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RESEARCH ARTICLE

Career Change Intentions of Science and Engineering Undergraduates: A Behavioral Neuroscience Inquiry

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ABSTRACT Based on self-determination theory, this study examined the mental and emotional states of final year Science and Engineering undergraduates in career change considerations. While prior work has explored students' career choice, career change intentions particularly among the new entrants in the contemporary workforce, remains an under researched domain. A purposive sample of thirty final-year Science and Engineering undergraduates participated in a laboratory experiment in which an electroencephalogram (EEG) device was used to detect their mental states when responding to career decision stimuli involving salary and work-life balance considerations for Research and Development Specialist (scientific career) and Management Associate (non-scientific) positions. The EEG results showed significantly higher beta activation (which indicated stress levels) for participants who were less self-determined, at the point of reviewing the job description (which included work-life balance company policies) for the Research and Development Specialist (R&D) position. The manipulation of salary levels did not have a significant impact on their stress levels. While almost all participants opted for a R&D career during the experiment, the survey data revealed a stronger intention among less self-determined individuals to leave science at a later juncture due to perceived lower salary and a lack of work-life balance. Overall, this study underscores the importance of self-determination to promote sustainable scientific career. From these findings, implications towards career counselling for contemporary science and engineering workforce are further discussed.

INDEX TERMS Career change, self-determination, STEM, EEG signals, behavioral experiment.

I. INTRODUCTION

As the global economies are adapting to post-pandemic transitions, university graduates continue to grapple with an uncertain employment prospect while navigating the contemporary career landscape, that transcends disciplinary, geographical and personal boundaries [1]. Within this context, the Covid-19 pandemic has also reinforced the importance of healthcare, science, engineering and related disciplines towards boosting research and development activity and Gross Domestic Product (GDP) growth [2]. These developments accentuate the vital roles that the higher education sector undertake in producing the necessary Science, Technology, Engineering, and Mathematics (STEM) human capital towards achieving the Sustainable Development Goal targets [3], [4] and enhancing students' career development strategies within an ever more challenging labor market context [5].

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The 'leaky' STEM pipeline phenomenon referring to the dropout in STEM education remains a national concern globally including the developed nations. National policies tend to focus upon increasing the production of more STEM graduates to meet labor market demands, while there is a lack of attention towards promoting STEM career persistence [6]. This is particularly vital when STEM graduates, as new entrants in the workforce are actively exploring their professional identities while navigating the unfamiliar terrain of working life.

As career choices may vary over time during the higher education pursuit, this study provides insights into the career change intentions of final-year science and engineering undergraduates as they begin to explore career options more deeply. To advance our understanding of the complex phenomenon of career change decisions among STEM undergraduates, this study employs a behavioral neuroscience approach that has rarely been undertaken in career studies to date. Alongside questionnaire administration, this methodological approach seeks to add value to existing discourse by examining the mental states and behavioral responses of students through conscious and subconscious decision-making processes in a laboratory experiment setting. This undertaking minimizes the potential impact of social desirability biases which may be a concern in self-reported survey instruments [7]. Given the importance of STEM career persistence and its implications for the individuals, organizations, and national priorities, this study examines the role of self-determination in influencing final year science and engineering undergraduates' career change considerations.

II. CAREER CHOICE AND PERSISTENCE

Career choice can be regarded as a particular case of decision-making under uncertainty when the aim is to reach an optimal choice among alternatives [8]. These decisions consider which values are important to the individual, what tasks and activities an individual finds interesting, how rewarding the prospective career will be and how work roles will interact with nonwork roles. Finding a job related to one's field of study or anticipated career is important for individual seeking full-time jobs for the first time, as this will have an impact on their immediate job prospects as well as long-term career trajectories [9]. Moreover, a successful career outcome can be interpreted as how closely a college graduate's job is related to the undergraduate field of study.

