 4 weeks. Total scores range from 10 to 50, with higher scores indicating greater psychological distress (32,34,35).

The **Brief Resilience Scale (BRS)** is a six-item self-report measure designed to assess an individual's ability to bounce back or recover from stress. Respondents rate each item on a 5-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree), with three items positively worded and three negatively worded. Negatively worded items are reverse-scored, and all item scores are then averaged to produce a final resilience score, with higher scores indicating greater resilience (36).

The **Sleep Condition Indicator (SCI)** is a brief self-report tool used to assess key dimensions of sleep quality, particularly sleep continuity. It typically includes items measuring how long it takes to fall asleep, total time awake during the night after initially falling asleep, and total sleep duration. Respondents provide their answers in minutes or hours, and scores are evaluated against established clinical thresholds (e.g., >30 minutes to fall asleep or >30 minutes of nighttime awakenings may indicate poor sleep continuity). The SCI helps identify individuals who may be experiencing sleep disturbances, with higher values generally reflecting poorer sleep quality (37,38).

2.4 Analysis

Quantitative survey data was analysed using R Statistical Software Version 4.5.1 (39). Descriptive statistics and measures of central tendency and dispersion were calculated for all variables where appropriate and stratified by both gender (male and female) and role (graduate student, undergraduate student, aviation/aerospace professional) for subgroup comparisons.

We conducted regression analyses to examine whether perceived barriers to sustainability were associated with work-related meaning and reported contributions to sustainability. The primary predictors included four binary indicators reflecting barriers to engagement: lack of support from team members, lack of belief in making a difference, lack of support from the employer, and lack of funding. Outcomes were analyzed in two forms. Six continuous measures captured different dimensions of work-related meaning, motivation, and commitment to work (positive meaning, meaning making, greater good, locus of control, motivation, and efficacy). These were modeled using multiple linear regression (*lm*, stats package). Three sustainability outcomes (social, environmental, and economic contributions) were analyzed after recoding the original ordinal responses into binary indicators, where ratings of 4 or 5 indicated "more" and ratings of 1 to 3 indicated "not more"; participants who responded "unsure" or had missing values on these items were excluded. Logistic regression models were then fit with a logit link (*glm*, stats package). Model estimates across all regression types were extracted, tidied, and formatted for reporting using the broom package. All models adjusted for demographic and psychological covariates, including age, gender, income group, role group, perceived stress, psychological distress,

resilience, sleep quality, and presence of a mental health diagnosis. Missing data were addressed through complete-case analysis. Results are presented as unstandardized regression coefficients for linear models and odds ratios with 95% confidence intervals for logistic models.

Qualitative data derived from focus groups was evaluated using a thematic analysis framework (40), with coders AE and BL completing independent qualitative analyses prior to collaboratively developing a codebook. A third researcher, RB, was available to break coding-related ties as needed. Overarching themes were summarized, with de-identified, supporting quotations from participants included where appropriate. An audit trail was maintained over the course of the project.

3 Results

3.1 Participant Demographics

The study sample consisted of 386 participants. Most respondents were between 26 and 45 years old, with 38.9% aged 26–35 and 39.7% aged 36–45. Smaller proportions were aged 18–25 (11.1%) and 46–55 (10.3%). The majority of participants identified as male (69.1%), while 30.9% identified as female. Gender distribution varied across roles: males comprised most aviation/aerospace professionals (70.6%), whereas females were more prevalent among undergraduate students (80%). Regarding participants' length of time in their current role, most had 5–9 years of experience (45.9%), followed by 0–5 years (30.4%) and 10+ years (23.7%). In terms of current income, participants most frequently reported earning between 75,000–99,999CAD (32.0%) or 50,000–74,999CAD (28.2%), with fewer participants at both the lower and higher ends of the income spectrum.

Table 1: Descriptive Statistics of Demographic Characteristics

	n (%)	Role		
		Graduate	Undergraduate	Professional
<u>Age</u>				
18–25	42 (11.1)	5 (11.6)	26 (66.7)	11 (3.8)
26–35	147 (38.9)	34 (79.1)	11 (28.2)	101 (34.6)
36–45	150 (39.7)	3 (7.0)	2 (5.1)	143 (49.0)
46–55	39 (10.3)	1 (2.3)	0 (0.0)	37 (12.7)
<u>Gender</u>				
Male	253 (69.1)	21 (48.8)	8 (20.0)	199 (70.6)
Female	112 (30.9)	22 (52.2)	32 (80.0)	83 (29.4)
<u>Length in Role</u>				
0–5 years	114 (30.4)	10 (23.3)	28 (70.0)	76 (26.0)
5–9 years	172 (45.9)	23 (53.5)	2 (5.0)	147 (50.3)
10+ years	89 (23.7)	10 (23.3)	10 (25.0)	69 (23.6)
<u>Income (CAD)</u>				
Up to 49,999	36 (9.8)	2 (4.7)	25 (62.5)	9 (3.2)
50,000–74,999	104 (28.2)	5 (11.6)	10 (25.0)	89 (30.5)
75,000–99,999	118 (32.0)	8 (18.6)	2 (5.0)	107 (36.6)
100,000–124,999	58 (15.7)	13 (30.2)	2 (5.0)	43 (14.7)
125,000–149,999	33 (9.0)	5 (11.6)	0 (0.0)	28 (9.6)
150,000–174,999	15 (4.1)	8 (18.6)	1 (2.5)	6 (2.1)
175,000+	2 (0.6)	2 (4.7)	0 (0.0)	10 (3.4)

3.2 Sustainability

Results showed that most respondents perceived themselves as having at least an average impact on sustainability efforts. Across all three sustainability dimensions, most respondents perceived themselves as having at least an average impact. A relatively small proportion reported “no impact,” while larger shares indicated “more” or “much more” impact compared to peers. Perceptions of high impact were most common for environmental sustainability, while social and economic sustainability showed more evenly distributed responses across categories. A breakdown of the distribution of responses by type of sustainability is shown in Figure 1.

