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The Role of Psychological Well-Being in Women Undergraduate Students' Engineering Self-Efficacy and Major Satisfaction*

SOONHEE HWANG
Department of Liberal Arts & Science, Hongik University 2639, Sejong-ro, Jochiwon-eup, Sejong-si, Korea.
E-mail: soonheehwang@hongik.ac.kr

This research examined the role of psychological well-being in women undergraduate students' engineering self-efficacy and major satisfaction in Korea. To achieve this purpose, first, differences in psychological well-being, engineering self-efficacy and major satisfaction among engineering students were examined. Second, the relationships among psychological well-being, engineering self-efficacy and major satisfaction were investigated. In addition, the effects of psychological well-being, as perceived by men and women engineering students, on engineering self-efficacy as well as major satisfaction were explored. A total of 253 engineering students from one university in Korea responded to survey based on a three-variables scale. The findings were that, firstly, men students scored higher in all of the three variables including psychological well-being, engineering self-efficacy and major satisfaction, and that these gender differences were statistically significant. Secondly, a positive correlation among psychological well-being, engineering self-efficacy and major satisfaction was identified. Thirdly, psychological well-being predicted engineering self-efficacy and major satisfaction's sub-factors. The practical implications of these findings are discussed herein, with particular attention on education for promotion of psychological well-being, engineering self-efficacy and major satisfaction.

Keywords: women undergraduate students; psychological well-being; engineering self-efficacy; major satisfaction

1. Introduction

Despite the increasing demands for women in engineering and efforts to increase the numbers of women in engineering programs, women remain underrepresented in engineering and in other, related fields [1]. Engineering traditionally is a male-dominated technical field; the 'chilly climate' of its education programs and culture reportedly serves to dissuade women from choosing to enter an engineering school or lead to campus-life maladjustment and relatively high drop-out rates [2, 3]. Also, even if successful in obtaining employment in the field, women in engineering can experience career barriers and the 'glass ceiling' [4]. This situation is not very different in Korea. Women undergraduates majoring in engineering in Korea reportedly experience difficulties choosing engineering as their major, navigating academic life after entering university and in pursuing their career in engineering after graduating, even though engineering students have a rather easier time finding a job than those majoring in other major fields [5, 6]. For example, the proportion of women working in engineering remains low in Korea: as of 2017, the employment rate of women in science and technology was only 20.1% relative to men [7].

Previous studies have addressed, in various ways, the question of why relatively few young women are attracted to engineering programs and careers [8]. Some studies found that young women in engineering suffer from 'a feeling of not being good enough' in engineering or difficulties resulting from a 'chilly climate' in male-dominated technical fields [9–12]. These difficulties were found to lead to lower self-efficacy [12], lower academic engagement and self-esteem [9], higher levels of emotional exhaustion or academic burnout [10] as well as negative impacts on the feeling of well-being [11]. In addition, various factors such as judgement of others [13], attitude to work [14, 15], women's attitudes to engineering [16] and different interest [17, 18] were shown to have a significant impact on women engineering students' major choice, academic continuation and career decisions. For example, parents of boys were more likely to encourage their children to pursue STEM careers, and boys were more likely to have STEM career intentions [13]. These findings implied that various variables should be considered in order to understand why there are relatively few women in engineering.

Quite a few studies have found gender gaps, specifically in math and spatial abilities [19–22] to be one of the main causes of young women's difficulties with respect to STEM and engineering, notwithstanding the reports of very few gender differences [23] or no evidence of gender bias [24]. For example, [19] reported gender differences in STEM achievement and persistence, and that these differences were due to individual differences in

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cognitive style. [21] found significant gender gaps in belief in math abilities, showing that women have lower beliefs in their math abilities, and that this relative confidence deficit can predict STEM career outcomes. Nonetheless, earlier studies indicated that a lack of exposure to appropriate environments, not women's ability, is the cause of the gender gap [25, 26]. Indeed, psychological factors including math anxiety, lower self-efficacy, self-concept, and interest are vital in the context of the academic engineering environment. Psychological well-being is a psychological factor that has been demonstrated to have influence and predictive power over individuals' life-related academic variables such as academic achievement [27], academic stress [28], self-esteem [29], writing apprehension [30], parent or peer attachment [31], and physical exercise [32].

In the present study, we examined the role of psychological well-being (a psychological factor affecting individuals' overall academic life) in its influence on individuals' behavioral, psychological, and academic outcomes. Although previous studies have shown how psychological well-being affects students' lives, the psychological well-being specifically of women engineering students and its relationship with academic-life-related variables such as engineering self-efficacy and major satisfaction has not been fully explained, despite its importance. Psychological well-being can be defined as a state, rather like 'happiness,' enabling individuals' positive psychological functioning and fulfillment of potential [33, 34]. Happy individuals are highly likely to accept themselves as they are, maintain control over their surroundings, have positive relationships with others, act autonomously, have a purpose in life, and have a need for growth. Additionally, in the field of engineering education, engineering self-efficacy has been considered to be an integral factor in achieving and maintaining successful academic performance [35, 36]. However, to date, little research exists on how psychological well-being is related to engineering self-efficacy. On the other hand, major satisfaction is defined as an individual's satisfaction with their major in university [37], which is expected to be further influenced by individuals' psychological well-being. Based on this rationale, the present study conducted an empirical study to understand the relationship between psychological well-being and engineering self-efficacy for women engineering students.

2. Literature Review

2.1 Psychological Well-Being

Over the course of the past approximately twenty years, mental health theory and practitioners have shifted from the 'pathological' problem-centered approach to a 'psychological' function-centered one based on positive psychology and human's positive resources [34, 38]. In general, 'well-being' can be divided into two senses, 'subjective' and 'psychological' [39]; the latter, considering a broader meaning of happiness in its theoretical basis, is considered to be more persuasive. Based on this line of research, [33] developed a Psychological Well-Being Scale (PWBS), measuring six subdivisions including self-acceptance, environmental mastery, positive relationship with others, purpose in life, autonomy, and personal growth.