In the context of career choice in STEM, a systematic review reported personal factors (personality, gender), environmental factors (parental influence, culture) and behavioral factors (motivation, goals, interest) play a role in influencing STEM major decisions [10]. While studies have examined factors shaping students' career choice in STEM as post-secondary pursuits [11], [12], [13], limited research has examined students' career change considerations at the critical juncture of university-to-work transition. A common view holds that STEM careers are imbalanced towards fulfilling broader life demands, which lead many science graduates to opt for non-STEM careers. Dissatisfaction with career identity and salary concerns also feature as barriers to a sustained scientific career, particularly for research scientists [14]. These perceptions seem to contradict reports that evidenced higher employability prospects and wages earned by STEM graduates, compared to non-STEM graduates [15].

In the contemporary career context, Gen Z, commonly characterized by individuals born around the mid-1990s/2000 reported to search for financial security, personal fulfillment, and work-life balance [16]. With mental health issues reported to be prevalent among Gen Z college students, there is a need for further research in examining the role of negative arousal emotions on career planning behaviors [17]. University-to-work transitions can be stressful especially during the job search phase as individuals are seeking to achieve certain employment goals. Given the importance of career decisions and the dynamic career environment, university students are increasingly seeking counseling services due to stress and confusion associated with career indecision.

III. CAREER CHANGE AND SELF-DETERMINATION

This study defines a career change as ''changing to a work position in a different occupation category or field, where previous skills and responsibilities are largely irrelevant and new training is undertaken'' [18]. In issues surrounding STEM human capital retention, STEM-prepared students are increasingly being recruited into non-STEM occupations that value the analytical abilities developed via STEM education, such as management consulting, data analytics, and supply chain roles in multinational firms. As job consideration is characterized by the need to be self-motivated and to cope with uncertainty, the mental states involved in a career change consideration remain under researched. Exploring this phenomenon in the context of STEM workforce, this study draws on self-determination theory (SDT) that highlights three fundamental needs, namely, autonomy, competence, and relatedness, that influence career decision and overall well-being [19], [20].

Self-Determination theory asserts that to understand why people participate in certain activities or behave in certain ways, the different types of motivation need to be distinguished as they would lead to varied outcomes [19]. Autonomous motivation is predominantly based on self-regulated orientation which comprises of intrinsic motivation and extrinsic motivation in which people have identified with an activity's value and integrated into the sense of self. On the other hand, controlled motivation consists of external regulation based on reward and punishment, approval motive, avoidance of shame or contingent self-esteem [20]. Both autonomous motivation and controlled motivation energize and direct behavior, unlike the state of amotivation which refers to a lack of intention and motivation.

Applying SDT in the academic context, the Academic Motivation Scale (AMS) measures a student's predisposition towards autonomous motivation (for the pleasure of

learning and internalized values of the pursuits), controlled motivation (external contingencies), and amotivation (a state of helplessness) in the pursuit of a college education [21]. This scale was further validated among university students in Malaysia and has provided insights into the ways different degrees of self-determination may lead to varied outcomes in students' learning experiences, satisfaction, and behavioral intention [22]. While external motivation may play a role in influencing one's career choice in Engineering, for instance [13] and [23], intrinsic motivation may lead to career persistence over time. Aligning to the 'possible selves' literature from social psychology, individuals who are more self-determined in the tertiary course enrolment are likely to envision their future selves in scientific careers and persist towards this career direction [24]. To further understand career change intentions among the new entrants of the STEM workforce, this study examines the influencing role of self-determination upon the mental states of the final year science and engineering students in career change intention while considering the common trade-offs involving work-life balance and salary concerns. This study postulates the following hypotheses:

H_1: Students with higher levels of self-determination in course enrolment will choose to remain in a scientific career, regardless of salary and work-life balance considerations.

H_2: Students with lower levels of self-determination in course enrolment will choose to leave the scientific career, in pursuit of work life balance despite trade off in lower salary.

H_3: Students with higher levels of self-determination in course enrolment will experience lower stress levels (compared to students with lower self-determination) in the career decision-making process.