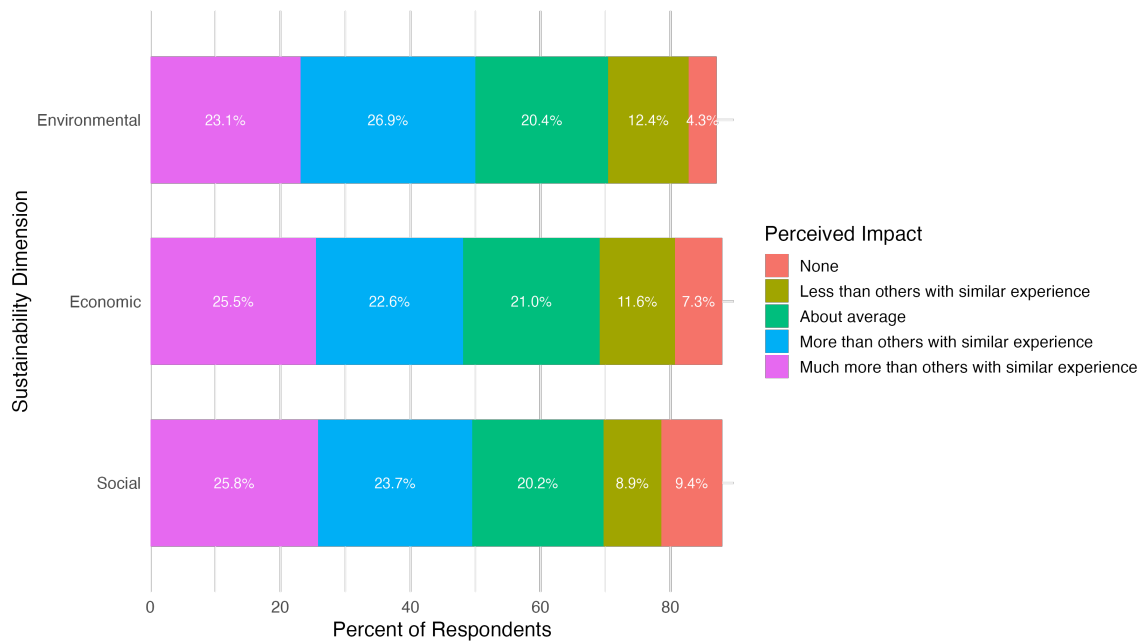


Figure 1: Perceived Impact on Sustainability Efforts. Perceived individual impact on sustainability efforts by domain. Bar chart shows the distribution of responses for social, economic, and environmental sustainability, categorized as none, less than others, about average, more than others, or much more impact.

Reported barriers to engaging in sustainability work included lack of support from the team (n = 170), lack of employer support (n = 155), and lack of funding (n = 135). A smaller number of respondents cited a lack of belief in their ability to make a difference (n = 118), and a few noted other unspecified barriers. These findings suggest that although many individuals perceive themselves as contributing positively, systemic and organizational challenges may hinder further engagement.

3.2.1 Contributions to Sustainability

Participants’ responses were collected in relation to the following open-ended survey question: “In what ways have you personally contributed to making aviation more sustainable?” The qualitative responses were then thematically analyzed to identify key patterns and insights. The table below presents the main themes that emerged from this analysis, along with brief descriptions of each. A total of 6 themes emerged from the data, including advocacy and policy, research and

innovation, improvement to operations, stakeholder involvement, public awareness, and waste and resource reduction. Summaries of these themes are included in Table 2.

Table 2: Themes from Extracted Qualitative Responses from Survey

Theme	Description
Advocacy and policy	Pilot responses showed a strong dedication to pushing for changes in the aviation industry’s rules and operations. Participants described working to help put environmental regulations into action, promote greener supply chains, and encourage airlines to use carbon offset programs. Support was expressed for the use of sustainable aviation fuels (SAFs), the creation of eco-friendly public policies, and incentives that encourage responsible environmental practices throughout the aviation sector. This theme highlights active efforts to bring about change both inside organizations and in broader policy landscapes.
Research and innovation	Respondents described work in research and the development of new technologies to support sustainable aviation. Projects included making lightweight materials, designing more aerodynamic aircraft, reducing noise, and developing alternative engines using hydrogen or electric power. Work also focused on software for optimizing flight routes, tracking emissions, and auditing environmental impact. Additional efforts included developing sustainable lubricants, recycling aircraft parts, and improving energy efficiency—placing sustainability at the heart of aircraft design and performance.
Improvement to operations	Responses indicated involvement in developing and delivering sustainability education and training modules for pilots, maintenance crews, and airport staff. Emphasis was also placed on youth and professional development, including student mentorship programs, academic collaborations, and support for diversity-focused initiatives (such as a women in aviation group). These efforts reflect a view of education as foundational to sustaining long-term environmental change in aviation.
Stakeholder involvement	Participants described collaboration across sectors, indicating that sustainability is not viewed as the responsibility of any single actor. Responses included partnerships with NGOs, governments, academic institutions, aircraft leasing companies, and environmental organizations. These collaborative efforts facilitated the implementation of joint initiatives such as emissions reduction strategies, sustainable leasing models, and fuel-

Theme	Description
Public awareness	efficiency campaigns. This points to recognition of the need for a networked, multi-stakeholder approach to sustainability. Respondents described the development of apps, games, and informational tools to help travelers understand their carbon footprint and adopt greener travel behaviors. Campaigns to raise awareness through social media, workshops, and public events were also noted. These efforts reflect an understanding of the importance of shifting consumer behavior and building public support for sustainable travel.
Waste and resource reduction	Responses included a wide range of initiatives aimed at reducing waste and promoting resource circularity. Examples included replacing single-use plastics with biodegradable alternatives, designing recyclable aircraft interiors, and implementing company-wide recycling systems. Descriptions also referenced lifecycle assessments of aviation products and initiatives to repurpose aircraft materials, indicating a systemic approach to waste management and circular economy principles.