In many ways, the role of psychological well-being has been supported in the scholarly literature. Among others, [34] analyzed psychological well-being according to diverse variables of gender, age, and culture, finding that environmental control and autonomy – sub-factors of psychological well-being – increased with age, while personal growth and purpose of life – other sub-factors of psychological well-being – decreased. Additionally, this study found that women of all ages consistently score themselves higher on positive relations with others and personal growth than do men, whereas the remaining four aspects of psychological well-being just as consistently show no significant differences between man and women. [40] likewise found gender differences in psychological well-being, while noting particularly low levels for full-time housewives and single men compared with other groups. In a similar vein, [41] showed that spiritual well-being was higher in women majoring in engineering than in women majoring in other subjects. [42] found that women scored higher than men on three dimensions of psychological well-being – personal growth, positive relationship with others, and purpose in life. On the contrary, [43] found that boys scored higher in three dimensions of psychological well-being, environmental mastery, purpose in life, and self-acceptance, than women, and that late adolescents scored higher than adults and the elderly. Taken together, it is concluded that women have greater psychological strength than men in most aspects of (psychological) well-being.

Psychological well-being, a concept that is related to personal growth and self-realization and that is indicative of how well a person functions as a member of society [33], promotes physical exercise [32] and contributes to improved mental and physical health [44], studies have shown. In the education realm in particular, psychological well-being is related to diverse variables. It is reported to predict not only academic achievement and performance [45] but various other achievement levels as well [42]. High levels of positive attitude were positively correlated with psychological well-being [42], and writing apprehension was negatively correlated with psychological well-being of Korean undergraduates [30]. Besides, psychological well-being of undergraduate students was shown to account for career-related variables [47], job satisfaction [48], job performance [46], resilience [42] and self-esteem [49].

These findings imply that happiness (broadly defined) will provide several positive benefits for individuals and help to produce better performance. Interestingly, in Korea, research on the relationship between psychological well-being and related variables has been actively conducted for more than a decade, and there are many accumulated studies. Of them, [50] pointed out that Korean college students' psychological well-being was lower than that of American college students. [51] noted that among the sub-factors of psychological well-being, Korean college students were shown to be relatively high in positive interpersonal relationships, but low in autonomy.

Based on previous research demonstrating the impact of psychological well-being on undergraduate students, including their physical and emotional states, that same metric was chosen in the current study, particularly as it reflects engineering students' potential to influence other areas of university life, which, in this case, are engineering self-efficacy and major satisfaction. Thus far, little is known about the relationship between engineering students' psychological well-being and those two variables. We would expect psychological well-being to predict engineering self-efficacy and major satisfaction.

2.2 Engineering Self-efficacy

Self-efficacy [52] reflects confidence in one's ability to perform a specific behavior or accomplish a specific task, and as such, is reported to be a predictor of high performance [52–55]. In the academic realm, self-efficacy, accordingly, is an important predictor of students' behavior, motivation, and outcomes [56]. Individuals with high self-efficacy think, feel and act in such a way that they can largely determine their own future [52]. Besides, self-efficacy is closely related to persistence in career-objective-related activities such as continuation in a college major and working for (and achieving) higher grades [57, 58].

In addition, self-efficacy is to be understood as 'domain-specific,' since the same individuals may hold very disparate estimations of their capability in different domains. From this point of view, 'engineering self-efficacy' can be conceptualized as belief or confidence in one's abilities to function as an engineer (or scientist) [53, 59]. In other words, higher engineering self-efficacy is likely to lead to increased commitment to pursuing a career in engineering [66], yielding good achievement and performance. For example, [61, 62] found that students with high engineering self-efficacy will achieve higher goals. They noted also that engineering students' belief in their ability to be high achievers significantly predicted their desire to become an engineer. Previous studies likewise found that strong self-efficacy in engineering is a predictor of academic achievement and engineering interest [63, 64], student achievement, motivation and persistence [65, 66], academic achievement and intent to persist in engineering [67, 68], interest and goals, adjustment, satisfaction and persistence [61, 62], and achievement, persistence and interest [36] among engineering students. [35] noted also that strong and positive engineering self-efficacy is significantly correlated with academic achievements manifested in higher grades. Conversely, other variables, such as cognitive motivation [69], course material understanding and learning, drive and motivation, teaming, computing abilities, problem-solving abilities, interest, and satisfaction are reported to affect engineering self-efficacy [36]. Some researchers attribute, to low engineering self-efficacy, the high dropout rate of underrepresented minority students in engineering programs [70] and women's low interest and retention in engineering [71].

Regarding gender differences in engineering self-efficacy, contradictory research results have been reported; [68] and [72] found no significant differences in engineering self-efficacy scores by gender, whereas [73] uncovered statistically significant differences in engineering self-efficacy by gender. Given the importance of engineering self-efficacy, the present study examined it as a predictor of engineering students' diverse characteristics and outcomes. Based on the prior findings, we embarked on our investigation under the expectation that engineering self-efficacy is related to psychological well-being and major satisfaction.

2.3 Major Satisfaction

Major satisfaction can refer to subjective experience – cognitive or emotional – one has about one's major [37]. It is associated with the degrees of the various emotions that an individual experiences with their major. On the other side, it is also related to the degree to which one perceives that one's expectations have been met. College students' appropriate choice of major helps them to develop their interests, aptitudes, and abilities by reinforcing their academic goals and achievement [74]. Moreover, major choice and satisfaction with the major can affect not only overall college life, but also career choices, future job, future earnings as well as overall quality of life moving forward [74, 75]. In this context, individuals' inconsistency with their major will lead to dissatisfaction with both the major and campus life, due to maladjustment to overall academic and school life.