IV. METHOD

A. SAMPLE

A purposive sample of thirty (30) final-year Malaysian science and engineering undergraduates born after the year 1996 was recruited for the experimental study, which was carried out at a neuroscience laboratory located in a private university. As reported in behavioral sciences literature, at least 20 data points [25] or 30 participants [26] are sufficient to draw a valid conclusion for applied neuroscience studies. As brain wave research is relatively novel especially in the job search context, similar guidelines for sample size determination are deemed relevant for this exploratory study. The sample recruited consisted of 12 males and 18 females with mean age (Mean:22±1 years), see Table 1, no previous history of psychiatric neurological disorders, and no excessive intake of caffeine or alcohol that might affect the experimental results. All participants provided their consent for the experimental study, which was approved by the University Ethics Committee. As a token of appreciation, each participant was given a cash voucher equivalent to approximately USD10 for their voluntary participation.

TABLE 1. Participants' profile.

ID	Academic Course	Gender	Age
1	Biotechnology	Male	22
2	Biotechnology	Male	22
3	Medical Bioscience	Female	22
4	Medical Bioscience	Female	22
5	Bachelor of Science	Female	22
6	Bachelor of Science	Female	22
7	Medical Bioscience	Female	23
8	Biotech. & Medical Bioscience	Female	21
9	Biology with Psychology	Male	20
10	Biology with Psychology	Female	21
11	Biotech. & Medical Bioscience	Female	21
12	Medical Bioscience	Female	21
13	Food Science & Technology	Female	20
14	Food Science & Technology	Male	22
15	Biomedical Science and Biotech.	Male	23
16	Medical Biotechnology	Female	21
17	Medical Biotechnology	Female	21
18	Biology with Psychology	Female	22
19	Bachelor of Science	Female	23
20	Chemistry	Male	23
21	Medical Bioscience	Female	22
22	Mechanical Engineering	Male	24
23	Optical Engineering	Male	22
24	Mechanical Engineering	Male	23
25	Chemical Engineering	Female	23
26	Pharmacy	Female	23
27	Medical Biotechnology	Male	21
28	Pharmacy	Female	22
29	Bachelor of Engineering	Male	23
30	Bachelor of Engineering	Male	23

B. EEG BETA WAVE AS STRESS INDICATORS

An electroencephalogram (EEG) device was used to capture dynamic, moment-by-moment insights into individuals' career decision-making processes. An EEG records the electrical voltage potential of the neuronal activities using multichannel montage over the scalp. The EEG oscillations reflect the neuronal ensemble responses concerning a particular stimulus or task [27], [28]. The objective of employing a neuroscience methodology was to detect the participants' responses to the job advertisement and job offer stimuli that may have substantial impacts on individuals' career decision-making. The typical EEG frequency ranges involved in human cognitive processes are 4–50 Hz. In particular, EEG readings at higher frequencies indicate beta activity (13–30 Hz), which is recognized as one of the features for the classification of stress in human [29]. Frontal lobe activity was captured using three electrodes (F3, F4, and Fz) locations, and accordingly EEG mean power was calculated in beta frequency band for each participant. Given that career uncertainty can pose barriers to career development and may have a negative impact on mental and physical adjustment [30], beta frontal activation is used as an indicator of stress and anxiety experienced in the decision-making process.

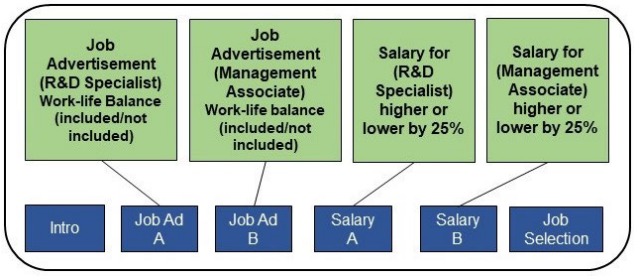

FIGURE 1. EEG experiment stimuli. (adapted from: Lee et al (2014)).

