Rest Well and Prosper

An Analysis of Sleep Deprivation and Academic Wellness among Undergraduates

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Abstract

Flooded by the pandemic, political unrest, and economic pressures, current college students are constantly under pressure they should not yet face. It is therefore important to understand if there are ways that help students alleviate their stress and attain *Ikigai*, a Japanese word that roughly translates to "the reason that makes life worth living," that they deserve at this age. In this study, we examine one particular aspect — how well students are rested given their workload — and analyze the potential impact it has on students perception of their academic experience, which we call "academic *Ikigai*." The study involved sixteen (16) undergraduate students from the University of Southern California based on convenient sampling, spanning over the first six days of June 2022. The findings suggested that the less well-rested a student is, the more passive they are toward their academic *Ikigai*. The study also noted that, interestingly, although double-majors are significantly less well-rested than single-majors, there is no statistically significant difference between how they perceive their academic *Ikigai*. Finally, we discuss some potential directions for follow-up researches at the end.

1 Introduction

Like any other freshmen, before my first semester at USC started, I made a few dozen friends who, like me, were about to begin their new chapter at USC. To better know everyone, I jotted down their majors. Needless to say, they covered a wide range of majors, from pre-med to STEM, from business to architecture, and so on. Yet, interestingly, after two years, a large portion of my friends have either declared or transferred into a math- or a coding-related major, or even both. My roommate, a religious study major, recently picked up Python. Half of BUAD (business administration) majors that I know are now CSBA (CS and business administration). Even I was no exception — admitted as a piano major, I now devote much more time on math and CS than piano.

Undoubtedly, this is partially because of my circle of friendship, which consists predominantly of Ascians,, since it is no secret that Asians, on average, are significantly more interested in majoring in STEM or computer science, as such majors are more likely to give them a stable and rewarding job upon graduation (Cueto; Wu). Nevertheless, this intriguing shift in preference of major is a phenomenon worth noting.

While many students attempt to transfer to majors that ensure a promising future, they are, however, not feeling more secure during their undergraduate studies despite having picked their "favorite" major. On the contrary, their average stress levels continue to increase, their mental health status declining. In 2021, a research conducted by Boston University suggested that college students had been demonstrating an unprecedented prevalence of anxiety due to the pandemic, political unrest, among all other factors (McAlpine).

While there is little what students can do to directly address the sources of stress that plague the entire society, they can nevertheless make individual efforts to make their undergraduate lives more fulfilling and pleasant, thereby attempting to achieve *Ikigai*. This paper discusses how USC undergraduate students' (perception of their) workload affects their academic *Ikigai* and how they can make improvements. In particular, we speculate that more abundant rest will contribute to achieving academic *Ikigai*. Data analysis on a convenience sampling via Google Form indeed suggests such a correlation, along with several other subsidiary findings.

2 Methods and Materials

In order to address the questions previously proposed, we designed a retrospective survey consisting of various qualitative and quantitative questions for later analysis. The survey was hosted by Google Forms. We distributed the survey between June 1 and June 6, collecting responses using a non-randomized convenience sampling on social media. 16 valid responses were recorded.

Procedure

Before prompting participants to answer questions, we began the survey by a mandatory section of informed consent. We acknowledged the right of participants to abort the survey whenever they wanted prior to final submission, and we endeavored to protect their confidentiality. We indeed asked participants to input their USC emails, but this served merely as a validity checker since this survey was intended for USC undergraduates only. After data were collected, during data processing, a script would rule out all answers from invalid email addresses (i.e., one not ending with `@usc.edu` or an invalid USC username). Once all remaining answers were valid, the script would proceed to erase all email entries. We asked the participants to not disclose any identifying info throughout the remainder of the survey.

Survey Design and Data Collection

The first section of the survey asked for participants' gender and year in school (e.g. sophomore).

The section of the survey proceeded to gather info on participants' major and how well-rested they were relative to their major. After recording their majors, we asked them the following questions.