Prior studies have noted that the degree of major satisfaction varies depending on personality traits and vocational interests [75] and that it is predictive of career decision(-efficacy) [75–76]. [77] found that major satisfaction was associated with career self-efficacy and intrinsic motivation. In a similar vein, [78] pointed out the needs for courses and programs strengthening career self-efficacy to enhance satisfaction with the major. Surprisingly, only a few studies have investigated relationships between psychological well-being and engineering undergraduates' major satisfaction. For instance, of the studies conducted in a similar context, [79] noted relationships among psychological well-being and job satisfaction, and [80] likewise found that the psychological well-being of employees moderated the relation between job satisfaction and job separation. As these findings were obtained in the job context, more work focused on engineering education and engineering students is needed in order to document the associated gains explaining how psychological well-being and major satisfaction are related.

2.4 Relationships among Psychological Well-Being, Engineering Self-Efficacy, and Major Satisfaction of Engineering Students

Although it is difficult to find studies directly examining the relationships among psychological well-being, engineering self-efficacy, and major satisfaction, some studies have done so indirectly. For example, [41] noted a significant correlation between spiritual well-being and general self-efficacy of engineering students and that physical health – one sub-scale of spiritual health – was the best predictor of students' self-efficacy. [65] found that engineering self-efficacy predicted satisfaction with the major. [76] uncovered that college students with high self-concepts showed significantly more congruence between their academic major and vocational interest than those with low self-concepts. [77] also found a significant relationship between self-efficacy and major satisfaction, in addition to career-related variables.

2.5 Hypotheses

Based on previously reported differences among psychological well-being, engineering self-efficacy and major satisfaction by gender, first, we expected that men engineering students would score higher in these three variables than would women. Further, based on the previously demonstrated relationships between psychological well-being and engineering self-efficacy on one hand, and between engineering self-efficacy and major satisfaction on the other, we hypothesized that the three variables would be closely correlated, and that psychological well-being would predict engineering self-efficacy and major satisfaction. We propose the following four hypotheses:

H1: Men engineering students will score higher in psychological well-being, engineering self-efficacy and major satisfaction than women.
H2: There will be significant correlations among psychological well-being, engineering self-efficacy and major satisfaction.
H3: Psychological well-being will have a positive effect on engineering self-efficacy.
H4: Psychological well-being will have a positive effect on major satisfaction.

3. Methods

3.1 Study Subjects

It was determined that women engineering students in Korea encounter many difficulties regarding overall campus life, academic performance, and continuing career in their engineering field after graduation relative to men engineering students [5, 6]. To overcome these difficulties and to enhance the competencies of women undergraduates majoring in engineering, there have been various educational programs launched and policies enacted in Korea, though not enough. As such, it is critical to understand how possible factors (i.e., psychological well-being, engineering self-efficacy and major satisfaction) affect performance of academic activities in engineering.

To investigate the relationships among those three variables, 253 students were recruited mainly through the author's personal webpage and the Innovation Center for Engineering Education at the author's affiliated university for participation in a survey. The students were enrolled in various disciplines of engineering (i.e., electronic engineering, software and communications engineering, materials science and engineering, architectural engineering, mechanical and design engineering, naval architecture and ocean engineering, and chemical engineering) for fulfillment of Abeek (the Accreditation Board for Engineering Education of Korea). Of the 253 participants, 123 were men (48.6%) and 130 were women (51.4%); 88 were sophomores (34.8%), 68 juniors (26.9%), 87 seniors (34.4%) and 10 freshmen (4.0%). The average age was 22.73, and all of them were single. The survey questionnaires were prepared online. The participants, after providing their informed consent to participate, were briefed on the survey procedures. All of them provided the demographic information indicated in the "Participants" section and responded to three questionnaires. Each respondent was given a small souvenir for participating in the study. The data were collected between August 10 and September 10, 2020, and study approval was granted by the Institutional Review Board (IRB) of the author's affiliated university. The data was screened for significant outliers, violations of assumed normality and homoscedasticity. Using the Box's M Test and the Kolmogorov-Smirnov Test, one independent variable (psychological well-being, PWBS) and two dependent variables (engineering self-efficacy and major satisfaction) were tested for normality. No violations of statistical assumptions were found.

3.2 Instrument

The survey instrument comprised four sections, including psychological well-being, engineering self-efficacy, major satisfaction, and demographic information.

3.2.1 Psychological Well-Being

The instrument used to assess psychological well-being in the current study was the scale designed by [33] to measure individuals' psychological well-being in their daily life. This instrument consists of six sub-dimensional factors, namely, self-acceptance, environmental mastery, positive relationship with others, purpose in life, autonomy, and personal growth. The Psychological Well-Being Scale (PWBS) is a widely utilized measure for which there is substantial evidence of reliability and validity. The original version consists of six dimensions with a total of 54 questions; however, in this study, a shortened 46-item scale translated into Korean and of verified validity in Korea [51] was used. Some representative questions are, "In general, I feel I am in charge of the situation in which I live", "I enjoy making plans for the future and working to make them a reality". Each question was to be answered on a 5-point Likert scale (score 1: strongly agree $\sim$ score 5: strongly disagree). This scale showed good reliability in the current sample, as Cronbach's reliability was 0.79. Further, each sub-scale showed good reliability: for self-acceptance, the factor reliability (Cronbach's alpha) was 0.72; for environmental mastery, it was 0.74; for positive relationship with others, it was 0.76; for purpose in life, it was 0.73; for autonomy, it was 0.82, and for personal growth, it was 0.74.