3.3 Meaning in and Commitment to Work

The average score on the Work and Meaning Inventory was 29.3 (SD = 7.2), reflecting a moderate level of meaning in work, while the average score on the commitment to work scale was 28.6, reflecting a moderate level of commitment to work. Figure 2 presents average subscale scores for the Commitment to Work and Work and Meaning Inventory across three participant roles: aviation/aerospace professionals, graduate students, and undergraduate students. Across all CTW subscales: Efficacy, Locus of Control, and Motivation—scores increased progressively from professionals to undergraduates, suggesting a trend of heightened perceived work commitment among younger or less experienced individuals. Similarly, WAMI subscales—Greater Good, Meaning-Making, and Positive Meaning—also showed increasing scores across roles, with undergraduates reporting the highest levels of perceived work meaning. These patterns may reflect developmental or contextual differences in how individuals relate to their work, with students potentially idealizing work as more meaningful and engaging compared to professionals with more practical experience.

Figure 1. Average WAMI and Commitment to Work subscale scores by role

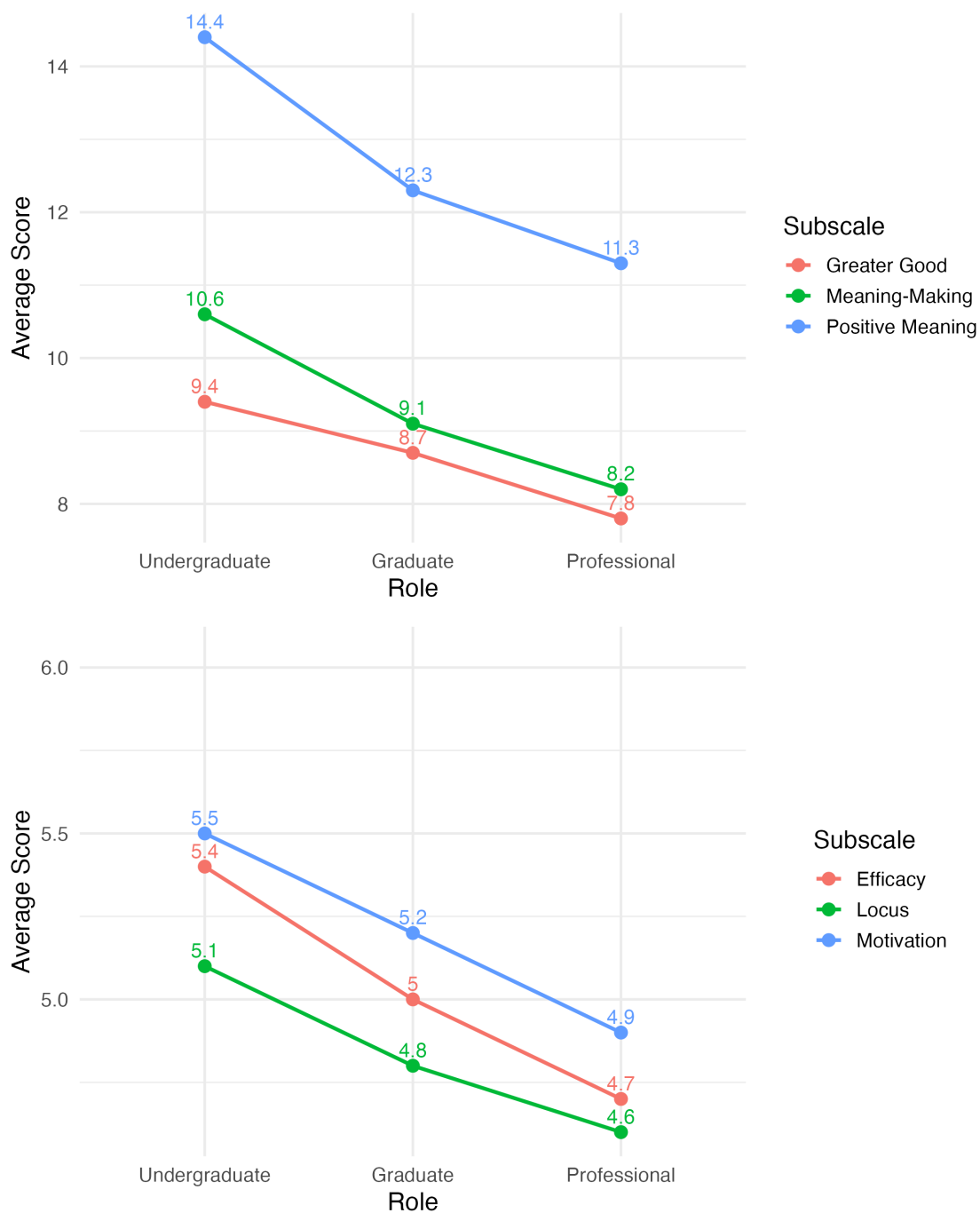


Figure 2: Average Work and Meaning and Commitment to Work Subscale Scores by Role. Line graphs display mean scores for three subscales from the WAMI and three subscales from CTW, grouped by role: Undergraduate, Graduate, and Professional.

3.4 Mental Health and Wellbeing

Scores on the PSS ranged from 0 to 35, with a mean score of 19.81 (SD = 4.05). Nearly half of the respondents (47.4%) scored between 20–24, indicating moderate levels of perceived stress. When asked about changes in their overall stress level over the past six months, responses were mixed: 31.8% indicated that their stress had decreased, 30.2% reported it had stayed the same, and 30.0% stated that it had increased. These results suggest considerable variability in how individuals perceive changes in their stress over time, despite a substantial portion reporting recent stressful experiences. The average score on the K10 was 29.1 (SD = 4.1), indicating a relatively high level of distress among respondents. The largest proportion of participants (38.9%) scored in the 30–34 range, while 28.4% fell in the 25–29 range. In addition, half of respondents (50.0%) reported experiencing a significantly stressful event in the past 30 days.

The majority of participants reported moderate resilience levels across all groups, ranging from 58.4% to 77.5%, with the overall sample at 64.4%. Only a small proportion of respondents were classified as having high resilience, ranging from 1.4% to 9.3% across subgroups, and just 3.2% overall. These findings suggest that while most individuals show average resilience, targeted support may be needed for groups with elevated rates of low resilience.