(M_1) How would you rate the difficulty of your major(s) among all USC undergraduate majors?

(M_2) How would you rate your workload?

We asked two questions in succession in order to offset the intrinsically different workload between different majors. We also asked for participants' average hours of sleep per day (S_a) as well as their ideal hours (S_i), hoping that these two questions would help gaining insight into the extent of sleep-deprivation each participant faced.

For the third section, we asked questions to determine participants' academic *Ikigai* status. Following the four components of *Ikigai* — expertise, passion, demand, and money, we asked the participants to rate the following question on a number scale from 1 to 5, with 1 being completely disagree and 5 completely agree:

(I_1) (Expertise) I am an expert or I am confident in becoming one in my area of study.

(I_2) (Passion) I genuinely enjoy learning what I learn.

(I_3) (Demand) The world currently needs more people of my major.

(I_4) (Money) What I learn will lead to a well-paid job.

We also included several optional questions like "is there anything else you would like to add" which are rather pointless to be mentioned here, therefore omitted.

Participants

Out of the 16 participants who filled out valid responses, eleven (11) were male and five (5) female. Half (8) were sophomores (i.e., rising junior in Fall 2020), five (5) were freshmen (rising sophomore), and three (3) were juniors (rising seniors). Half (8) of the participants reported double majors, whereas the other half (8) reported single major.

Though no questions collected the ethnicity of the participants, since the survey was based on convenience sampling, we can safely assume that almost all participants are Asian.

Tools for Assessment

Google Form generated a `.csv` file and equivalently a Google Spreadsheet containing all the responses. We designed a specific metric to calculate one's "Academic *Ikigai* Index", a number in $[0, 1]$, based on their answers to several questions. We also derive a "Sleep-Deprivation Index." Both will be further mentioned in the following section. For quantitative visualization we used Google Spreadsheet's built-in "chart" feature. For qualitative visualization, e.g., word cloud, we used Voyant, an online visualization tool for textual analysis.

3 Results

The survey collected a set of numeric responses from the participants. For notational convenience, we will denote each answer of interest using a different variable, as listed in the table below.

Variable	Question	Range
M_1	Difficulty of Major	1 – 5
M_2	Academic workload	1 – 5
S_a	Avg. hrs of sleep / day	0 – 24
S_i	Ideal hrs of sleep / day	0 – 24
I_1	Expertise in major	1 – 5
I_2	Passion for major	1 – 5
I_3	Workplace demand	1 – 5
I_4	Earning money	1 – 5

Table 1: List of variables collected in the survey and also to be used in designing formulas below.

The Sleep-Deprivation Index, SDI

We first designed a formula to describe how well-rested a participant is, taking their major and the corresponding workload into account. Intuitively, the greater the disparity between one's ideal sleep time and actual sleep time, the less well-rested they are. On the other hand, when one faces a heavier workload, it is also reasonable to assume they are less likely to be well-rested. Therefore, a variable describing academic workload is required. In doing so we compute a weighted average of M_1 and M_2, taking 30% of a major's difficulty and 70% of experienced workload into account. We define the Sleep-Depreviation Index, SDI, to be

$$\begin{aligned}\text{SDI} &:= \frac{S_i - S_a}{S_a}\cdot(0.3\cdot M_1 + 0.7\cdot M_2)\\ &= \frac{\text{ideal sleep} - \text{actual sleep}}{\text{actual sleep}}\cdot\text{major difficulty index.}\end{aligned}\tag{*}$$

Here we implicitly assumed SDI $\geqslant 0$. In an ideal situation where one sleeps as long as they wish to, $S_i = S_a$, resulting in SDI $= 0$. The more sleep-deprived one becomes, the higher the SDI is.

The Academic *Ikigai* Index, AII

Having crafted the SDI, we then defined an Academic *Ikigai* Index using I_1, I_2, I_3, and I_4. The perfect situation is where a participant answers 5 for all questions, namely, they are experts in their field, are extremely passionate about what they study, are studying something the world constantly needs, and will be able to make a significant amount of money. On the contrary, the least ideal situation is where a participant answers 1 for all questions.