3.2.2 Engineering Self-Efficacy

The instrument used to assess engineering self-efficacy in the current study was [81], for which related work guiding its development was done in [52, 53, 59]. It has already been adapted for multiple South Korean studies assessing engineering self-efficacy, for example [82]. In the present study, the instrument was used to measure engineering self-efficacy – belief and confidence in the required competence in the engineering field – among engineering students and consisted of 33 questions in four sub-factors, including major-related knowledge efficacy, career expectations efficacy, team-activity-related efficacy, and creativity-related efficacy. Some representative items include "I can understand math required in the field of engineering", "I have a clear goal of what to do as an engineer in the future". Each question was to be answered on a 5-point Likert scale (score 1: not at all $\sim$ score 5: very much). This scale showed good reliability in the current sample, as Cronbach's reliability was 0.83. Further, each sub-scale showed good reliability: for major-related knowledge efficacy, the factor reliability (Cronbach's alpha) was 0.77; for career expectations efficacy, it was 0.72; for team-activity-related efficacy, it was 0.85, and for creativity-related efficacy, it was 0.77.

3.2.3 Major Satisfaction

In this study, the instrument used to assess major satisfaction was [83], developed considering the context of Korean higher education. The scale measuring undergraduate students' major satisfaction consists of four sub-dimensional factors, including general satisfaction, relation satisfaction, curriculum satisfaction, and social perception satisfaction, with a total of 18 questions. The representative examples include, "I am satisfied with my major in university", "I am interested in curriculum of my major". Each question was to be answered on a 5-point Likert scale (score 1: strongly disagree $\sim$ score 5: strongly agree). This scale showed good reliability in the current sample, as Cronbach's reliability was 0.76. Further, each sub-scale showed good reliability: for general satisfaction, the factor reliability (Cronbach's alpha) was 0.63; for social perception satisfaction, it was 0.78; for curriculum satisfaction, it was 0.65, and for relation satisfaction, it was 0.73.

3.3 Data Analysis Method

The data collected for this study were processed with the SPSS 26.0 program for frequency analysis, EFA, reliability analysis, correlation analysis, and multiple regression analysis. The AMOS 20.0 program was employed to perform CFA. The two major analysis methods used in this study were Pearson correlation analysis to investigate the relationship among psychological well-being, engineering self-efficacy and major satisfaction, and stepwise multiple regression analysis to examine the effect of psychological well-being on the two variables, engineering self-efficacy and major satisfaction.

4. Results

4.1 Differences in Psychological Well-Being, Engineering Self-efficacy and Major Satisfaction of Engineering Students by Gender

The mean scores of the men and women engineering students on each of three variables are presented in Table 1. Men engineering students scored higher in all of three variables' totals, psychological well-being, engineering self-efficacy and major satisfaction as well as most of their sub-factors.

First, the mean score of psychological well-being (total) was 3.42. The mean score for men engineering students was 3.44, while that for women was 3.40. Descriptive analyses carried out for the six dimensions of psychological well-being demonstrated that engineering students reported higher levels of positive relationship with others (M = 3.72, sd = 0.65), personal growth (M = 3.60, sd = 0.54), and purpose in life (M = 3.51, sd = 0.66) than the levels of autonomy (M = 3.11, sd = 0.4), self-acceptance (M = 3.27, sd = 0.65), and environmental mastery (M = 3.33, sd = 0.53) (Wilks' lambda = 0.847, F = 7.39, $p < 0.001$).

Second, the mean score of engineering self-efficacy (total) was 3.49. The mean score for men engineering students was 3.56, while that for women was 3.42. Descriptive analyses carried out for the four dimensions of engineering self-efficacy demonstrated that engineering students reported higher levels of team-activity-related efficacy (M = 3.70, sd = 0.5) than the levels of major-related knowledge efficacy (M = 3.47, sd = 0.6), career expectations efficacy (M = 3.42, sd = 0.64), and creativity-related efficacy (M = 3.35, sd = 0.57) (Wilks' lambda = 0.958, F = 2.71, $p < 0.05$).

Thirdly, the mean score of major satisfaction (total) was 3.54. The mean score for men engineering students was 3.57, while that for women was 3.50. Descriptive analyses carried out for the four dimensions of major satisfaction demonstrated that engineering students reported higher levels of social perception satisfaction (M = 3.90, sd = 0.8) and general satisfaction (M = 3.62, sd = 0.84) than the levels of curriculum satisfaction (M = 3.25, sd = 0.82) and relation satisfaction (M = 3.38, sd = 0.89) (Wilks' lambda = 0.949, F = 3.36, $p < 0.05$).

MANOVA was used to determine whether differences in the three variables by gender were statistically significant. Table 2, which consists of the three variables' sub-factors, shows that there were statistically significant differences: in psychological well-being, engineering self-efficacy and major satisfaction by gender with Wilks' lambda = 0.847 at the 0.001 level, 0.958 at the 0.05 level, and 0.949 at the 0.05 level, respectively. A univariate

Table 1. Mean and SD of men and women engineering students on three-variables measure

