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Effects of Engineering Students' Soft Skills and Empathy on Their Attitudes toward Curricula Integration

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Abstract: Recently, various integrated education curricula for STEM curricula have been provided. This research sought to investigate the effects of engineering students' soft skills and empathy on their attitudes toward curricula integration (hereafter, attitudes toward integration). First, students' attitudinal differences respecting integration, soft skills and empathy were examined. Second, the relationships among attitudes toward integration, soft skills and empathy were identified in terms of various sub-factors of those three variables. Third, the effects of soft skills and empathy on attitudes toward integration, as perceived by men and women engineering students, were explored. A total of 302 engineering students from three universities in Korea responded to a survey based on a three-variable scale. Analysis of the data found that: firstly, men scored higher in most of the sub-factors of two variables, namely attitudes toward integration and soft skills; women scored higher in most of the sub-factors of one variable, empathy; and that these gender differences were statistically significant. Secondly, a positive correlation among attitudes toward integration, soft skills and empathy was identified. Thirdly, it was determined that attitudes toward integration were affected significantly by soft skills and empathy. The practical implications of these findings for engineering education are discussed herein, with particular attention devoted to the issue of the cultivation of engineering students' soft skills, empathy, and attitudes toward integration.

Keywords: engineering students; STEM; integrated curriculum; attitudes toward curricula integration; soft skills; empathy

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1. Introduction

Given the shift to Industry 4.0 and the characteristics of a rapidly advancing technological society, it is difficult to solve complex problems of various facets within a single discipline or on an individual level [1–4]. Accordingly, the needs for convergence education and fostering of convergence-type talents are being emphasized worldwide. Indeed, various competences (e.g., the 4Cs: communication, collaboration, critical thinking, creativity) necessary for driving future society and addressing sustainable solutions to complex problems faced in this century are continuously required from learners [3,5]. Many efforts have been made to prepare students for convergence education and the needed 21st century skills and competences. The integrated curriculum, for example, has been introduced to inculcate and enhance these skills and competencies. Also, as a part of such efforts, STEM education has been variously applied and studied in many countries such as the United States, Canada, UK, Australia, and the Republic of Korea [6–9].

These convergence approaches are important in that they can contribute to students' choice of engineering as a major and then as a career path, specifically by improving their academic achievement in STEM subjects, changing their attitudes regarding their interest and curiosity, and inspiring science motivation [8]. All of these, in turn, can lead to sustainable human resources development and supply for the crucial science and engineering fields. This situation is not much different at home (in Korea) or abroad. "Convergence" and "Integration", often interchangeable, have a wide range of definitions: *convergence* can be defined as "the deep integration of knowledge, techniques, and expertise from multiple fields to form new and expanded frameworks for addressing scientific and societal challenges and opportunities” [10]; *integration* can refer to the concept of curricular integration or a specific integrated curriculum [3], or even to different processes whereby integrated curricula are constructed (e.g., fusion, multidisciplinary, interdisciplinary, and/or transdisciplinary curricula). Further, *integration* is often used in interdisciplinary studies to refer to the process of combining, or to specific combinations of approaches, insights or perspectives [1], to ‘trading zones’ denoting interdisciplinary partnerships in which two or more perspectives are combined [2], or to collaborations of multiple forms of expertise [4].

Within the field of engineering education in Korea, “convergence”—the preferred term over “integration”—education has been conducted in three main directions [11–13]. First, university departments themselves are established by integrating two majors within the college of engineering, such as the Department of Automobile and IT Convergence, the Department of Convergence IT, and the Department of Human ICT Convergence. Second, convergence education is put in place at the level of the engineering major itself, in the forms of various interdisciplinary design courses and curricula such as design and software convergence. Third, convergence-competency-enhancing education is conducted at the level of liberal arts, mainly through extra-curricular programs such as writing and communication, humanities, art, and design. Overall, in order for learners to strengthen their convergence competency, it is important to inculcate, in advance, positive attitudes toward convergence itself.

Diverse integrated education experiences of STEM curricula can have ripple effects on students’ attitudes toward integration. Attitudes research in science has a long history [14], and much work has been done on attitudes toward specific areas, e.g., STEM [15,16] and mathematics [17,18]; in a similar context, [19] dealt with affective dispositions of teacher candidates toward STEM education, whereas there are fewer studies on attitudes toward engineering education [15]. The notion of “attitude” referring to someone’s basic liking or disliking of a familiar target [20], is defined as a “psychological tendency that is expressed by evaluating a particular entity with some degree of favor or disfavor” [21]. In this vein, attitudes toward curricula integration (hereafter, attitudes toward integration) can be defined in terms of attribute dimensions including good–bad, harmful–beneficial, pleasant–unpleasant, and likable–dislikable as well as in terms of positive integrational change [22]. It is hoped that if the incorporation of more detail into technology and engineering curricula is emphasized and improved, students’ attitudes toward integration will be positively changed. It can be deduced that engineering students’ diverse experiences of integrated curricula are closely linked to their attitudes toward integration. So far, little is known about attitudes toward integration or their relationship to other factors for which correlation is predicted.