For each I_i, $1 \leqslant i \leqslant 4$, we wanted to find a function that maps 1 (least) to 0, 5 (most) to 1, and last but not least, 3 (neutral) to 0.5. Whereas linear scaling (i.e., $\{1,2,3,4,5\}$ to $\{0, 0.25, 0.5, 0.75, 1\}$ respectively) would have done the job, we chose a logistic scaling over it. Empirical data have shown that in a Likert scale from 1 to 5, 4 is closer to 5 than to 3, and similarly 2 to 1 than 3 (Harpe). Using a shifted logictic function composited with a linear scaling, we derive the following function:

$$f(I_i) := 0.5 + \underbrace{\frac{0.5}{1/(1+e^{-2}) - 0.5}}_{\text{linear scaling factor}}\cdot\underbrace{\left[\frac{1}{1+\exp(3-I_i)} - 0.5\right]}_{\text{shifted logistic}}.$$

In particular, the function defined as above satisfies $f(1) = 0, f(2) \approx 0.197, f(3) = 0.5, f(4) \approx 0.803$, and $f(5) = 1$.

Finally, we perform a weighted average of I_1 to I_4 to obtain our final Academic *Ikigai* Index, AII. We prescribe the weight of expertise, passion, demand, and money to be $0.15, 0.5, 0.15$, and 0.2, respectively. That is,

$$\text{AII} := 0.15\cdot f(I_1) + 0.5\cdot f(I_2) + 0.15\cdot f(I_3) + 0.2\cdot f(I_4).\tag{**}$$

The Processed Data

Since the research implemented a convenience sampling and most people that the author knows well are STEM-oriented, it was speculated beforehand that the majors of the participants would mostly consist of STEM majors. This is indeed confirmed once data was collected. Among the 16 responses collected, the most common majors were mathematics (5) and computer science (4), followed by CS-related majors (CS with business administration, CSBA, or CS with game design, CSGA) and applied math. These are shown in the following figure.

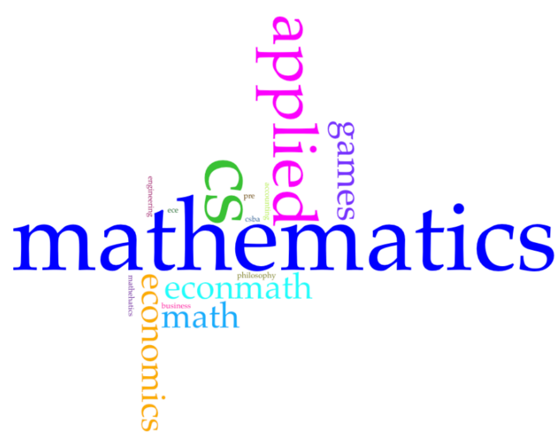


Figure 2: A textual visualization of participants' majors using Voyant. The larger the font, the more frequent the word appears. In this sample, the two most common majors are "mathematics" and "CS."

We computed the two indices for each survey response and plotted the data pairs in a scatterplot, as shown in the next figure.

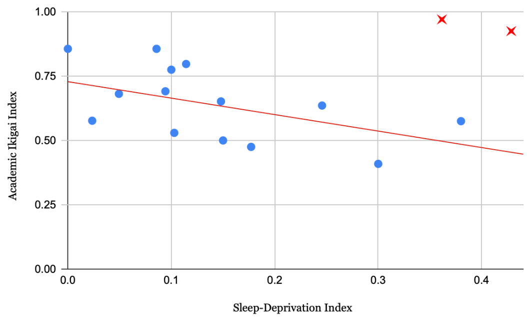


Figure 3: Relationship between each individual's AII, as presented by the vertical axis, and SDI, the horizontal axis ($n = 16$). Excluding the two outliers on the topright marked as ×*, there exists a negative correlation between the two indices, with $r \approx -0.65$ and linear best-fit line $y = 0.73 - 0.7x$. Data collected via Google Forms and provided by the participants.*

Assuming the two red ×'s on the topright are outliers (the reason for which will be discussed later) , there exists a negative correlation between the AII and the SDI: the more sleep-deprived a student is, the less they achieve academic *Ikigai*.