Variables	Men students		Women students		Total	
	M (SD)		M (SD)		M (SD)	
1.1.	3.24	(0.6)	3.30	(0.69)	3.27	(0.65)
1.2.	3.81	(0.63)	3.63	(0.65)	3.72	(0.65)
1.3.	3.17	(0.44)	3.04	(0.35)	3.11	(0.4)
1.4.	3.42	(0.49)	3.24	(0.56)	3.33	(0.53)
1.5.	3.47	(0.64)	3.55	(0.68)	3.51	(0.66)
1.6.	3.54	(0.51)	3.66	(0.57)	3.60	(0.54)
1.	3.44	(0.4)	3.40	(0.4)	3.42	(0.4)
2.1.	3.53	(0.53)	3.41	(0.66)	3.47	(0.6)
2.2.	3.47	(0.57)	3.38	(0.69)	3.42	(0.64)
2.3.	3.79	(0.52)	3.62	(0.47)	3.70	(0.5)
2.4.	3.44	(0.52)	3.28	(0.6)	3.35	(0.57)
2.	3.56	(0.42)	3.42	(0.5)	3.49	(0.47)
3.1.	3.60	(0.76)	3.64	(0.91)	3.62	(0.84)
3.2.	3.83	(0.78)	3.96	(0.81)	3.90	(0.8)
3.3.	3.32	(0.76)	3.19	(0.86)	3.25	(0.82)
3.4.	3.55	(0.84)	3.23	(0.9)	3.38	(0.89)
3.	3.57	(0.58)	3.50	(0.68)	3.54	(0.63)

1.1. self-acceptance, 1.2. positive relationship with others, 1.3. autonomy, 1.4. environmental mastery, 1.5. purpose in life, 1.6. personal growth, 1. psychological well-being (total); 2.1 major related knowledge efficacy, 2.2. career expectations efficacy, 2.3. team-activity-related efficacy, 2.4. creativity-related efficacy, 2. engineering self-efficacy (total); 3.1. general satisfaction, 3.2. social perception satisfaction, 3.3. curriculum satisfaction, 3.4. relation satisfaction, 3. major satisfaction (total).

Table 2. MANOVA for psychological well-being, engineering self-efficacy and major satisfaction in engineering students by gender

Sub-factors	*Wilks' lambda*	*F*	*df*	Univariate		
				MS	*F*	*df*
Positive relationship with others	0.847	7.39***	6	2.384	5.81*	1
Autonomy				0.978	6.15*	1
Environmental mastery				1.980	7.16**	1
Team-activity-related efficacy	0.958	2.71*	4	1.917	8.02**	1
Creativity-related efficacy				1.631	5.09*	1
Relation satisfaction	0.949	3.36*	4	6.235	8.07**	1

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

significance test was used to assess which of the dependent variables contributed to the overall difference between the two groups, and stepdown analysis was used to assess individually the differences of the dependent variables after eliminating the effects of the other dependent variables preceding them in the analysis [84]. First, there were statistically significant differences in the three sub-factors of psychological well-being, namely positive relationship with others (0.05 level), autonomy (0.05 level), and environmental mastery (0.01 level) between the two groups; there were differences also in the two sub-factors of engineering self-efficacy, namely team-activity-related efficacy (0.01 level) and creativity-related efficacy (0.05 level), as well as in the one sub-factor of major satisfaction, namely relation satisfaction (at the 0.01 level).

These results support Hypothesis 1, which stated that men engineering students would score higher in psychological well-being, engineering self-efficacy and major satisfaction than women students do.

4.2 Relationships among Psychological Well-Being, Engineering Self-Efficacy and Major Satisfaction

To identify the relationship among the three variables (i.e., psychological well-being, engineering self-efficacy and major satisfaction) as perceived by engineering students, a Pearson correlation analysis was conducted. The results (see Table 3) indicated a significant correlation among the sub-factors of the three variables. First, specifically, at the significance level $p < 0.01$, a positive correlation ($0.18 \sim 0.56$) was observed between the psychological well-being sub-factors and the sub-factors of engineering self-efficacy; second, at the significance level $p < 0.01$, a positive correlation ($0.17 \sim 0.37$) was observed between the psychological well-being sub-factors and the sub-factors of major satisfaction. As such, the correlation values among all of the factors were smaller than 0.08, proving that there was no problem in terms of multicollinearity.

These results support Hypothesis 2, which stated that there would be significant correlations among psychological well-being, engineering self-efficacy and major satisfaction.

4.3 Effects of Psychological Well-Being on Engineering Self-Efficacy and Major Satisfaction

4.3.1 Effect of Psychological Well-Being on Engineering Self-Efficacy

Table 4 shows the effects of psychological well-being's sub-factors (self-acceptance, positive relationship with others, autonomy, environmental

Table 3. Correlations among psychological well-being, engineering self-efficacy and major satisfaction

	1.1.	**1.2.**	**1.3.**	**1.4.**	**1.5.**	**1.6.**	**1**
2.1.	0.31**	-.01	0.19**	0.41**	0.36**	0.20**	0.35**
2.2.	0.43**	0.12	0.26**	0.46**	0.55**	0.36**	0.52**
2.3.	0.27**	0.47**	0.23**	0.41**	0.37**	0.43**	0.53**
2.4.	0.30**	0.18**	0.33**	0.38**	0.38**	0.30**	0.44**
2	0.41**	0.22**	0.31**	0.51**	0.52**	0.39**	0.56**
3.1.	0.27**	0.03	0.02	0.29**	0.35**	0.17**	0.28**
3.2.	0.18**	0.07	0.01	0.21**	0.22**	0.15*	0.21**
3.3.	0.30**	0.17**	0.07	0.33**	0.26**	0.14*	0.31**
3.4.	0.24**	0.25**	0.1	0.25**	0.24**	0.20**	0.31**
3	0.33**	0.17**	0.07	0.35**	0.35**	0.22**	0.37**

*$p < 0.05$, **$p < 0.01$.
1.1 self-acceptance, 1.2. positive relationship with others, 1.3. autonomy, 1.4. environmental mastery, 1.5. purpose in life, 1.6. personal growth, 1. psychological well-being (total); 2.1 major-related knowledge efficacy, 2.2. career expectations efficacy, 2.3. team-activity-related efficacy, 2.4. creativity-related efficacy, 2. engineering self-efficacy (total); 3.1. general satisfaction, 3.2. social perception satisfaction, 3.3. curriculum satisfaction, 3.4. relation satisfaction, 3. major satisfaction (total).