An integrated curriculum is reportedly an effective way of enhancing diverse 21st century competences [3,23] such as adaptability, complex communication, social skills, non-routine problem solving, self-management/self-development, and systems thinking, and STEM disciplines present opportunities to develop those skills [7]. Such competences are defined and classified in different ways; one of these, ‘soft skills’, which refers to a mix of dispositions, understandings, attributes, and practices [24], can be defined as personality traits, goals, motivations, and preferences that are valued in the labor market, in school, and in many other domains [25]. Significantly, theses competences are not to be taught or acquired in isolation, but rather within a core body of knowledge [26]. Recently, much attention has been paid to the utility of soft skills for flexibly coping with rapidly changing times or complicated social structures. In engineering education also, soft skills have been inculcated over the past decades to complement the ‘hard skills’ essential to that field [27–31]. As such, a close relationship between soft skills and attitudes toward integration is expected. To date, though, little research exists on how soft skills are related to attitudes toward integration, which, significantly, is a variable predicted to be changed or enhanced through integrated STEM curricula.

Additionally, as the world becomes more complex and integrated, empathy is more and more required, even in engineering. Even so, engineering education traditionally has focused on a set of technical skills (e.g., problem solving, design, modeling), and the lack of research on the connection between engineering and empathy is glaring [32]. Empathy is broadly defined as "the reactions of one individual to the observed experiences of another" ([33], p. 113). In engineering, human-centered design or empathic communication skills enable engineers to develop personal connections with users [34]. Empathy in social and emotional skills, with self-awareness, respect for others and communicativeness, are becoming essential at home, work and in the community. And as soft skills, often called "emotional intelligence", can include empathy as a component [35], a close relationship between the two is predicted. Also, as attitudes toward integration include comprehension and tolerance of difference, they are expected to be linked with empathy. Nonetheless studies on how empathy and attitudes toward integration are related are rare.

In the present study, we examined the relationships among attitudes toward integration, soft skills and empathy as well as the effects of soft skills and empathy on attitudes toward integration. Although previous studies have shown mainly how STEM education affects students' academic achievement as well as attitudes toward STEM, the attitudes toward integration itself, specifically of engineering students, and their relationship with integrated curriculum-related variables such as soft skills and empathy have not been fully explained, despite their importance. Also, to date, little research exists on how attitudes toward integration are related to soft skills and empathy. Thus, the present study conducted an empirical study to understand the relationships among attitudes toward integration, soft skills and empathy. If the relationships among these variables are adequately identified, they can be utilized to suggest routes to education improvement in related fields and to help bring about positive change in students' attitudes toward integration.

2. Literature Review

2.1. Attitudes toward Integration

With the emerging global consensus on the importance of developing 21st century competences—often called "soft skills"—efforts have been focused on integrated curricula as an effective means of enhancing those skills [3]. Many studies on various aspects of integrated curricula in STEM have been conducted. Scholars have identified numerous benefits for STEM education and have proposed meaningful changes in various cognitive, affective, psychomotor, and career domains [36–41]. For example, [37] found integrative approaches to have a positive effect in terms of academic achievement in STEM subjects, while STEM education has been shown to have a positive effect on attitudes toward STEM [38]. As such, STEM education is emphasized as an effective way to improve students' desire and motivation to learn, especially their attention and interest [36]. Specifically, [13] reported a positive influence of Korea's integrated STEAM education on students' learning in both the cognitive and affective domains, particularly the latter. Also, STEM education promotes students' problem-solving ability, creativity, and collaboration-related competences [39–42]. As such, it is expected that as STEM is increasingly incorporated into the framework of integrated curricula, attitudes toward integration will be further strengthened. Attitude, as an acquired behavioral disposition, is an affective characteristic, i.e., a characteristic whose qualities express human emotions, and it is presented as a construct of affective characteristics along with interests, emotions, will, and values [43,44]. In this vein, attitudes toward integration consist of noncognitive variables of affect, beliefs, interests, motivation, curiosity, temperament, social sensitivity, coping strategies, cognitive styles, creativity, and values, including affective, emotional, and psychological aspects of convergence [20,45].

Globally, there have been few studies on engineering students' attitudes toward integration itself, while a few attempts have been made in South Korea to experimentally investigate changes in engineering students' attitudes toward integration. And recently, instruments have been developed to measure attitudes toward integration [11,12]. Ref. [11] found significant differences in such attitudes, specifically in terms of engineering education accreditation, gender, and academic year. Women engineering students, despite their higher empathy and social sensitivity, scored significantly lower than men in attitudes toward integration's sub-factors such as knowledge, interest, and self-efficacy. These findings were determined to be related to the engineering field's male-dominant culture [46,47].

Based on previous research results demonstrating the impact of STEM education on undergraduate students' attitudes toward STEM fields, including their attention to and career interest in STEM, that same metric was chosen in the current study, particularly as diverse integrated curricular experiences influence engineering students' attitudes toward integration as related to other factors, in this case, soft skills and empathy. Thus far, little is known about the relationship between those two variables and engineering students' attitudes toward integration, though we would expect it to be a close one.

2.2. Soft Skills in Engineering Education

Given the emerging global consensus on the importance of education curricula imparting 21st century capabilities, there is a growing interest in the development of soft skills as they relate to capabilities to flexibly cope with rapidly changing times and social structures, and engineering education has been representative for the past two decades in this regard [27–31]. In fact, nowadays, soft skills are considered to be as important to engineering and architectural work as technical knowledge or hard skills [48]. Varying definitions of 21st century competences exist, and it is difficult to define and measure them [49,50]. The following are some nomenclatural examples: 21st century skills [51,52]; soft skills (including the 4Cs, problem-solving ability, metacognition, self-directed learning ability, leadership, teamwork, creativity, and critical and innovative thinking, etc.) [30,53–55]; and transferable skills or transversal skills [27,56]. Besides, soft skills can be compared to "human qualities" [31,57] and refer to the emotional side of human beings [58]. Naturally then, the perception of soft skills differs from context to context [29], with the result that their list is far from complete [27,29].