We were also interested in the potential correlation between SDI and some individual components of AII, in particular, "expertise," I_1, and "passion," I_2. We chose these two specifically because I_1 and I_2 are directly related to the participants' levels of stress whereas I_3 and I_4 are relatively more independent. Excluding outliers, we found a strong negative correlation between AII and I_2 ($r = -0.745$) and a weak but nevertheless negative correlation between AII and I_1 ($r = -0.109$). These are demonstrated in the figures below.

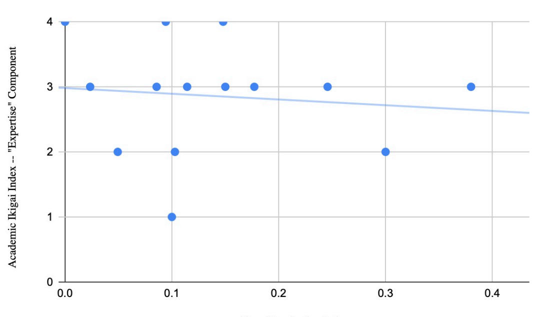


Figure 4: Relationship between each individual's "expertise" component answer, represented by the vertical axis, and their computed SDI, represented by the horizontal axis, i.e., I_1 vs. SDI. The outliers from Figure 3 were excluded. Overall, there exists a (weak) correlation between I_1 and SDI ($r = -0.109$).

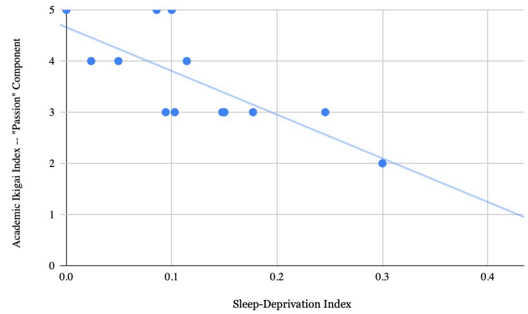
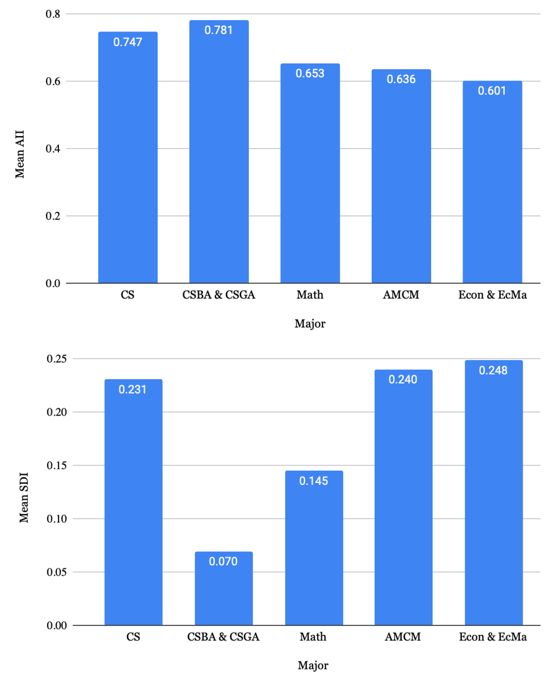


Figure 5: Relationship between each individual's "passion" component answer, represented by the vertical axis, and their computed SDI, represented by the horizontal axis, i.e., I_2 vs. SDI. The outliers from Figure 3 were excluded. There exists a stronger correlation between I_2 and SDI ($r = -0.745$).

Next up, we computed the mean SDI and AII according to the five major categories that appear most frequently: CS, CSBA or CSGA, mathematics, AMCM (applied mathematics), and economics or EcMa (Econ-Math).