Table 4. Multiple regression analysis of engineering self-efficacy's sub-factors respecting psychological well-being

Dependent variable	**Independent variable**	***B***	*β*	***t***	***R***^{2}	**Multicollinearity**	
						Tolerance	**VIF**
Major-related knowledge efficacy	(constant)	1.622		4.751***			
	positive relationship with others	–0.256	–0.274	–4.286***	0	0.724	1.381
	autonomy	0.185	0.123	2.216*	0.037	0.957	1.045
	environmental mastery	0.354	0.312	4.328***	0.161	0.570	1.755
	purpose in life	0.252	0.275	3.783***	0.124	0.560	1.786
	R = 0.522, R^2 = 0.273, adjusted R^2 = 0.255, F = 15.392, p = 0.000, Durbin-Watson = 1.861.						
Career expectations efficacy	(constant)	0.522		1.625			
	positive relationship with others	–0.22	–0.223	–3.915***	0.016	0.724	1.381
	autonomy	0.277	0.175	3.529***	0.720	0.957	1.045
	environmental mastery	0.250	0.209	3.251**	0.208	0.570	1.755
	purpose in life	0.427	0.441	6.808***	0.312	0.560	1.786
	R = 0.650, R^2 = 0.423, adjusted R^2 = 0.409, F = 30.006, p = 0.000, Durbin-Watson = 1.927.						
Team-activity-related efficacy	(constant)	0.975		3.698***			
	self-acceptance	–0.156	–0.204	–2.848**	0.072	0.511	1.959
	positive relationship with others	0.240	0.313	5.206***	0.220	0.724	1.381
	autonomy	0.197	0.16	3.055**	0.059	0.957	1.045
	environmental mastery	0.239	0.257	3.790***	0.168	0.570	1.755
	personal growth	0.195	0.215	3.189**	0.185	0.576	1.737
	R = 0.597, R^2 = 0.356, adjusted R^2 = 0.340, F = 22.677, p = 0.000, Durbin-Watson = 1.736.						
Creativity-related efficacy	(constant)	0.595		1.841			
	autonomy	0.383	0.271	4.864***	0.114	0.957	1.045
	environmental mastery	0.243	0.227	3.145**	0.147	0.570	1.755
	purpose in life	0.191	0.220	3.023**	0.149	0.560	1.786
	R = 0.521, R^2 = 0.271, adjusted R^2 = 0.253, F = 15.235, p = 0.000, Durbin-Watson = 1.832.						

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

mastery, purpose in life, and personal growth) on engineering self-efficacy's sub-factors.

First, the analysis results showed that the sub-factors of psychological well-being could explain about 27.3% (R^2 = 0.273) of major-related knowledge efficacy – a sub-factor of engineering self-efficacy. Of that percentage, environmental mastery had the largest explanatory power, at 16.1%. When the other sub-factors, namely positive relationship with others, autonomy, and purpose in life were added, this rose by 11.2% to reach 27.3% of the total. In other words, in terms of the relative explanatory power of major-related knowledge efficacy, environmental mastery was found to be the strongest influence, followed by purpose in life. For the F value, 15.392 was found to be significant, at $p < 0.001$, indicating the validity of this regression model. The tolerance limits of the independent variables were higher than 0.1, at 0.560 and 0.957, respectively, indicating no problem in multicollinearity. The Durbin-Watson value of 1.861 was closer to 2, showing no correlation among the residuals in support of regression model validity.

Secondly, the analysis results showed that the sub-factors of psychological well-being could explain about 42.3% (R^2 = 0.423) of career expectations efficacy – a sub-factor of engineering self-efficacy. Of that percentage, purpose in life had the largest explanatory power, at 31.2%. When positive relationship with others, autonomy, and environmental mastery were added, this rose by 11.1% to reach 42.3% of the total. In other words, in terms of the relative explanatory power of career expectations efficacy, purpose in life was found to be the strongest influence, followed by environmental mastery. For the F value, 30.006 was found to be significant, at $p < 0.001$, indicating the validity of this regression model. The tolerance limits of the independent variables were higher than 0.1, at 0.560 and 0.957, respectively, indicating no problem in multicollinearity. The Durbin-Watson value of 1.927 was closer to 2, showing no correlation among the residuals in support of regression model validity.

Thirdly, the analysis results showed that the sub-factors of psychological well-being could explain about 35.6% (R^2 = 0.356) of team activity related efficacy – a sub-factor of engineering self-efficacy. Of that percentage, positive relationship with others had the largest explanatory power, at 22.0%. When self-acceptance, autonomy, environmental mastery, and personal growth were added,

Table 5 Multiple regression analysis of major satisfaction's sub-factors respecting psychological well-being

Dependent variable	**Independent variable**	***B***	*β*	***t***	***R***^{2}	**Multicollinearity**	
						Tolerance	**VIF**
General satisfaction	(constant)	2.301		4.573***			
	positive relationship with others	–0.234	–0.181	–2.662**	0.013	0.724	1.381
	environmental mastery	0.251	0.160	2.086*	0.123	0.570	1.755
	purpose in life	0.422	0.332	4.300***	0.137	0.560	1.786
	$R = 0.421$, $R^2 = 0.178$, adjusted $R^2 = 0.157$, $F = 8.849$, $p = 0.000$, Durbin-Watson = 1.795						
Curriculum satisfaction	(constant)	1.481		2.933**			
	environmental mastery	0.321	0.208	2.651***	0.139	0.570	1.755
	$R = 0.372$, $R^2 = 0.139$, adjusted $R^2 = 0.118$, $F = 6.596$, $p = 0.000$, Durbin-Watson = 2.081.						