Participants reported varying sleep difficulties, with the most common being 2 nights per week (30.6%), followed by 3 nights (25.7%) and 0–1 nights (16.9%). Fewer reported problems on 4 nights (18.7%) or 5–7 nights (8.1%) weekly.

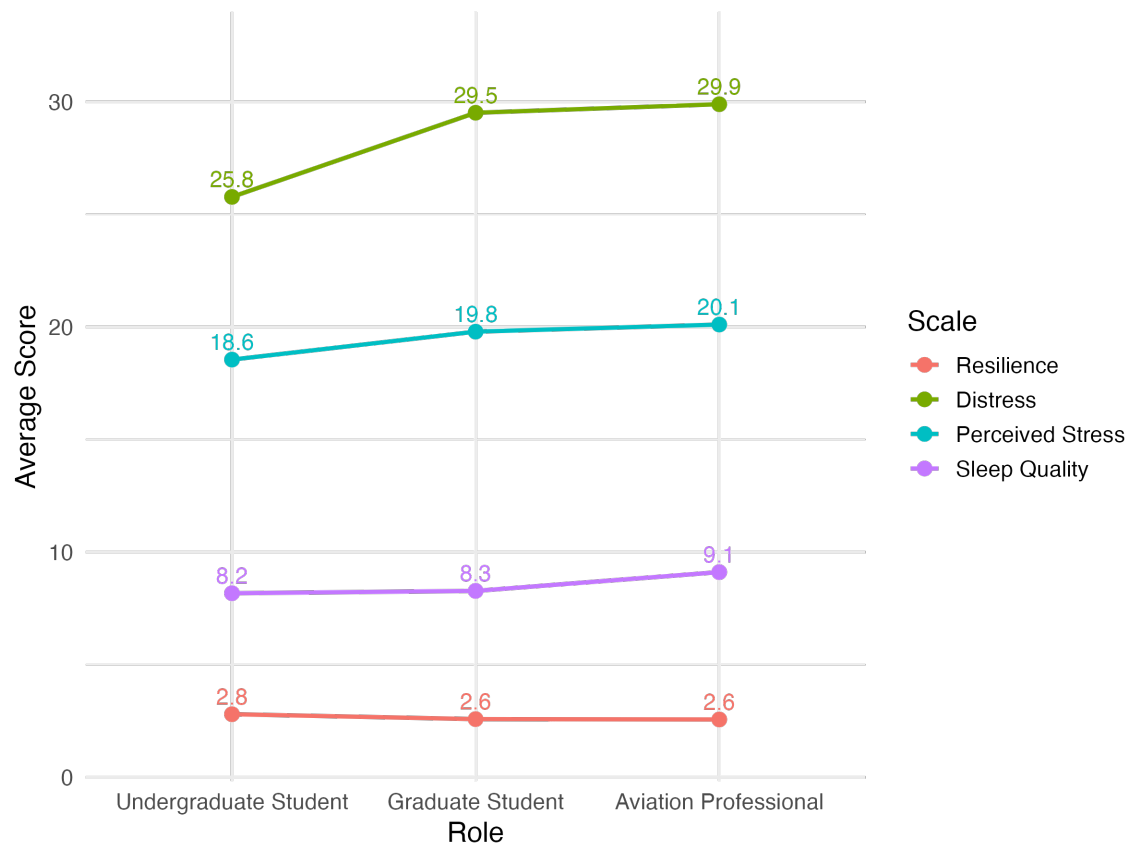


Figure 3: Average mental health scale scores by role. Line graph displays mean scores for Resilience, Distress (K10), Perceived Stress (PSS), and Sleep Quality across three roles: Undergraduate Student, Graduate Student, and Aviation/Aerospace Professional.

3.5 Model Results

Perceived barriers were selectively associated with work-related meaning, motivation, and sustainability contributions. Lack of belief in making a difference was linked to lower efficacy ($b = -0.68$, 95% CI $[-1.32, -0.04]$), suggesting participants who felt their efforts were unlikely to influence outcomes reported reduced self-efficacy. Interestingly, lack of funding was positively associated with positive meaning ($b = 1.49$, 95% CI $[0.70, 2.28]$), indicating that participants perceiving funding barriers paradoxically reported greater positive meaning at work. For sustainability outcomes, lack of employer support was consistently associated with higher reported contributions across domains: environmental ($b = 0.68$, 95% CI $[0.17, 1.20]$) and economic contributions ($b = 0.79$, 95% CI $[0.26, 1.32]$), while the association with social contributions ($b = 0.50$, 95% CI $[0.00, 1.01]$) did not reach significance. All models controlled for demographic (age, gender, income, role) and psychological covariates (perceived stress, distress, resilience, sleep quality, mental health diagnosis), and missing data were handled via complete-case analysis. Overall, these results suggest that specific motivational and organizational barriers differentially influence employees' perceived efficacy and engagement in sustainability-related behaviors, highlighting the nuanced role of organizational support and personal beliefs in shaping meaningful work experiences.

Table 3: Results of Regression Models

	Meaning and Work			Commitment to Work			Sustainability		
	Positive Meaning	Meaning-Making	Greater Good	Locus	Motivation	Efficacy	Social	Environmental	Economic
Lack of support from team	0.52 (-0.26, 1.30)	0.31 (-0.27, 0.89)	0.54 (-0.10, 1.18)	0.12 (-0.55, 0.79)	0.58 (-0.06, 1.22)	0.31 (-0.29, 0.91)	0.05 (-0.46, 0.55)	-0.27 (-0.79, 0.25)	0.50 (-0.02, 1.01)
Lack of belief you will make a difference	-0.28 (-1.11, 0.56)	0.04 (-0.58, 0.66)	0.27 (-0.42, 0.96)	0.29 (-0.42, 1.01)	0.20 (-0.49, 0.89)	-0.68 (-1.32, -0.04)	0.33 (-0.24, 0.90)	0.45 (-0.13, 1.03)	0.18 (-0.39, 0.74)
Lack of support from employer	0.17 (-0.61, 0.95)	-0.28 (-0.86, 0.29)	0.15 (-0.49, 0.79)	0.36 (-0.30, 1.03)	-0.08 (-0.71, 0.56)	0.29 (-0.30, 0.89)	0.50 (0.00, 1.01)	0.79 (0.26, 1.32)	0.68 (0.17, 1.20)
Lack of funding	1.49 (0.70, 2.28)	0.45 (-0.14, 1.05)	0.32 (-0.34, 0.98)	0.52 (-0.17, 1.21)	0.46 (-0.20, 1.12)	0.34 (-0.27, 0.96)	-0.21 (-0.72, 0.30)	-0.05 (-0.58, 0.49)	-0.27 (-0.79, 0.26)

3.6 Focus Group Results

A total of 12 individuals participated in focus groups. All participants were students in the aviation/aerospace field.