This study examines the extent of differences in EEG beta activities (higher stress levels) in the frontal cortex of participants who reported high or low self-determination in undertaking a science and engineering degree. To complement the brain wave data, behavioral data was captured via experimental responses and questionnaire survey to offer further insights into participants' self-determination in the course of study, and perceptions towards R&D and management careers.

C. DESIGN

The ANT Neuro device which consists of 32 channels was used. Upon wearing the EEG cap which usually took about 1 to 1.5 hours for necessary preparation, each participant was brought to an EEG laboratory and seated inside a Faraday enclosure. Before the experiment began, the participant was led to feel calm and at rest while the baseline EEG activity for this initial state was measured. As per standard practice in EEG experiments, a '5-minutes eyes closed and 5-minutes eyes opened' procedure was carried out before the stimuli presentation. The frontal lobe activity was captured by using three EEG electrodes (F3, F4, and Fz) for each participant [27].

All participants demonstrated 'normal' brain wave responses, with alpha waves during eyes opened were lower than alpha waves during eye closed (at a relaxed state). As part of the pre-experimental procedures, the participants were asked to complete a questionnaire survey regarding their demographic profiles and their academic motivation and perceptions, such as their attitudes towards science, perceived future self in science, and perceptions of R&D and management associate careers.

A within-subject design was used, and all participants were exposed to the same experimental scenarios and stimuli. Each participant was presented with both a job advertisement for an R&D specialist position in a scientific research firm and a job advertisement for a Management Associate position responsible for branch operations and corporate planning tasks in the banking sector. After the subjects had read the job advertisements, the salary and work-life balance information for each job option were presented to them, and the subjects were then asked to make their choice of jobs. After viewing the job advertisements, the salary information of each job option was presented, followed by the job choice decision,

FIGURE 2. Contents of jobs advertisement.

as described in Fig. 1. E-Prime software was used for the configuration of the experimental interface.

Three rounds of job decisions were operationalized in this study, with varied manipulation of salary and work-life balance factors in the experimental design.

(1) In Round One, the same salary offers were presented for both job positions, and neither job advertisement provided work-life balance information.

(2) In Round Two, only the management associate advertisement contained information on work-life balance; however, the management associate job offered a lower salary (25% variance) than the R&D specialist job.

(3) In Round Three, only the R&D specialist job advertisement contained additional information on work-life balance; however, the R&D specialist job offered a lower salary than the management associate job (25% variance).

As mentioned, all participants were required to go through all three rounds and indicate their job choice for each round. The job advertisement can be seen in Fig. 2.

D. MEASURES

The Academic Motivation Scale (AMS) was adapted in this research study to measure students' degree of self-determination for STEM course enrolment. The mean score for each subscale of the AMS was used to calculate the self-determination index (SDI) [21]. Other measurements of student perceptions included perceived future self in science [31], attitudes towards science [32], and levels of satisfaction with STEM courses [33]. Overall, the Cronbach's

alpha values for all measures used in this study were more than 0.7, which indicated adequate internal consistency. Further questions were designed to capture participants' perceptions of positions as a Research and Development (R&D) specialist (a scientific job) and a Management Associate (a non-science job) before the experimental procedure.

V. RESULTS

A. QUESTIONNAIRE SURVEY

Based upon the self-determination index, participants with high and low self-determination were grouped by using the median split procedure, which resulted in 16 participants being allocated to the high self-determination group and 14 participants being allocated to the low self-determination group. The median split procedure is commonly applied in experimental studies to facilitate intergroup comparison [34], [35]. Further analyses of gender attributes showed that there were no significant differences in the SDIs between female participants ($M_{female} = 5.67$ vs $M_{male} = 5.83$, $t(28) = 0.105$, $p = 0.917$) and male participants.