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

this rose by 13.6% to reach 35.6% of the total. In other words, in terms of the relative explanatory power of team-activity-related efficacy, positive relationship with others was found to be the strongest influence, followed by personal growth. For the F value, 22.677 was found to be significant, at $p < 0.001$, indicating the validity of this regression model. The tolerance limits of the independent variables were higher than 0.1, at 0.511 and 0.957, respectively, indicating no problem in multicollinearity. The Durbin-Watson value of 1.736 was closer to 2, showing no correlation among the residuals in support of regression model validity.

Fourth, the analysis results showed that the sub-factors of psychological well-being could explain about 27.1% ($R^2 = 0.271$) of creativity-related efficacy – a sub-factor of engineering self-efficacy. Of that percentage, purpose in life had the largest explanatory power, at 14.9%. When autonomy and environmental mastery were added, this rose by 12.2% to reach 27.1% of the total. In other words, in terms of the relative explanatory power of creativity-related efficacy, purpose in life was found to be the strongest influence, followed by environmental mastery. For the F value, 15.235 was found to be significant, at $p < 0.001$, indicating the validity of this regression model. The tolerance limits of the independent variables were higher than 0.1, at 0.560 and 0.957, respectively, indicating no problem in multicollinearity. The Durbin-Watson value of 1.832 was closer to 2, showing no correlation among the residuals in support of regression model validity.

These results support Hypothesis 3, which stated that psychological well-being will have a positive effect on engineering self-efficacy.

4.3.2 Effect of Psychological Well-Being on Major Satisfaction

Table 5 shows the effects of psychological well-being's sub-factors (self-acceptance, positive relationship with others, autonomy, environmental mastery, purpose in life, and personal growth) on major satisfaction's sub-factors.

First, the analysis results showed that the sub-factors of psychological well-being could explain about 17.8% ($R^2 = 0.178$) of general satisfaction – a sub-factor of major satisfaction. Of that percentage, purpose in life had the largest explanatory power, at 13.7%. When the other sub-factors, namely positive relationship with others and environmental mastery were added, this rose by 4.1% to reach 17.8% of the total. In other words, in terms of the relative explanatory power of general satisfaction, purpose in life was found to be the strongest influence, followed by environmental mastery. For the F value, 8.849 was found to be significant, at $p < 0.001$, indicating the validity of this regression model. The tolerance limits of the independent variables were higher than 0.1, at 0.560 and 0.724, respectively, indicating no problem in multicollinearity. The Durbin-Watson value of 1.795 was closer to 2, showing no correlation among the residuals in support of regression model validity.

Second, the analysis results showed that the sub-factors of psychological well-being could explain about 13.9% ($R^2 = 0.118$) of curriculum satisfaction – a sub-factor of major satisfaction. Of that percentage, environmental mastery had the largest explanatory power, at 13.9%. For the F value, 6.596 was found to be significant, at $p < 0.001$, indicating the validity of this regression model. The tolerance limits of the independent variables were higher than 0.1, at 0.570, which indicates no problem in multicollinearity. The Durbin-Watson value of 2.081 was closer to 2, showing no correlation among the residuals in support of regression model validity.

These results support Hypothesis 4, which stated that psychological well-being will have a positive effect on major satisfaction.

5. Discussion

This study sought to investigate differences in psychological well-being, engineering self-efficacy and major satisfaction among engineering students in Korea by gender. It also aimed to examine the relationships among psychological well-being, engineering self-efficacy and major satisfaction as well as the effects of psychological well-being on engineering self-efficacy and major satisfaction. The main study findings are as discussed below.

First, differences in psychological well-being, engineering self-efficacy and major satisfaction by gender of engineering students were investigated, and a statistically significant difference was found in the three variables' sub-scales between the two groups. First, the finding of this study indicating difference in psychological well-being by gender is consistent with the results from previous studies [34, 43]. On the other hand, contradictory findings [34, 40, 42] revealing higher scores by girls and women in most of the sub-dimensions of psychological well-being also are found in the literature. However, as shown in [34], psychological well-being can differ according to gender, age, and culture variables; and indeed, the results of the present study on gender gaps in psychological well-being of Korean engineering students can be explained by considering, besides gender bias, the particular cultural context as well as the specific academic engineering environment. In addition, the finding on differences in engineering self-efficacy by gender is in agreement with the results from [73, 82]. [82] found low scores in the engineering self-efficacy of women engineering students in Korea, which differs from the results from [68, 72], which showed no significant differences in engineering self-efficacy by gender. These findings imply that engineering self-efficacy should be explained in consideration of differences in academic culture and environment, as women engineering students in Korea experience more difficulties than their counterparts. Further studies considering specific educational environment are to follow, and more attention to the interpretation of results on gender difference in engineering self-efficacy will be required. Also, regarding gender difference in major satisfaction, there have been a few studies exploring gender gaps, and they arrived at different results. Taking these points together, further analyses disaggregating by discipline and other related factors simultaneously would be informative. Accordingly, the present study's findings on engineering students' gender differences in psychological well-being, engineering self-efficacy and major satisfaction can contribute to generalizing the previous studies' conclusions that gender differences in psychological well-being, engineering self-efficacy and major satisfaction are in fact found, in both Western and East Asian undergraduate engineering students.