3.6.1 Types of Sustainability

When discussing sustainability, participants described it in environmental, social, and economic terms. From an environmental perspective, sustainability was primarily understood through the lens of fuel efficiency, the development of sustainable aviation fuels, and interest in new technologies such as electric planes, all connected to the overarching goal of reducing emissions. Participants expressed interest in seeing new developments in the field, one stating *“So with respect to environmental sustainability, [...] we’re quite interested in just seeing the technology and stuff grow.”* Social sustainability was interpreted as addressing diversity and inclusion in aviation, with a particular focus on supporting minorities and women, challenging the culture of pressure, and promoting mental health awareness. Economic sustainability was described as being shaped by the significant financial burden of flight training, the high costs associated with implementing new technologies, and the realities of job prospects in aviation. These three dimensions of sustainability were deeply interconnected, shaping how students and early-career professionals viewed both the challenges and the possibilities for sustainable practices in aviation.

3.6.2 Structural Barriers to Sustainability

Focus group participants described several structural barriers to advancing sustainable practices, such as limited infrastructure to support sustainable technologies. For example, several student pilots spoke about the electric plane available at their workplace or school. They explained that its use was largely restricted to research purposes, that it had a short flight range, and that its availability for students was limited. As one participant put it, *“Yeah, while we are seeing amazing advancement, development and certifying truly 0 emission aircraft for industrial use is a massive undertaking that takes a lot of time and investment.”*

Cost was another critical factor shaping the feasibility of sustainable practices. Participants noted that sustainable fuels, as well as education and training in emerging technologies, were expensive. Financial sustainability in general was described as difficult to achieve, both at the student and institutional levels. Beyond costs, participants raised concerns about accessibility, particularly in relation to transportation to and from flight centers. Some students highlighted personal struggles, or those faced by peers, in reaching training sites without reliable transportation. One student explained, *“From a personal standpoint, I know that I’ve experienced a little bit of prejudice when it comes to being a woman in aviation and I have a lot of fellow friends who also struggle with some of those barriers.”* In addition, participants emphasized that there was little incentive to practice sustainability in day-to-day flight training. For example, both instructors and students were said to lack any direct benefits for engaging in fuel-efficient flying behaviors, which discouraged consistent adoption of sustainable practices.

3.6.3 Barriers to Meaning in Work

Participants also identified specific factors that hindered their ability to seek or sustain meaning in their work and education. A central theme was the misalignment between passion and practice.

Many described a deep love for flying or teaching that often clashed with systemic stressors such as low pay, rigid timelines, and a lack of autonomy. This disconnect was especially evident for those aspiring to become flight instructors. While the role was seen as personally meaningful, it was often described as undervalued compared to airline pilot positions. The resulting stigmatization of alternative career paths reduced the sense of legitimacy and satisfaction participants could derive from roles they otherwise found fulfilling.

The culture of comparison and pressure further compounded these challenges. Students often measured their progress against that of their peers, which led to feelings of inadequacy and diminished self-worth. The fast pace of training and high performance expectations created an environment where individuals felt they were “not good enough” or “not progressing fast enough,” undermining personal growth and motivation. As one student reflected, *“I wouldn’t really say that barriers have stopped me in any sense, but it has definitely made me experience a bit of a learning curve.”* Another added, *“But I think these kind of barriers actually shaped me to be even more passionate about the role, you know, as a pilot, you learn about how you have to be disciplined. You have to manage workload.”*

Instructor–student dynamics also played a role. Participants spoke about mismatched teaching styles, poor adaptability among instructors, and limited institutional responsiveness, all of which left students feeling unsupported in their development. One participant described, *“I’ve noticed though it’s motivating for some, I just noticed that the culture at our flight center, often with the instructors and the staff, sometimes they can be pushing students. I know it’s an encouraging way, but I’ve just seen other peers... sometimes get a little bit discouraged.”* Together, these conditions created significant barriers to finding and sustaining meaning in their work, even among those with strong intrinsic motivation and commitment to the field.

3.6.4 Mental Health, Wellbeing, and Supports Needed

Focus group participants also shared their experiences with or knowledge of struggles related to mental health and wellbeing, many of which they described as deeply embedded in the culture of aviation training. One of the most prominent concerns was the stigma and taboo surrounding mental health. Disclosing conditions such as migraines, substance use, or emotional distress was widely perceived as risky and potentially career-threatening. This culture of silence was reinforced by the competitive environment of aviation, which fostered isolation, comparison, and reluctance to engage in open dialogue. Work-life imbalance was another recurring issue. Irregular schedules, performance pressures, and academic demands disrupted sleep, personal routines, and overall wellbeing. For international students, these challenges were compounded by cultural adjustments and limited access to established support systems, which heightened feelings of isolation and vulnerability.

In response to these challenges, participants called for more safe spaces and opportunities for open dialogue around mental health—environments where individuals could speak freely without fear of judgment or professional consequences. One participant emphasized this need, stating: *“Every everyone in the industry and everyone like in this room, everyone has problems. And I think if we can kind of be more honest about that and have a safe space to talk about that sort of thing, that would be a lot more. That would give a lot more like support.”* They also highlighted the importance of stronger

mentorship and community-building initiatives, particularly for international students. Greater transparency and education around health and legal requirements in aviation were identified as additional priorities. Finally, participants recommended that institutions take a more active role in supporting student wellbeing, including the introduction of mental health seminars, regular check-ins, and more responsive student management systems. Such supports, they suggested, would help to mitigate the psychological toll of aviation training and create a healthier, more sustainable learning environment.