Soft-skills education in engineering has been provided to complement hard skills in order that students can better manage their careers and contribute to finding innovative solutions to societal problems [57,59,60]. Interestingly, [27], analyzing the correlation of personality with project management, found engineering students to be lower in soft skills and women students to be significantly higher in sensitivity to others, empathy, and emotion contagion. Although soft skills, which are cross-disciplinary and independent of job or industry, generally cannot be learned passively or even actively [28], and some of them, furthermore, are even unlearnable through conventional teaching [31], they can at least be improved [29]. Taken together, soft skills enable people to cope with the challenges of professional and everyday life. Although hard skills are more essential to performing a specific job, the lack or absence of soft skills can be a limitation in one's overall career, work-related activities, and daily life [35,61]. Despite the importance of these soft skills, many employers report their lack in graduates [29,56]; therefore, to improve student employability worldwide, universities have increasingly been developing them and imparting them to students.

Given the importance of soft skills in engineering education, the present study examined them as a predictor of engineering students' diverse characteristics and outcomes. Based on prior findings, we embarked on our investigation under the expectation that engineering students' soft skills are related to their attitudes toward integration and empathy.

2.3. Empathy in Engineering Education

Empathy can refer to taking the perspective of another or imagining oneself in another's position [62]. In general, it is understood as being composed of two facets, cognitive and affective/emotional [33,62]: cognitively, it means a process involving an understanding of the experiences of others, and emotionally, it is understood as the capacity to enter into or join the experiences and feelings of another person [32,63]. Above all, as the school and work environments of the future society become more diverse, social and emotional competences such as empathy and respect for others are expected to be emphasized more and more as well as widely. Likewise, as the world becomes more complex and integrated in various ways, empathy in engineering is coming to be required, such as in the form of empathetic design or empathic communication skills, as well as in the cultivation of engineering students' empathy for their users in user-centered design [34]. Basically, as the engineering profession saves and/or betters peoples' lives and society as a whole [64], it is self-evidently required to understand the perspective and needs of those being served.

Although few studies have been conducted on the connection between engineering, or engineering students, and empathy [32], academic discussion on engineering empathy has actually been relatively active since 2011 [63]. For instance, [65] has pointed out that as engineering students deepen their major knowledge, their socio-cultural sensibility decreases, and as their understanding of the engineering field increases, they tend to think of engineering and social issues disparately. Ref. [63] reported that despite awareness of the importance of empathy in engineering research or application processes, engineering students tend not to know how to apply empathy to actual engineering design. Ref. [66] noted that the higher the empathy capacity, the higher the interpersonal skills. Also, three studies showing differences in empathy by major and gender found engineering students' empathy to be somewhat lower than that of humanities students and women's empathy scores to be higher than those of men [67–69].

Taken together, empathy is an important factor, in that future engineers need to develop specific character qualities, affective dispositions, and habits of mind in order to adapt to rapidly changing work environments and technology [32,70]. By extension, empathy, as a major constituent of soft skills, is related to personal traits and habits [29], and as such can be learned and improved. More work focused on engineering students is needed in order to determine how their attitudes toward integration and empathy are related.

Based on previously reported differences among attitudes toward integration, soft skills and empathy by gender we first expected that men would score higher in attitudes toward integration than women engineering students. Also, it was expected that women engineering students would score higher in two variables, soft skills and empathy, than men. Further, based on the previously demonstrated relationships between attitudes toward integration and soft skills on the one hand, and between attitudes toward integration and empathy on the other, we hypothesized that the three variables would be closely correlated, and that soft skills and empathy would predict attitudes toward integration. We hereby propose the following four hypotheses:

Hypothesis 1 (H1): *There will be gender differences in three variables:*

Hypothesis 1-1 (H1-1): *Men engineering students will score higher in attitudes toward integration than women;*

Hypothesis 1-2 (H1-2): *Women engineering students will score higher in soft skills and empathy than men.*

Hypothesis 2 (H2): *There will be significant correlations among attitudes toward integration, soft skills and empathy.*

Hypothesis 3 (H3): *Soft skills will have a positive effect on attitudes toward integration.*

Hypothesis 4 (H4): *Empathy will have a positive effect on attitudes toward integration.*

3. Methods

3.1. Study Subjects

To foster competent future engineers, various integrated curricula for convergence education have been launched, and policies enacted, in Korea. It is critical to understand how possible factors (i.e., attitudes toward integration, soft skills, and empathy) are correlated, and how soft skills and empathy affect attitudes toward integration.

To investigate the relationships among the three variables, 302 men and women engineering students were recruited mainly through the Innovation Center for Engineering Education at the author's affiliated university and the author's personal webpage for participation in a survey. The participants, having given their informed consent, were briefed on the survey procedures. Of the 302 participants, 176 were men (58.3%) and 126 were women (41.7%). They consisted of 85 sophomores (28.1%), 82 juniors (27.2%), 92 seniors (30.5%) and 43 freshmen (14.2%). All 302 questionnaires were collected and utilized in the analysis. The data were collected between 1 November and 31 November 2021, and study approval was granted by the Institutional Review Board (IRB) of the author's affiliated university.

3.2. Instrument

The survey instrument comprised four sections: attitudes toward integration, soft skills, empathy, and demographic information.