Second, the correlations among psychological well-being, engineering self-efficacy, and major satisfaction were investigated, and positive correlations were found between most of the sub-factors of the three variables (i.e., psychological well-being, engineering self-efficacy, and major satisfaction). As there have been only a few studies directly dealing with the correlations among these three variables, it is difficult to directly compare them with the results of the current study. However, based on prior studies [41, 45, 46, 48], we can predict that the higher a student's psychological well-being, the higher their engineering self-efficacy. Also, the higher one's psychological well-being, the higher one's major satisfaction. This is due to the fact that a student's psychological well-being, a construct representing individual potential and a state of psychological functioning, is closely related to factors affecting academic achievement and performance as well as overall campus life. Previous studies attempted to suggest engineering programs or a motivating role of professors in the academic environment to reinforce engineering self-efficacy [60, 69, 70]. These studies show that to improve engineering self-efficacy, it is necessary to provide incorporate diversity-promoting in initiatives into regular academic engineering programs. Through enhanced engineering self-efficacy, psychological well-being as well as major satisfaction can be expected to be enhanced as well.

Third, this study also investigated the effect of engineering students' psychological well-being on engineering self-efficacy and on major satisfaction. First, psychological well-being naturally had a considerable effect on engineering self-efficacy. Specifically, regarding the effect on major-related knowledge efficacy, environmental mastery was found to have the greatest effect. As for the effect of psychological well-being on career expectations efficacy, purpose in life was found to have the greatest effect. Concerning the effect of psychological well-being on team-activity-related efficacy, positive relationship with others was found to have the greatest effect. Finally, regarding the effect of psychological well-being on creativity-related efficacy, purpose in life was found to have the greatest effect. Notwithstanding the paucity of studies that have directly examined the relationship between psychological well-being and engineering self-efficacy, the results of the current study on the effect of psychological well-being on engineering self-efficacy are, at least, congruent with the literature [41]. [41] found a general but significant relationship between spiritual well-being and self-efficacy for engineering students. In light of the current study's results, engineering self-efficacy (in particular, purpose in life, environmental mastery, and positive relationship with others, which are the sub-factors of psychological well-being) needs to be strengthened. Second, psychological well-being had a considerable effect on major satisfaction. Specifically, on curriculum satisfaction, environmental mastery was found to have the greatest effect. In addition, on general satisfaction, purpose in life was found to have the greatest effect. This finding indicates that purpose in life and environmental mastery have the greatest effect on major satisfaction. The results of the current study on the effect of psychological well-being on major satisfaction can be supported by several similar studies that examined the relationship between psychological well-being and academic achievement and performance [45], between psychological well-being and achievement levels [46], between psychological well-being and resilience [42], and between psychological well-being and job satisfaction. In this sense, it can be stated that to enhance the major satisfaction of engineering students, psychological well-being needs to be reinforced.

Consequently, in reference to the effect of psychological well-being on engineering self-efficacy and major satisfaction within the framework of the findings obtained from the research, it could be suggested that, for example, educators' intervention should be provided in order to increase the psychological well-being of students. As shown in [46], such intervention helps students learn to be happier and to have positive effects on their own academic achievement and overall life, thereby. Changes in attitude toward the major in order to increase major satisfaction could also be offered as another suggestion. Few research studies have empirically investigated whether there are significant effects of psychological well-being on engineering self-efficacy and major satisfaction. Thus, the conclusions of this empirical study with respect to the fact that psychological well-being has positive impacts on both engineering self-efficacy and major satisfaction will contribute to promoting the fostering of a better environment and education for women engineering students.

This study has a limitation in generalizing its findings to all undergraduate students majoring in engineering, because its sample was drawn from only undergraduate students at a large university in Korea. In addition, the findings from the current study were derived from only quantitative data. If the results had been drawn from both quantitative and qualitative data, they would have been supported by stronger evidence. Finally, the study survey and data collection took place from August 10 to September 10 2020, during the COVID-19 pandemic. The unexpected learning-environment change (from face-to-face to online) thus necessitated might have skewed the lens and perception of the undergraduate students toward psychological well-being, especially environmental mastery, one sub-factor of psychological well-being. Thus, if the results had been drawn from data collected pre-COVID-19, they would have been supported by more integrated evidence. These limitations provide some suggestions for future research. First, future studies need to be conducted with more extensive and larger samples so that the findings can be generalized to more engineering students and further expand the parameters of the engineering education environment. Second, future research needs to employ a mixed-method research design in order to support the findings of the current study with stronger and more concrete evidence. Third, future studies need to examine more and different variables possibly related to psychological well-being, because psychological well-being is closely related to individuals' overall life [41, 43] including academic life [45–49]. Based on subsequent studies considering engineering students' gender gap or career persistence in engineering, more appropriate ways to improve engineering self-efficacy and major satisfaction can be explored in order to induce more convincing conclusions.

6. Conclusions

Based on the findings presented on the pages above, it is evident that engineering students' psychological well-being is related to both engineering self-efficacy and major satisfaction. Specifically, environmental mastery was found to affect major-related knowledge efficacy the most, purpose in life to affect career expectations efficacy, positive relationship with others to affect team-activity-related efficacy, and purpose in life to affect creativity-related efficacy the most. Meanwhile, purpose in life was found to also affect general satisfaction and environmental mastery to also affect curriculum satisfaction. Therefore, to bring about a positive change and enhancement in students' engineering self-efficacy as well as major satisfaction, methods for improving psychological well-being or methods that are relevant to the curriculum need to be considered further. Also, our findings highlight the general importance of psychological well-being for engineering students. The results contribute to the body of research on engineering student's psychological well-being and its close relationship to academic achievement and major persistence, which measures point in turn to the critical importance of students' engineering self-efficacy and satisfaction in their major.

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Soonhee Hwang, PhD, is an Assistant Professor in the Department of Liberal Arts and Science at Hongik University in Korea. She received her Master's degree from Université de Rouen and her PhD from Université Paris VIII in Paris, France. She serves as an Editor of the *Journal of Engineering Education Research* (Korean Society for Engineering Education) and is a former Vice Director of the CTL (Center for Teaching and Learning) at Hongik University. Her current research interests include creativity & convergence education for engineering students, women in engineering, and communication education.