4 Discussion

This study offers new insights into the psychological and motivational dimensions of sustainable work in the aviation and aerospace sector. While study participants generally reported a moderate level of meaningful work, findings suggest that there remains considerable scope to improve alignment between individuals' values, responsibilities, and broader sustainability goals. Many participants perceived themselves as contributing positively yet also described systemic barriers that limited their engagement. These findings echo previous literature indicating that organizational conditions are central to meaningful work (15,29,30). For instance, consistent with studies showing that job insecurity and underemployment undermine meaning (17–19), participants described concerns about precarious employment and lack of long-term career pathways in sustainable aviation. Yet, in contrast to studies that highlight primarily negative outcomes of systemic barriers, study participants also reported resilience and strong intrinsic motivation to contribute to sustainability goals, suggesting a high degree of personal investment in this sector. This balance between structural constraints and individual purpose underscores that meaningful work is not only shaped by external job characteristics but also by personal values and commitments, extending prior research by highlighting how sustainability-oriented sectors may foster distinct forms of motivation despite systemic challenges.

Focus group participants articulated a multidimensional understanding of sustainability, encompassing environmental, social, and economic concerns. These insights illustrate that students perceive sustainable work not only in abstract or technical terms but as intertwined with personal and systemic constraints, reinforcing prior work on the contextual nature of meaningful work (5,6). Limited access to sustainable technologies, high costs of training, and logistical challenges were described as hindering engagement in sustainable practices. Similarly, barriers to meaning in work were evident in the misalignment between students' intrinsic motivations—such as passion for flying or teaching—and institutional recognition or career valuation. Roles like flight instruction, though they may be personally fulfilling, were described as undervalued relative to airline pilot positions, mirroring broader findings on the negative impact of lack of recognition on meaningful work (2,41). Participants also discussed the culture of pressure and peer comparison in aviation training, which exacerbated stress and undermined personal growth, highlighting the relational dimensions of meaningful work and motivation that may be particularly salient in high-performance environments (42,43).

Mental health and wellbeing emerged as further concerns. Consistent with survey data, students described elevated stress, disrupted sleep, and limited access to support. The stigma surrounding

mental health was widely noted, with disclosure perceived as risky due to potential career consequences. International students and women reported additional vulnerabilities due to cultural, financial, and systemic barriers, aligning with literature on help-seeking inequities in high-pressure professions (44,45). Participants recommended structural and cultural interventions, including safe spaces for dialogue, mentorship programs, mental health education, and responsive institutional supports. These perspectives reinforce the need for interventions that integrate both systemic reform and the promotion of psychological safety, extending prior research on meaningful work by emphasizing the interplay between intrinsic motivation, social support, and organizational culture in sustaining engagement in sustainability-oriented fields (43,46).

Integrating survey and focus group findings highlights a dual reality: students and early-career professionals demonstrate strong commitment and resilience toward sustainable work, yet their experiences are constrained by structural, cultural, and recognition-related barriers. Addressing these challenges requires targeted institutional strategies that simultaneously enhance meaningful work, support wellbeing, and facilitate engagement with sustainability practices.

4.1 Limitations

Several limitations of this study should be considered. Quantitative data were collected via self-report measures, which may be subject to social desirability, recall bias, or subjective interpretation, potentially affecting the accuracy of reported behaviors, mental health status, and sustainability contributions. Recruitment relied on targeted outreach through institutional and professional networks, and participation was voluntary, which may have introduced selection bias by over-representing highly motivated or engaged individuals.

Focus group participants were predominantly students or individuals also working in aviation, limiting the diversity of perspectives, particularly from mid-career professionals or those outside academic settings. The cross-sectional design of the survey restricts causal inference, as observed associations between barriers, work meaning, and mental health outcomes may reflect bidirectional or confounded relationships. Some survey constructs, including sustainability contributions and perceived barriers, were adapted or novel items; while pilot-tested, their psychometric properties in this population remain uncertain. Most participants were affiliated with Canadian institutions, and although international students were included, the findings may not be generalizable to other cultural or geographic contexts. The focus on aviation and aerospace sustainability also limits applicability to other sectors, as unique industry stressors and organizational factors may influence the experiences observed. Finally, focus group discussions may have been influenced by social desirability or group dynamics, potentially leading participants to underreport sensitive experiences, such as mental health struggles or institutional criticisms. These limitations highlight areas for cautious interpretation and underscore the need for future research using longitudinal designs, broader sampling strategies, and multi-method approaches to further validate and expand these findings.

5 Conclusion

This study highlights the complex interplay between meaningful work, sustainability engagement, and mental health in the aviation and aerospace sector. Consistent with prior research

linking meaningful work to well-being and job satisfaction (1,2), participants who perceived alignment between their values and work reported higher motivation, yet systemic barriers (including misaligned recognition, high performance pressure, and limited autonomy) undermined their engagement. Mental health challenges were prevalent, echoing literature on stress and psychological risk in high-performance, safety-sensitive industries (39,40). Despite these challenges, participants actively contributed to sustainability through research, education, advocacy, and innovation, demonstrating the potential of individual agency when supported by enabling organizational environments. These findings underscore the need for interventions that integrate support, inclusive leadership, and structural reforms to enhance both workforce well-being and sustainable practices in aviation and aerospace.