Most of the participants in the low self-determination group were funded by their families (12 participants), and 2 participants received scholarships. The high self-determination group consisted of an equal number of participants of each gender, with 8 male and 8 female participants. In this group, a majority of the participants had scholarships (9 participants), a participant was funded by the employer and 6 participants were funded by their families. The participants with high self-determination tended to do better academically in their current courses of study (a majority of these participants graduated with either a first-class or a second-class upper degree classification) than the participants with low self-determination (a majority of the participants graduated with either a second lower class or a lower category degree). Further analyses showed that participants with higher self-determination tended to have a significantly higher autonomous motivation to know the subject matter ($M_{highSD} = 6.29$ vs $M_{lowSD} = 5.33$, $t(28) = 4.43$, $p = 0.00$), to accomplish ($M_{highSD} = 5.43$ vs $M_{lowSD} = 4.64$, $t(28) = 2.67$, $p = 0.012$), and to experience stimulation ($M_{highSD} = 5.00$ vs $M_{lowSD} = 4.11$, $t(28) = 2.35$, $p = 0.026$) and had higher extrinsic motivation, which was identified with the sense of self ($M_{highSD} = 5.73$ vs $M_{lowSD} = 4.77$, $t(28) = 3.06$, $p = 0.005$). Those with lower self-determination tended to report higher levels of amotivation, which is a state of helplessness and indecisiveness ($M_{highSD} = 1.66$ vs $M_{lowSD} = 3.82$, $t(28) = 7.2$, $p = 0.00$). There were no significant differences in terms of externally driven motivations such as a higher salary or a 'good life' in the future.

To further understand participants' perceptions regarding science and management careers, analyses were conducted to test the significant differences between the participants in aspects related to their beliefs and attitudes towards science, perceived future self in science careers, and their likelihood to pursue an R&D or a management career. Table 2 presents the statistical results by level of self-determination (SDI). The results show that participants with lower self-determination in undertaking their courses of study reported significantly less favorable attitudes towards science ($M_{lowSD} = 4.86$ vs $M_{highSD} = 5.79$, $t(28) = 4.42$, $p = 0.00$) and less positive perceptions of their future self in a science career ($M_{lowSD} = 4.41$ vs $M_{highSD} = 5.16$, $t(28) = 4.65$, $p = 0.00$). These participants also tended to feel less happy in their courses of study ($M_{lowSD} = 3.65$ vs $M_{highSD} = 1.81$, $t(28) = 8.41$, $p = 0.00$) than those with higher self-determination. In terms of perceptions of an R&D career, the participants with lower self-determination perceived their careers as less likely to enable them to achieve work-life balance ($M_{lowSD} = 3.71$ vs $M_{highSD} = 5.12$, $t(28) = 3.57$, $p = 0.08$) and less promising in terms of an attractive salary ($M_{lowSD} = 4.21$ vs $M_{highSD} = 5.12$, $t(28) = 1.79$, $p = 0.00$).

TABLE 2. Behavioral survey results.

Survey Item	Group	*M*	*SD*	*t*	*Sig.*
Feelings about current course (1 – most positive feelings; 7 – least positive feelings)	Low SDI High SDI	3.65 1.81	0.62 0.57	8.41	0.00
Attitudes towards science (1 – least favorable attitudes; 7 – most favorable attitudes)	Low SDI High SDI	4.86 5.79	0.61 0.53	4.42	0.00
Perceived future self in a science career (1 – least positive perceptions; 7 – most positive perceptions)	Low SDI High SDI	4.41 5.16	0.53 0.30	4.65	0.00
R&D Specialist Career					
I think this career would enable me to earn an attractive salary (1 – strongly disagree; 7 – strongly agree)	Low SDI High SDI	4.21 5.12	1.47 1.31	1.79	0.08
I think this career would enable me to strike a balance between myself, family/friends and career (1 – strongly disagree; 7 – strongly agree)	Low SDI High SDI	3.71 5.12	1.13 1.02	3.57	0.00
I am likely to pursue this career as soon as I graduate. (1 – strongly disagree; 7 – strongly agree)	Low SDI High SDI	4.21 4.93	1.96 1.48	1.15	0.26
I am likely to pursue this career at some point in my work life. (1 – strongly disagree; 7 – strongly agree)	Low SDI High SDI	3.50 5.18	1.74 1.47	2.88	0.01
Management Associate Career					
I think this career would enable me to earn an attractive salary (1 – strongly disagree; 7 – strongly agree)	Low SDI High SDI	5.71 4.50	0.82 1.21	3.16	0.00
I think this career would enable me to strike a balance between myself, family/friends and career (1 – strongly disagree; 7 – strongly agree)	Low SDI High SDI	4.35 4.43	1.55 1.26	0.16	0.87
I am likely to pursue this career as soon as I graduate. (1 – strongly disagree; 7 – strongly agree)	Low SDI High SDI	3.35 3.00	1.94 1.93	0.50	0.62
I am likely to pursue this career at some point in my work life. (1 – strongly disagree; 7 – strongly agree)	Low SDI High SDI	4.50 3.25	1.34 1.80	2.12	0.04