3.2.1. Attitudes toward Integration

The instrument used to assess attitudes toward integration was the scale developed by [12] to measure individuals' attitudes toward integration. It consists of 31 questions in five sub-dimensional factors: interests in various disciplines, aesthetic sensitivity, commitment to integrated task, comprehension and tolerance of difference, and willingness to integrate disciplines. Some representative items included "I am interested in several subjects", "The more complex the problem, the stronger the desire to solve it", and "I can make friends with people with different opinions". Each question was to be answered on a 5-point Likert scale (1: not at all, 5: very much). This scale showed good reliability with the current sample (Cronbach's reliability: 0.79). Also, each sub-scale showed good reliability: for interests in various disciplines, the factor reliability (Cronbach's alpha) was 0.77; for aesthetic sensitivity, 0.72; for commitment to integrated task, 0.85; for comprehension and tolerance of difference, 0.77, and for willingness to integrate disciplines, 0.85.

3.2.2. Soft Skills

The instrument used to assess soft skills in the current study was that of [71], for which related work guiding its development was done in [72]. In the present study, the instrument was used to measure engineering soft skills consisting of 79 questions in fourteen subfactors: accurate, energetic, self-reliant, resourceful, versatile, flexible, perceptive, assertive, altruistic, charismatic, dependable, pioneering, creative, and cooperative. Some representative questions were: "I can take on adventures with a happy heart", "I tend to work hard in whatever I do", "I believe that working together can bring better results than alone". Each question was to be answered on a 5-point Likert scale (1: strongly agree, 5: strongly disagree). This scale showed good reliability in the current sample (Cronbach's reliability: 0.94). Also, each sub-scale showed good reliability (Cronbach's alpha = 0.93~0.94).

3.2.3. Empathy

The instrument used to assess empathy was that of [73]: the Questionnaire of Cognitive and Affective Empathy (QCAE) developed by [74] and translated into Korean. The scale consists of five sub-dimensional factors under two categories, 'cognitive' (including perspective taking and online simulation), and 'affective' (emotion contagion, proximal responsivity, and peripheral responsivity), with a total of 31 questions. The sub-dimensional factors were 'perspective taking', or the ability to understand the position and point of view of others; 'online simulation', or the ability to imagine yourself in another person's position in order to understand him/her; 'emotion contagion', or the degree to which people are emotionally affected by the emotions of others; 'proximal responsivity', or the responsiveness of face-to-face contact with other people's direct emotional expressions; and 'peripheral responsivity', or reactivity when indirectly facing the emotions of others through novels or movies. Some representative examples included, "I am strongly influenced by the mood of the people I am with", "It's easy for me to put myself in someone else's shoes", and "I can easily figure out what the other person is trying to say". Each question was to be answered on a 5-point Likert scale (1: strongly disagree, 5: strongly agree). This scale showed good reliability in the current sample (Cronbach's reliability: 0.76). Also, each sub-scale showed good reliability: for perspective taking, the factor reliability (Cronbach's alpha) was 0.75; for online simulation, 0.73; for emotion contagion, 0.75; for proximal responsivity, 0.70, and for peripheral responsivity, 0.79.

3.3. Data Analysis Method

The data collected were processed with SPSS 26.0 for frequency analysis, (exploratory factor analysis) (EFA), reliability analysis, correlation analysis, and multiple regression analysis. AMOS 20.0 was employed to perform confirmatory factor analysis (CFA). The two major analysis methods used in this study were Pearson correlation analysis to investigate the relationship among attitudes toward integration, soft skills, and empathy, and stepwise multiple regression analysis to examine the effects of the two variables, soft skills and empathy, on attitudes toward integration.

4. Results

4.1. Differences in Attitudes of Engineering Students toward Integration, Soft Skills and Empathy by Gender

The mean scores of the men and women on each of three variables are presented in Table 1. Men scored higher in all cases for two variables: attitudes toward integration and soft skills, as well as most of their sub-factors, whereas women scored higher in empathy and most of its sub-factors.

The mean score for attitudes toward integration (total) was 3.76; for men, 3.77, and for women, 3.75. Descriptive analyses carried out for the five dimensions of attitudes toward integration demonstrated higher levels of comprehension and tolerance of difference (M = 4.03, sd = 0.53) and commitment to integrated task (M = 3.81, sd = 0.69) than the levels of others, e.g., aesthetic sensitivity (M = 3.42, sd = 0.6) (Wilks' lambda = 0.927, F = 4.691, $p < 0.001$).

The mean score for soft skills (total) was 3.72. The mean score for men was 3.76, while that for women was 3.67. Descriptive analyses carried out for the fourteen sub-categories of soft skills demonstrated relatively higher levels for flexible (M = 4.03, sd = 0.44), resourceful (M = 3.93, sd = 0.53), cooperative (M = 3.85, sd = 0.62) and assertive (M = 3.85, sd = 0.53) than for the others, e.g., pioneering (M = 3.48, sd = 0.82), and versatile (M = 3.30, sd = 0.78) (Wilks' lambda = 0.915, F = 1.896, $p < 0.05$).

The mean score for empathy (total) was 2.85; for men, 2.81, and for women, 2.90. Descriptive analyses carried out for the five dimensions of empathy demonstrated higher levels for online simulation (M = 3.10, sd = 0.41) and perspective taking (M = 3.06, sd = 0.45) than for the others, e.g., emotion contagion (M = 2.58, sd = 0.64) (Wilks' lambda = 0.945, F = 3.470, $p < 0.001$).