Appendix

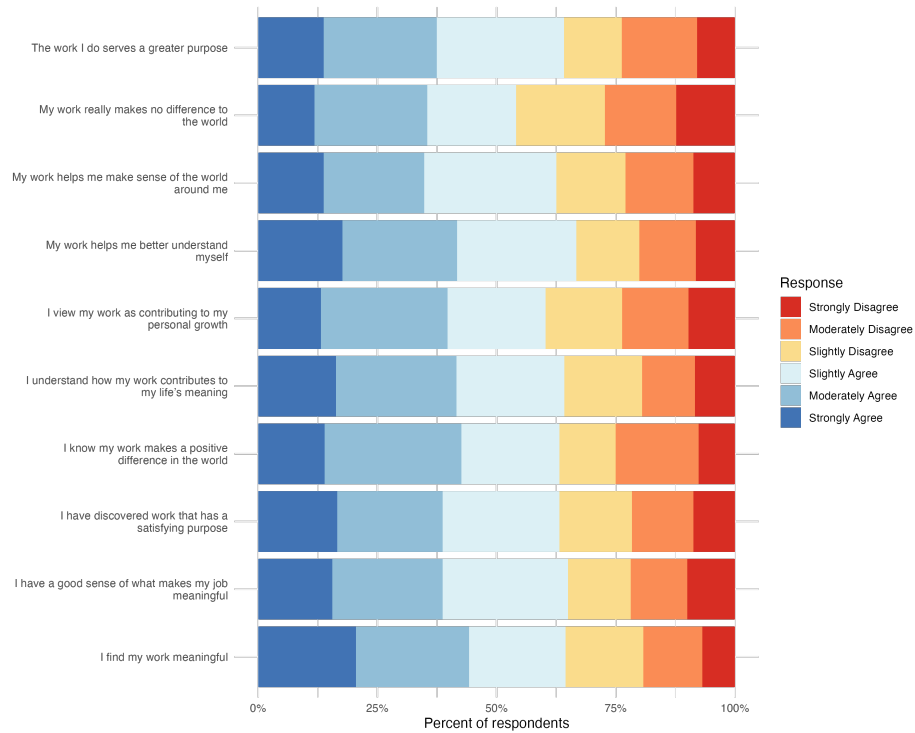


Figure A.1: Distribution of respondents' agreement levels with statements from the Work and Meaning Inventory (WAMI). This figure presents the percentage breakdown of responses to ten WAMI items assessing perceptions of work's purpose, personal growth, and meaningfulness. Agreement levels range from "Strongly Disagree" to "Strongly Agree," offering insight into how individuals experience meaning in their professional roles.

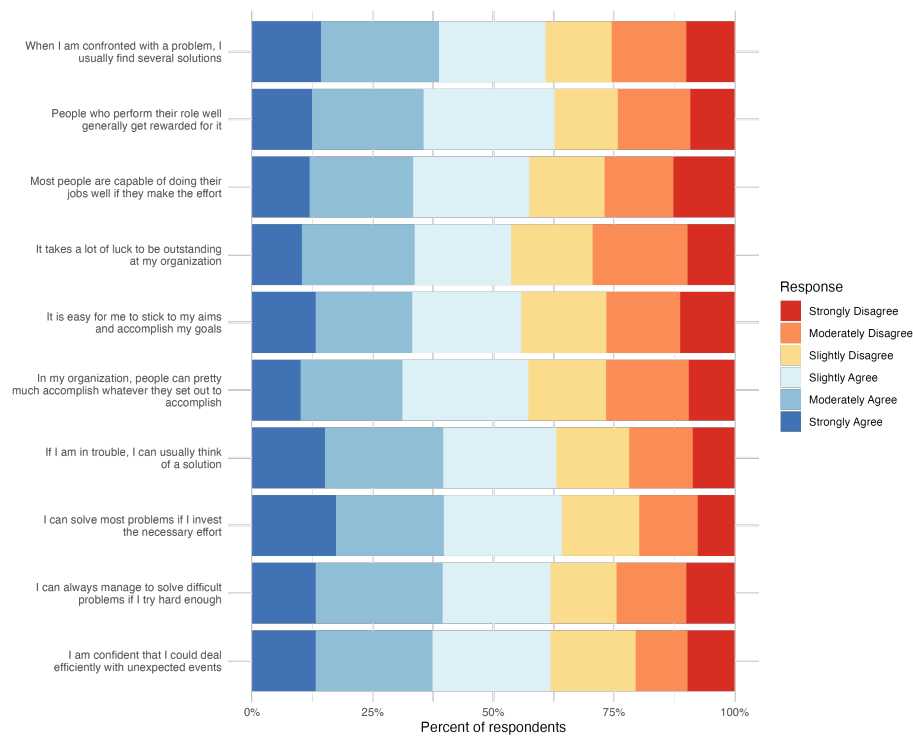


Figure A.2: Distribution of respondents' agreement levels with statements related to commitment to work. This figure presents the percentage breakdown of responses to ten items assessing locus of control, efficacy, and motivation. Agreement levels range from “Strongly Disagree” to “Strongly Agree,” offering insight into how individuals experience meaning in their professional roles.