TABLE 3. Behavioral responses in job selection in the experiment.

Self-Determination in Science/ Engineering Course	Job Decision for Round 1		Job Decision for Round 2		Job Decision for Round 3	
	R&D	MA	R&D	MA	R&D	MA
Low	9	5	8	6	9	5
High	15	1	14	2	14	2
Total	24	6	22	8	23	7

Note: Round 1: Same salary offers were presented for both job positions, and neither job advertisement provided work-life balance information. Round Two: Only the management associate (MA) job advertisement contained information on work-life balance; however, the management associate job offered a lower salary (25% variance) than the Research and Development (R&D) specialist job advertisement. Round Three: Only the R&D specialist job advertisement contained additional information on work-life balance; however, the R&D specialist job offered a lower salary than the management associate job (25% variance).

Although there were no significant differences between the intentions of the two groups regarding pursuing an R&D career as soon as they graduated (M_{lowSD} = 4.21 vs M_{highSD} = 4.93, $t(28) = 1.15$, $p = 0.26$), the participants in the low self-determination group were less likely to want to stay in science careers later in their work life (M_{lowSD} = 3.50 vs M_{highSD} = 5.18, $t(28) = 2.88$, $p = 0.01$) and reported a stronger inclination to undertake management careers at a later juncture (M_{lowSD} = 4.50 vs M_{highSD} = 3.25, $t(28) = 2.12$, $p = 0.04$). This inclination may be due to the perception that a management career can lead to an attractive salary (M_{lowSD} = 5.71 vs M_{highSD} = 4.50, $t(28) = 3.16$, $p = 0.00$). The two groups, however, did not differ in their perceptions of management associate positions in terms of work-life balance characteristics and their intention to embark upon this career as soon as they graduate.

In terms of the behavioral responses during the experiment, at Round 1 (without salary and work life balance manipulation), almost all participants who were more self-determined, opted for the R&D Specialist position with only one participant who chose the management associate position. Among the less self-determined group, only 64% of the participants in this group opted for a R&D career. The manipulation of salary levels and work life balance information in the job advertisements at Round 2 and Round 3 did not demonstrate a significant change to the initial job selections. Table 3 presents the behavioral responses of participants in the job selections.

B. BETA SIGNAL

Significant differences were detected in the beta wave patterns in the job description and job decision phases between those with high and low self-determination. Table 4 presents the statistically significant mean differences in the EEG beta power from the three frontal channels (F3, F4, and Fz) based on the stimuli utilized in the experiment. A graphical representation of the mean differences in the beta power is presented in Fig. 3 and Fig. 4.

The beta activity was significantly higher for participants with lower self-determination as they reviewed the job

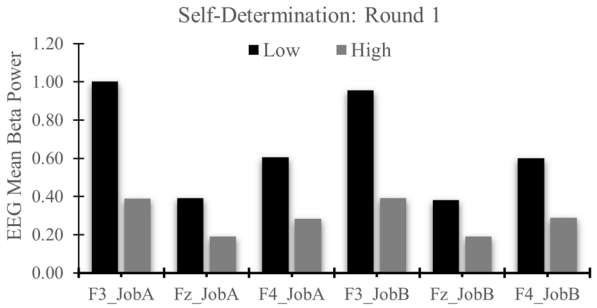

FIGURE 3. Differences of mean scores in EEG beta power for high and low self-determination in round 1. F3, F4, Fz – channel locations at frontal lobe of the brain. Job A – R&D specialist, Job B – management associate in a bank.