Figures 6 and 7. Mean AII (6) and SDI (7) of participants of several common majors. The horizontal axis shows the five most common majors based on survey response, and the vertical axis represents the mean AII (6) and SDI (7) of each major. If a respondent declared more than one major, their AII/SDI were multi-counted for different categories. The two outliers from Figure 2 were not included.

Besides CS major, which exhibited both a relatively high mean AII and a mean SDI, the other four groups seemed to follow the trend as illustrated in Figure 2. The mean SDI's of the other four categories increase, and their mean AII's decrease.

Finally, we subdivided our sample based on the number of majors each participant had. We analyzed the SDI and AII for each group, looking for statistically significant differences.

Single Major	SDI	AII	Double Major	SDI	AII
CSGA	0	0.856	CS, Math	0.1	0.775
Math	0.086	0.856	ECE, Math	0.103	0.529
Math	0.15	0.5	CS, AMCM	0.429	0.925
Business	0.3	0.409	CSGA, AMCM	0.114	0.758
CS	0.246	0.636	Econ, Math	0.380	0.575
Math	0.049	0.681	EcMa, Phil	0.362	0.971
CSBA	0.094	0.691	Acct, CS	0.148	0.652
EcMa	0.024	0.577	Econ, AMCM	0.177	0.475

Table 8: A table showing the SDI and AII of each survey respondent. The ones on the left are those who declared a single major; the ones on the right are those who declared double major. Glossary: ECE for electrical and computer engineering; Acct for accounting; Phil for philosophy.

By running Mann-Whitney U-test on the two indices separately, we found that students with multiple majors tend to have higher SDI than their single-major counterparts, meaning they tend to be more sleep-deprived, and the difference is statistically significant ($p \approx 0.032$). For AII, however, though the double-major group exhibited a larger mean AII, it was not statistically significant ($p \approx 0.318$ for right-tail; not significant for two-tail and left-tail Mann-Whitney, either).

```r
# For Mann-Whitney on SDI
x1<-c(0.100,0.103,0.429,0.114,0.380,0.362,0.148,0.177)
x2<-c(0.000,0.086,0.150,0.300,0.246,0.049,0.094,0.024)
wilcox.test(x1, x2, alternative = "greater", paired =
    FALSE, exact = TRUE, correct = TRUE)
# res$p.value = 0.03248
# For Mann-Whitney on AII
x1<-c(0.775,0.529,0.925,0.758,0.575,0.971,0.652,0.475)
x2<-c(0.856,0.856,0.500,0.409,0.636,0.681,0.691,0.577)
wilcox.test(x1, x2, alternative = "greater", paired =
    FALSE, exact = FALSE, correct = TRUE)
# res$p.value = 0.3181
```

Code Snippet 9: Implementation of right-tail Mann-Whitney U-test in R to determine if SDI and AII are affected by the number of majors students declare. First group, x_1, represents the group of participants with $\geqslant 2$ majors; second group, x_2, consists of participants with one major only. There was a statistical significance between the SDI's of two groups, with group 1 exhibiting significantly higher SDI's. No significance was found between the AII's of the two groups.
Note: outliers were included in this test; if removed, the two p-values would become 0.114 and 0.373, respectively.

4 Discussion

Overall, the data collected and the indices computed matched our expectations on the relationship between the students' levels of well-restedness and perception of their academic experience. We would like to start, however, by addressing the issue of outliers spotted in the previous section.

As mentioned in almost all figures and tables, we excluded the two outliers. It was determined not quantitatively, but rather qualitatively. After reviewing the collected data, we noticed that these two participants both reported below-average hours of sleep per day, yet they both answered extraordinarily high numbers for the *Ikigai* questions — one responded $5, 5, 4, 5$ and the other $5, 5, 3, 5$, far more than anyone else, especially for the first two questions (I_1 and I_2). One plausible explanation for this is that those who made these responses are indeed outliers in terms of academic performance. Among my closest friends, there happens to be a few extraordinarily bright minds who, as undergraduates, are acquainted with researches and are already doing Ph.D.-level work, totally enjoying themselves in academia. In parametric statistical methods, the prime example being regression, it is customary to exclude these outliers from analysis (Mahapatra). On the other hand, since ranked tests (e.g. Mann-Whitney) are nonparametric, we initially included outliers when computing statistical significance of the Mann-Whitney U-test.