MANOVA was used to determine statistically significant differences in the three variables (i.e., attitudes toward integration, soft skills, empathy) by gender. Table 2 shows that there were in fact such differences: Wilks' lambda = 0.927 at the 0.001 level, 0.915 at the 0.5 level, and 0.945 at the 0.01 level. A univariate significance test was used to assess which of the dependent variables had contributed to the overall intergroup difference, and step-down analysis was used to individually assess the differences of the dependent variables after eliminating the effects of the dependent variables preceding them in the analysis [75]. First, there were statistically significant differences in one sub-factor of attitudes toward integration, namely willingness to integrate disciplines (0.01 level); there were differences also in the three sub-factors of soft skills, namely accurate (0.05 level), versatile (0.01 level), and dependable (0.05 level), as well as in empathy (total) (0.05 level) and its two sub-factors, namely proximal responsivity (0.05 level), and peripheral responsivity (0.01 level).

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.	3.75	(0.60)	3.82	(0.548)	3.78	(0.581)
1.2.	3.37	(0.69)	3.50	(0.63)	3.42	(0.66)
1.3.	3.92	(0.66)	3.65	(0.71)	3.81	(0.69)
1.4.	4.04	(0.53)	4.03	(0.52)	4.03	(0.53)
1.5.	3.76	(0.64)	3.77	(0.63)	3.76	(0.63)
1.	3.77	(0.42)	3.75	(0.41)	3.76	(0.42)
2.1.	3.69	(0.62)	3.55	(0.60)	3.64	(0.61)
2.2.	3.78	(0.63)	3.66	(0.68)	3.73	(0.65)
2.3.	3.83	(0.56)	3.71	(0.55)	3.78	(0.56)
2.4.	3.97	(0.53)	3.88	(0.53)	3.93	(0.53)
2.5.	3.40	(0.78)	3.16	(0.76)	3.30	(0.78)
2.6.	4.03	(0.46)	4.02	(0.41)	4.03	(0.44)
2.7.	3.77	(0.66)	3.65	(0.65)	3.72	(0.65)
2.8.	3.88	(0.54)	3.80	(0.51)	3.85	(0.53)
2.9.	3.79	(0.52)	3.74	(0.55)	3.77	(0.53)
2.10.	3.65	(0.63)	3.72	(0.58)	3.68	(0.61)
2.11.	3.66	(0.57)	3.50	(0.52)	3.59	(0.56)
2.12.	3.49	(0.86)	3.47	(0.77)	3.48	(0.82)
2.13.	3.77	(0.57)	3.70	(0.62)	3.74	(0.59)
2.14.	3.87	(0.61)	3.84	(0.63)	3.85	(0.62)
2.	3.76	(0.46)	3.67	(0.45)	3.72	(0.46)
3.1.	3.08	(0.46)	3.04	(0.44)	3.06	(0.45)
3.2.	3.09	(0.43)	3.10	(0.38)	3.10	(0.41)
3.3.	2.54	(0.65)	2.65	(0.64)	2.58	(0.64)
3.4.	2.58	(0.50)	2.75	(0.59)	2.65	(0.55)
3.5.	2.69	(0.51)	2.91	(0.58)	2.78	(0.55)
3.	2.81	(0.30)	2.90	(0.33)	2.85	(0.32)

1.1. interests in various disciplines, 1.2. aesthetic sensitivity, 1.3. commitment to integrated task, 1.4. comprehension and tolerance of difference, 1.5. willingness to integrate disciplines, 1. attitudes toward integration (total); 2.1. accurate, 2.2. energetic, 2.3. self-reliant, 2.4. resourceful, 2.5. versatile, 2.6. flexible, 2.7. perceptive, 2.8. assertive, 2.9. altruistic, 2.10. charismatic, 2.11. dependable, 2.12. pioneering, 2.13. creative, 2.14. cooperative, 2. soft skills (total); 3.1. perspective taking, 3.2. online simulation, 3.3. emotion contagion, 3.4. proximal responsivity, 3.5. peripheral responsivity, 3. empathy (total).

Table 2. MANOVA for engineering students' attitudes toward integration, soft skills and empathy by gender.

Sub-Factors	Wilks' Lambda	F	df	Univariate		
				MS	F	df
Willingness to integrate disciplines	0.927	4.691 ***	5	5.367	11.579 **	1
Accurate	0.915	1.896 *	14	1.461	3.922 *	1
Versatile				4.315	7.203 **	1
Dependable				1.757	5.749 *	1
Proximal responsivity	0.945	3.470 **	5	1.966	6.690 *	1
Peripheral responsivity				3.439	11.829 **	1
Empathy (total)				0.578	5.904 *	1

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

These results support Hypothesis 1-1: men will score higher in attitudes toward integration than women engineering students. Also, these results partially support Hypothesis 1-2: women engineering students will score higher in soft skills and empathy than men.

4.2. Relationships among Attitudes toward Integration, Soft Skills and Empathy

To identify the relationships among these three variables as perceived by engineering students, a Pearson correlation analysis was conducted. The results, summarized in Table 3, indicate significant correlations among the sub-factors of the three variables. First, at the significance level $p < 0.01$, a positive correlation (0.16~0.71) was observed between the attitudes toward integration and soft skills sub-factors; second, there were correlations among most of the sub-factors of attitudes toward integration and empathy. At the significance levels $p < 0.01$ and $p < 0.05$, a positive correlation (0.13~0.57) was observed between the soft skills and empathy sub-factors. Also, at the significance level $p < 0.05$, a negative correlation (−0.14) was observed between commitment to integrated task (a soft skills sub-factor) and peripheral responsivity (an empathy sub-factor). The correlation values among all factors were smaller than 0.08, proving that there was no multicollinearity problem. These results support Hypothesis 2: there will be significant correlations among attitudes toward integration, soft skills and empathy.