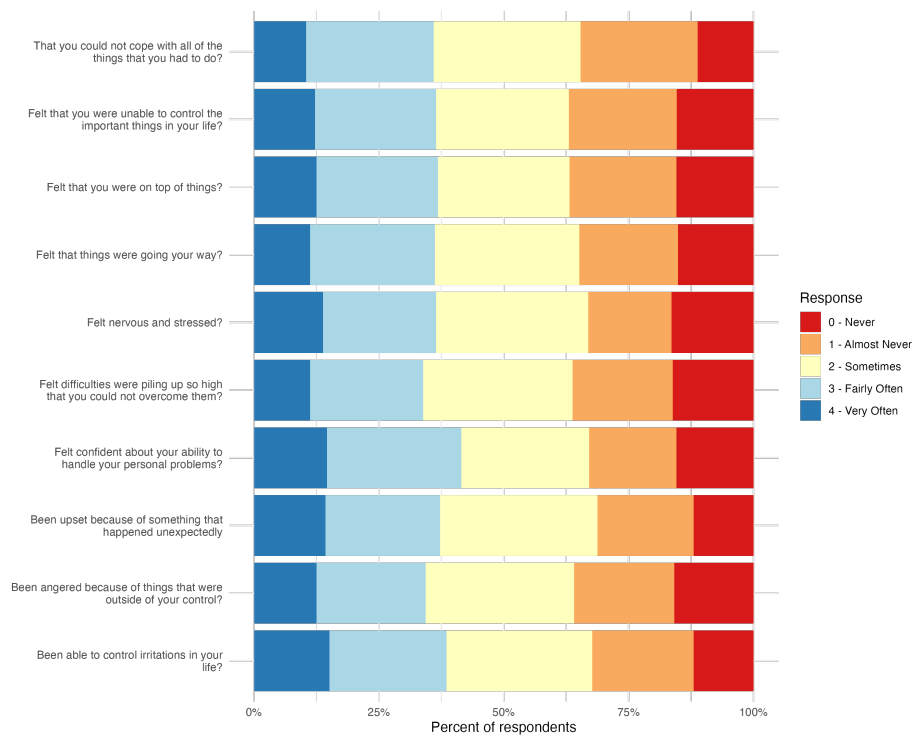


Figure A.3: Distribution of respondents' frequency ratings for items from the Perceived Stress Scale (PSS). This figure displays the percentage of responses to ten PSS items assessing perceived stress and coping ability. Response options range from "Never" to "Very Often," illustrating how frequently individuals experience stress-related thoughts and emotions in their daily lives.

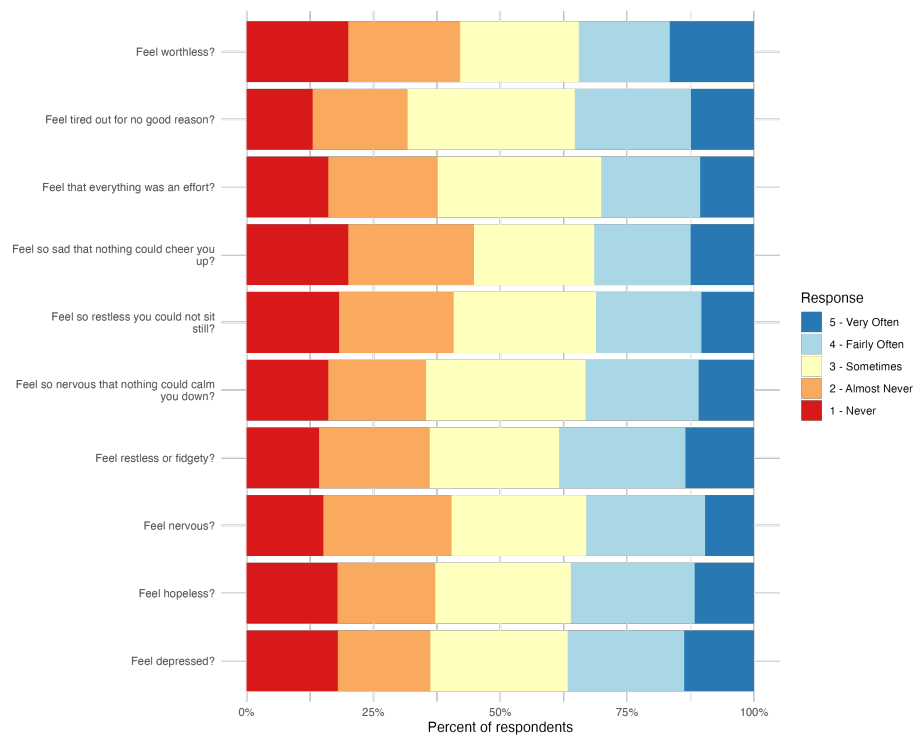


Figure A.4: Distribution of respondents' frequency ratings for items from the Kessler Psychological Distress Scale (K10). This figure presents the percentage of responses to ten K10 items assessing psychological distress, including feelings of hopelessness, nervousness, and fatigue. Response options range from "Never" to "Very Often," offering a snapshot of how frequently individuals experience symptoms associated with mental health challenges.

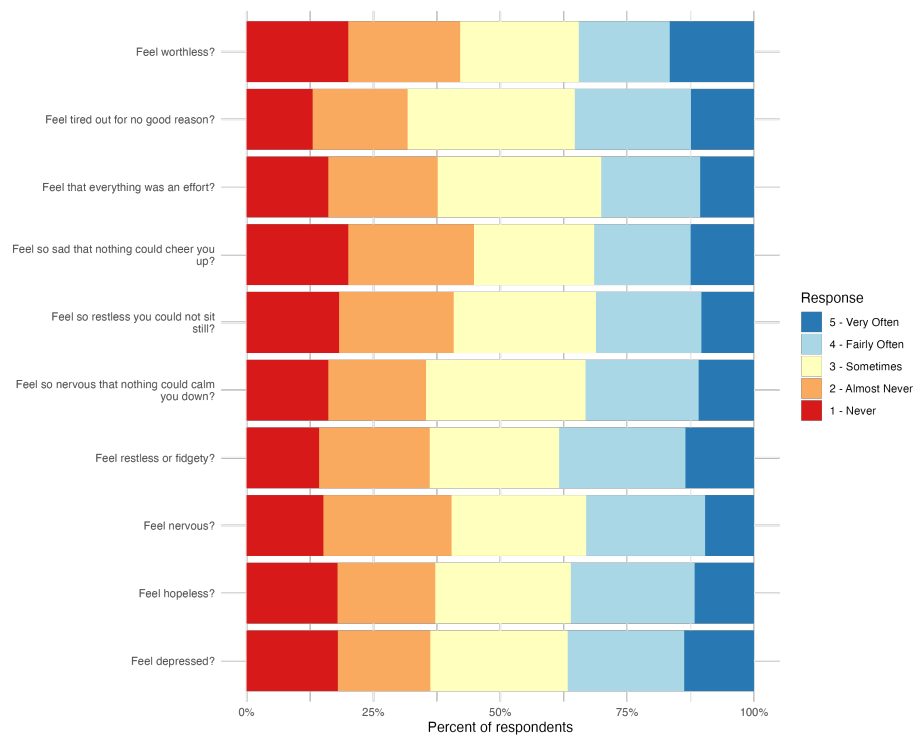


Figure A.5: Distribution of respondents' agreement levels with items from the Brief Resilience Scale (BRS). This figure shows the percentage of responses to six BRS items assessing individuals' ability to recover from stress and adversity. Agreement levels range from "Disagree" to "Agree," providing insight into self-reported resilience and emotional recovery.

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