When summarizing results from Figures 6 and 7, we treated CS major as an outlier as well, for it clearly defied the supposedly negative correlation between AII and SDI. This can, hopefully, be explained by the nature of CS major. On one hand, CS is notoriously known for being time consuming. Programmers need to spend a tremendous amount of time "debugging," trying to pinpoint the mistakes that were unintentionally made. That so many computer programmers become bald is not just a meme floating online, but also a reflection of how programmers are constantly short of rest. In the survey, all CS majors answered 4 or 5 for all SDI-related questions. On the other hand, CS majors are absolutely rewarding in terms of finding jobs and profiting. In the current industry where numerous fields such as machine learning are quickly expanding, the demand for programmers will continuously rise in the near future. Consequently, in the survey, we see that all CS majors answered high numbers for I_3 and I_4 (demand and money), thereby significantly boosting their AII. These factors combined lead to CS major having both a high AII and a high SDI.

Finally, the major findings in this research mostly agree with its predecessors. Early in 2006, researchers found out that increasing sleep loss or fragmentation turns detrimental to "an efficient consolidation of [declarative] knowledge and [procedural] skills." (Curcio). A decade and a half later, the claim still seems to hold: in Figure 4, a higher SDI weakly corresponds to a lower I_1, the *Ikigai* "expertise" self-rating. A more recent report suggested that one's extent of social anxiety is correlated to how abundant they sleep and also its quality, and a group of Chinese researches recently concluded that, for Chinese students, "[s]ocial anxiety significantly negatively associated with academic engagement" (Horenstein; Mou). Putting these all together, we see that a lower SDI leads to lower anxiety level which then leads to higher academic engagement, hence a higher *Ikigai* "passion" self-rating, as shown in Figure 5.

There are, however, several limitations that this research has encountered. The first and most obvious one is the inherent bias coming from convenience sampling. Since the author is heavily STEM-oriented, most of the resulting participants are too; this can be seen in Figure 2's word cloud, in which almost every single word is STEM-related. For the same reason, it is extremely likely that an overwhelming majority of the participants are Asians and in particular, Chinese. Therefore, the findings should not be casually generalized to a general USC student body, which is much more diverse, both in areas of study and in ethnicity. Should a more general research be conducted, the researchers should keep in mind the potential composition of their participant pool.

Another limitation is the lack of empirical data to support the formulas used to calculate SDI (*) and AII (**). Consequently, the formulas adopted in this study were more based on common sense, and by doing so, weights for $M_1, M_2, I_1, I_2, I_3,$ and I_4 were more arbitrarily assigned. To solve this issue, a potential solution is to appeal to psychological methods by first designing questions that help quantifying the level of happiness and "sense of worthiness of life" of each participant. With these data recorded, the researchers can then post-determine the corresponding weights of each factor using mathematics tools, for example backpropagation. By doing so, the coefficients would seem less arbitrary, leading to more stable AII calculation even when fed with different data.

5 Conclusion

To reiterate, in this study, we found a negative correlation between the AII and the SDI, as expected. We also noticed that the "expertise" and "passion" components also form negative correlations with SDI, respectively, albeit the former being a weak one. We believed that SDI increases as students declare an extra major, yet their AII seems rather unchanged — at least in terms of statistical significance. These results obtained from USC undergraduate students seemed to support various previous related researches, although past experiments were conducted under a different context. To generalize our result, we suggest that future research be conducted on more general populations, e.g., on a sample of college students with random demographic background. Along with already established studies in methods to improve sleep quality, we may find a new way to help students achieve their academic *Ikigai*.

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