Table 3. Correlations among attitudes toward integration, soft skills and empathy.

	1.1.	1.2.	1.3.	1.4.	1.5.	1
2.1.	0.33 **	0.21 **	0.48 **	0.35 **	0.44 **	0.54 **
2.2.	0.38 **	0.20 **	0.54 **	0.25 **	0.43 **	0.55 **
2.3.	0.39 **	0.21 **	0.58 **	0.30 **	0.50 **	0.60 **
2.4.	0.35 **	0.23 **	0.53 **	0.28 **	0.41 **	0.54 **
2.5.	0.28 **	0.31 **	0.39 **	0.16 **	0.41 **	0.47 **
2.6.	0.28 **	0.26 **	0.26 **	0.66 **	0.24 **	0.49 **
2.7.	0.40 **	0.31 **	0.48 **	0.27 **	0.48 **	0.59 **
2.8.	0.39 **	0.30 **	0.49 **	0.31 **	0.44 **	0.58 **
2.9.	0.29 **	0.36 **	0.29 **	0.50 **	0.34 **	0.52 **
2.10.	0.35 **	0.29 **	0.38 **	0.31 **	0.38 **	0.52 **
2.11.	0.30 **	0.16 **	0.44 **	0.30 **	0.46 **	0.50 **
2.12.	0.33 **	0.32 **	0.28 **	0.30 **	0.29 **	0.45 **
2.13.	0.50 **	0.42 **	0.53 **	0.28 **	0.52 **	0.68 **
2.14.	0.38 **	0.36 **	0.39 **	0.33 **	0.30 **	0.53 **
2.	0.46 **	0.37 **	0.57 **	0.42 **	0.53 **	0.71 **
3.1.	0.28 **	0.25 **	0.30 **	0.40 **	0.27 **	0.44 **
3.2.	0.27 **	0.21 **	0.22 **	0.60 **	0.21 **	0.43 **
3.3.	−0.06	0.13 *	−0.03	0.03	0.02	0.03
3.4.	0.00	0.22 **	0.01	0.21 **	0.05	0.14 *
3.5.	0.08	0.31 **	−0.14 *	0.22 **	-0.10	0.10
3.	0.17 **	0.36 **	0.10	0.44 **	0.13 *	0.35 **

* $p < 0.05$, ** $p < 0.01$, 1.1. interests in various disciplines, 1.2. aesthetic sensitivity, 1.3. commitment to integrated task, 1.4. comprehension and tolerance of difference, 1.5. willingness to integrate disciplines, 1. attitudes toward integration (total); 2.1. accurate, 2.2. energetic, 2.3. self-reliant, 2.4. resourceful, 2.5. versatile, 2.6. flexible, 2.7. perceptive, 2.8. assertive, 2.9. altruistic, 2.10. charismatic, 2.11. dependable, 2.12. pioneering, 2.13. creative, 2.14. cooperative, 2. soft skills (total); 3.1. perspective taking, 3.2. online simulation, 3.3. emotion contagion, 3.4. proximal responsivity, 3.5. peripheral responsivity, 3. empathy (total).

4.3. Effects of Soft Skills and Empathy on Attitudes toward Integration

4.3.1. Effects of Soft Skills and Empathy on Attitudes toward Integration

Table 4 shows the effects of soft skills and empathy on attitudes toward integration (total).

Table 4. Multiple regression analysis of attitudes toward integration respecting soft skills and empathy.

Model	Independent Variables	B	SE	β	t	R^2	ΔR^2_{adj}	ΔR^2	F	Multicollinearity	
										Tolerance	VIF
1	(constant)	1.384	0.138		10.006 ***	0.500	0.498	0.500	300.145 ***		
	soft skills	0.639	0.037	0.707	17.325 ***					1.000	1.000
2	(constant)	0.995	0.178		5.593 ***	0.519	0.515	0.019	11.506 **		
	soft skills	0.600	0.038	0.663	15.743 ***					0.906	1.103
	empathy	0.188	0.056	0.143	3.392 **					0.906	1.103

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

The analysis results show that soft skills and empathy explained about 51.9% ($R^2 = 0.519$) of attitudes toward integration (total). Of that percentage, soft skills (total) had larger explanatory power, at 50.%. When the other sub-factor, empathy (total) was added, this rose by 1.9% to 51.9% of the total. For the F value, 11.506 was significant, at $p < 0.01$, indicating the validity of this regression model. The tolerance limits of the independent variables were higher than 0.1, at 0.906 for each, indicating no multicollinearity problem. The Durbin–Watson value of 1.743 was closer to 2, showing no correlation among residuals, in support of regression model validity.

4.3.2. Effects of Soft Skills and Empathy on Interest in Various Disciplines

Table 5 shows the effects of soft skills' and empathy's sub-factors on interest in various disciplines, a sub-factor of attitudes toward integration.

Table 5. Multiple regression analysis of interest in various disciplines respecting soft skills and empathy.