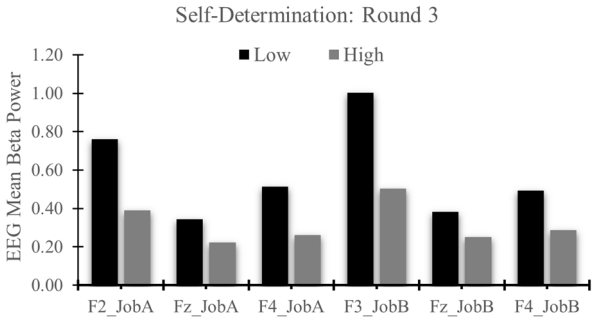

FIGURE 4. Differences of mean scores in EEG beta power for high and low self-determination in round 3. F3, F4, Fz – channel locations at frontal lobe of the brain. Job A – R&D specialist, Job B – management associate in a bank.

descriptions. As beta activity is usually associated with stress levels [36], [37], participants with lower self-determination in science might be more likely to experience higher stress and anxiety levels while engaging in job description information processing and the decision-making process. This trend was observed in Round 1 of the experiment, in which the participants with lower self-determination experienced higher levels of stress than other participants. In examining the questionnaire survey results, participants with lower self-determination tend to view R&D careers as more demanding, hence posing difficulties in balancing family and personal priorities. This perception is, however, contrary to the job scenario in Round 3, which presented the R&D job as offering work-life balance to the employees (and with lower salary). This may have led to a greater level of cognitive dissonance among the individuals with lower self-determination. In Round Two, there were no significant differences in stress levels detected between groups. This job scenario may not trigger a significant stress response as the participants were from a STEM background, and some may not be interested in a Management Associate position despite manipulations of work life balance or salary.

VI. DISCUSSION

The outcome of this study underscores the importance of self-determination in course enrolment in predicting confidence in career decision-making and the prospect for a sustainable career in the chosen field. The experimental results rendered support to H1, which posits that undergradu-

TABLE 4. Significance test of the mean differences in beta power signals for round 1 and 3.

Item	Group	*M*	*SD*	*t*	*Sig.*
Round 1: Both job advertisements do not consist of a work-life balance description, and the salary is the same for both job advertisements					
F3_R&D Job Advertisement	Low SDI	1.00	0.95	2.31	0.02
	High SDI	0.39	0.30		
Fz_ R&D Job Advertisement	Low SDI	0.39	0.28	2.59	0.02
	High SDI	0.19	0.08		
F4_R&D Job Advertisement	Low SDI	0.61	0.48	2.43	0.03
	High SDI	0.28	0.11		
F3_Management Associate Job Advertisement	Low SDI	0.96	0.09	2.25	0.04
	High SDI	0.39	0.29		
Fz_Management Associate Job Advertisement	Low SDI	0.38	0.29	2.40	0.03
	High SDI	0.19	0.08		
F4_Management Associate Job Advertisement	Low SDI	0.60	0.52	2.18	0.04
	High SDI	0.29	0.12		
Round 3: Work-life balance description in the R&D position, at a lower salary					
F3_R&D Job Advertisement	Low SDI	0.76	0.59	2.15	0.04
	High SDI	0.39	0.28		
F4_ R&D Job Advertisement	Low SDI	0.51	0.32	2.82	0.01
	High SDI	0.26	0.11		
F4_Management Associate Job Advertisement	Low SDI	0.49	0.34	2.13	0.04
	High SDI	0.29	0.17		

ates who are more self-determined in their decision in STEM course enrolment will persist in a scientific career. Brainwave data rendered support for H3, with individuals with higher levels of self-determination experienced less stress in career decision-making. This is in line with the findings that self-determined individuals reported higher levels of confidence in career decisions [30]. This can be explained by greater congruence in students' mental and affective states as their career decisions are aligned with their favorable attitudes towards science, perceived future self in science, and feelings towards STEM courses.