Model	Independent Variables	B	SE	β	t	R^2	ΔR^2_{adj}	ΔR^2	F	Multicollinearity	
										Tolerance	VIF
1	(constant)	1.923	0.187		10.297 ***	0.252	0.25	0.252	101.245 ***		
	creative	0.496	0.049	0.502	10.062 ***					1.000	1.000
2	(constant)	1.68	0.202		8.315 ***	0.273	0.268	0.021	8.610 **		
	creative	0.412	0.057	0.417	7.276 ***					0.741	1.350
	energetic	0.15	0.051	0.168	2.934 **					0.741	1.350
3	(constant)	1.332	0.255		5.214 ***	0.285	0.278	0.012	4.871 *		
	creative	0.41	0.056	0.416	7.302 ***					0.741	1.350
	energetic	0.159	0.051	0.178	3.119 **					0.736	1.358
	peripheral responsivity	0.115	0.052	0.109	2.207 *					0.992	1.008

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

The analysis results show that soft skills' and empathy's sub-factors explained about 28.5% ($R^2 = 0.285$) of interest in various disciplines—a sub-factor of attitudes toward integration. Of that percentage, creative had the largest explanatory power, at 25.2%. When the other sub-factors, energetic and peripheral responsivity, were added, this rose by 3.3% to 28.5% of the total. So, in terms of the relative explanatory power of interests in various disciplines, creative was the strongest influence, followed by energetic and peripheral responsivity. For the F value, 4.871 was significant, at $p < 0.05$, indicating the validity of this regression model. The tolerance limits of the independent variables were higher than 0.1, at 0.736, 0.741 and 0.992 for each, indicating no multicollinearity problem. The Durbin–Watson value of 1.903 was closer to 2, showing no correlation among residuals, in support of regression model validity.

4.3.3. Effects of Soft Skills and Empathy on Aesthetic Sensitivity

Table 6 shows the effects of soft skills' and empathy's sub-factors on aesthetic sensitivity, a sub-factor of attitudes toward integration.

Table 6. Multiple regression analysis of aesthetic sensitivity respecting soft skills and empathy.

Model	Independent Variables	B	SE	β	t	R^2	ΔR^2_{adj}	ΔR^2	F	Multicollinearity	
										Tolerance	VIF
1	(constant)	1.635	0.224		7.311 ***	0.179	0.177	0.179	65.528 ***		
	creative	0.478	0.059	0.423	8.095 ***					1	1
2	(constant)	0.505	0.271		1.86	0.282	0.277	0.103	42.917 ***		
	creative	0.491	0.055	0.435	8.874 ***					0.999	1.001
	peripheral responsivity	0.389	0.059	0.321	6.551 ***					0.999	1.001
3	(constant)	0.043	0.302		0.141	0.307	0.3	0.025	10.663 **		
	creative	0.502	0.055	0.444	9.191 ***					0.995	1.005
	peripheral responsivity	0.39	0.058	0.322	6.673 ***					0.999	1.001
	emotion contagion	0.163	0.05	0.158	3.265 **					0.997	1.003
4	(constant)	−0.002	0.301		−0.006	0.317	0.308	0.01	4.440 *		
	creative	0.427	0.065	0.379	6.614 ***					0.701	1.426
	peripheral responsivity	0.391	0.058	0.323	6.734 ***					0.999	1.001
	emotion contagion	0.155	0.05	0.15	3.108 **					0.990	1.010
	pioneering	0.097	0.046	0.12	2.107 *					0.703	1.422

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

The analysis results show that soft skills' and empathy's sub-factors explained about 31.7% (R^2 = 0.317) of aesthetic sensitivity—a sub-factor of attitudes toward integration. Of that percentage, creative had the largest explanatory power, at 17.9%. When the other sub-factors, peripheral responsivity, emotion contagion, and pioneering, were added, this rose by 13.8% to 31.7% of the total. So, in terms of the relative explanatory power of aesthetic sensitivity, creative was the strongest influence, followed by peripheral responsivity, emotion contagion, and pioneering. For the F value, 4.440 was significant, at $p < 0.05$, indicating the validity of this regression model. The tolerance limits of the independent variables were higher than 0.1, at 0.701, 0.703, 0.990 and 0.999 for each, indicating no multicollinearity problem. The Durbin–Watson value of 2.039 was closer to 2, showing no correlation among residuals, in support of regression model validity.

4.3.4. Effects of Soft Skills and Empathy on Commitment to Integrated Task

Table 7 shows the effects of soft skills' and empathy's sub-factors on commitment to integrated task, a sub-factor of attitudes toward integration.

The analysis results show that soft skills' and empathy's sub-factors explained about 42.7% (R^2 = 0.427) of commitment to integrated task—a sub-factor of attitudes toward integration. Of that percentage, self-reliant had the largest explanatory power, at 34.0%. When the other sub-factors, creative, energetic, and altruistic, were added, this rose by 8.7% to 42.7% of the total. So, in terms of the relative explanatory power of commitment to integrated task, self-reliant was the strongest influence, followed by creative, energetic, and altruistic. For the F value, 7.882 was significant, at $p < 0.01$, indicating the validity of this regression model. The tolerance limits of the independent variables were higher than 0.1, at 0.397, 0.467, 0.575 and 0.64 for each, indicating no multicollinearity problem. The Durbin–Watson value of 2.228 was closer to 2, showing no correlation among residuals, in support of regression model validity.

Table 7. Multiple regression analysis of commitment to integrated task respecting soft skills and empathy.