The behavioral responses during the experiment did not show a significant tendency of less self-determined individuals to leave the scientific career, despite the manipulation of work-life balance and salary trade-offs, which renders H2 unsupported. Further analysis in the survey data shows that although these individuals may opt for a STEM career immediately following their graduation, they have a greater likelihood of changing to other careers later in their lives. With complementary data from the brainwave analysis, insights into the trigger points of anxiety and stress levels for students with lower self-determination could be identified. Beta activation was shown to be significantly higher at the point of reviewing the job advertisement that contained a work-life balance description, which was only available in the R&D job position. There was no significant difference detected in beta activation between groups during the salary consideration phase with a lower salary offer. This could be in line with their expectations that STEM careers are less financially rewarding, as captured in the questionnaire responses and their less inclination to extrinsic motivation (salary factor) as reported in the self-determination scale. The presence of the work-life balance description in the R&D job advertisement was however, contrary to their prior expectations, which could very likely have triggered a significant degree of cognitive dissonance in these students.

While the experiment shows behavioral responses that opt for the R&D job position, this choice might have been influenced by a lack of interest in a management associate position as an alternative non-science career. Other non-science career choices, for instance, administrators, social media influencers, gig worker were excluded from this study to avoid confounding variables in the experimental design. While this configuration is acknowledged as a limitation of this study, the brainwave data play an important role in highlighting subconscious responses that may be a significant feature of the decision-making processes, providing insight into the conscious choices that students make. Furthermore, the use of survey data and a simulated laboratory environment of career decision-making provide additional dimensions for triangulation into the results.

VII. IMPLICATION AND CONCLUSION

In this study, we found that self-determination in science and engineering course enrolment is a key factor to a sustainable career in STEM profession. Furthermore, self-determined individuals preserve a sense of calmness and confidence in the process of vocational decision-making, even at the critical juncture of university-to-work transition. However, less self-determined undergraduates experienced significantly higher stress levels in their vocational considerations. Therefore, career support services in higher education needs to take a proactive role in facilitating transitional processes for new graduates by prioritizing well-being and availing meaningful conversations to take place based on students' motivational orientations and career change considerations. This demands urgent attention as the post-millennial generation is prone to anxiety and depressive states [38] which are now amplified by the pandemic.

The role of universities in sustaining STEM aspirations cannot be overstated to reinforce students' self-determination via industry collaborations and community engagement in curriculum design, and potential career pathways. These endeavors provide an authentic learning experience while connecting undergraduates to a sense of purpose and possible selves in science and engineering careers [24]. Alongside efforts to support student retention in STEM careers, greater awareness can be instilled among science and engineering undergraduates on prospective employers that actively promote work life balance and employee well-being. Academic and industry mentorship will also be useful to offer support to university students in their career considerations.

To cater to diverse career aspirations of science and engineering undergraduates at varied levels of self-determination, wider career options can be promoted beyond laboratory-based R&D career opportunities that are traditionally associated with scientific careers. Students can be exposed to career opportunities include business development or marketing roles in science or engineering-based companies, gaming design, science communication, or entrepreneurial start-ups, for instance, promoting sustainable solutions in modern agriculture. A renewed approach in defining 'STEM careers' will be important as the industry moves towards a multi-disciplinary focus and valuing dynamic capabilities in their workforce. The call for transformative Science, Technology, Engineering, Arts and Mathematics (STEAM) education is timely in support of these paradigm shifts [39]. As the future workforce is driven by passion, curiosity and dreams, contemporary engineering and science education will need to prepare students for a broader vision of the professional role to thrive in an ever-evolving career landscape [40].

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