Model	Independent Variables	B	SE	β	t	R^2	ΔR^2_{adj}	ΔR^2	F	Multicollinearity	
										Tolerance	VIF
1	(constant)	1.07	0.223		4.805 ***	0.34	0.338	0.34	154.472 ***		
	self-reliant	0.725	0.058	0.583	12.429 ***					1	1
2	(constant)	0.624	0.232		2.687 **	0.391	0.387	0.051	25.048 ***		
	self-reliant	0.514	0.07	0.413	7.316 ***					0.639	1.565
	creative	0.333	0.066	0.283	5.005 ***					0.639	1.565
3	(constant)	0.541	0.23		2.350 *	0.412	0.406	0.021	10.563 **		
	self-reliant	0.346	0.086	0.278	4.016 ***					0.411	2.435
	creative	0.303	0.066	0.257	4.578 ***					0.626	1.597
	energetic	0.222	0.068	0.209	3.250 **					0.476	2.1
4	(constant)	0.821	0.248		3.303 **	0.427	0.419	0.015	7.822 **		
	self-reliant	0.391	0.087	0.314	4.504 ***					0.397	2.519
	creative	0.357	0.068	0.303	5.237 ***					0.575	1.739
	energetic	0.249	0.068	0.234	3.643 ***					0.467	2.141
	altruistic	−0.199	0.071	−0.154	−2.797 **					0.640	1.562

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

4.3.5. Effects of Soft Skills and Empathy on Comprehension and Tolerance of Difference

Table 8 shows the effects of soft skills' and empathy's sub-factors on comprehension and tolerance of difference, a sub-factor of attitudes toward integration.

Table 8. Multiple regression analysis of comprehension and tolerance of difference respecting soft skills and empathy.

Model	Independent Variables	B	SE	β	t	R^2	ΔR^2_{adj}	ΔR^2	F	Multicollinearity	
										Tolerance	VIF
1	(constant)	0.823	0.211		3.902 ***	0.439	0.437	0.439	234.698 ***		
	flexible	0.797	0.052	0.663	15.320 ***					1	1
2	(constant)	0.318	0.206		1.546	0.525	0.522	0.086	54.075 ***		
	flexible	0.582	0.056	0.484	10.366 ***					0.729	1.371
	online simulation	0.442	0.06	0.343	7.354 ***					0.729	1.371
3	(constant)	0.478	0.212		2.254 *	0.537	0.532	0.012	7.588 **		
	flexible	0.645	0.06	0.536	10.742 ***					0.624	1.601
	online simulation	0.47	0.06	0.365	7.794 ***					0.708	1.412
	resourceful	−0.127	0.046	-0.127	−2.755 **					0.729	1.371
4	(constant)	0.398	0.208		1.91	0.559	0.553	0.022	14.777 ***		
	flexible	0.627	0.059	0.521	10.638 ***					0.620	1.612
	online simulation	0.46	0.059	0.357	7.788 ***					0.707	1.415
	resourceful	−0.229	0.052	−0.229	−4.376 ***					0.542	1.844
	accurate	0.161	0.042	0.187	3.844 ***					0.628	1.592
5	(constant)	0.345	0.207		1.661	0.568	0.56	0.009	6.176 *		
	flexible	0.651	0.059	0.541	10.991 ***					0.604	1.656
	online simulation	0.459	0.059	0.357	7.844 ***					0.707	1.415
	resourceful	−0.174	0.056	−0.174	−3.082 **					0.459	2.181
	accurate	0.213	0.046	0.247	4.579 ***					0.503	1.989
	perceptive	−0.12	0.048	−0.148	−2.485 *					0.411	2.434

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

The analysis results show that soft skills' and empathy's sub-factors explained about 56.8% (R^2 = 0.568) of comprehension and tolerance of difference—a sub-factor of attitudes toward integration. Of that percentage, flexible had the largest explanatory power, at 43.9%. When the other sub-factors, online simulation, resourceful, accurate, and perceptive, were added, this rose by 12.9% to 56.8% of the total. So, in terms of the relative explanatory power of comprehension and tolerance of difference, flexible was the strongest influence, followed by online simulation, resourceful, accurate, and perceptive. For the F value, 6.176 was significant, at $p < 0.05$, indicating the validity of this regression model. The tolerance limits of the independent variables were higher than 0.1, at 0.411, 0.459, 0.503, 0.604 and 0.707 for each, indicating no multicollinearity problem. The Durbin–Watson value of 2.090 was closer to 2, showing no correlation among residuals, in support of regression model validity.

4.3.6. Effects of Soft Skills and Empathy on Willingness to Integrate Disciplines

Table 9 shows the effects of soft skills' and empathy's sub-factors on willingness to integrate disciplines, a sub-factor of attitudes toward integration.

Table 9. Multiple regression analysis of willingness to integrate disciplines respecting soft skills and empathy.

Model	Independent Variables	B	SE	β	t	R^2	ΔR^2_{adj}	ΔR^2	F	Multicollinearity	
										Tolerance	VIF
1	(constant) creative	1.686 0.555	0.202 0.053	 0.515	8.343 *** 10.399 ***	0.265	0.263	0.265	108.138 ***	 1.000	 1.000
2	(constant) creative self-reliant	1.127 0.362 0.339	0.224 0.064 0.068	 0.336 0.298	5.020 *** 5.635 *** 4.993 ***	0.322	0.317	0.057	24.935 ***	 0.639 0.639	 1.565 1.565

*** $p < 0.001$.

The analysis results show that soft skills' and empathy's sub-factors explained about 32.2% ($R^2 = 0.322$) of willingness to integrate disciplines—a sub-factor of attitudes toward integration. Of that percentage, creative had the largest explanatory power, at 26.5%. When the other sub-factor, self-reliant, was added, this rose by 5.7% to 32.2% of the total. So, in terms of the relative explanatory power of willingness to integrate disciplines, creative was the strongest influence, followed by self-reliant. For the F value, 24.935 was 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 0.639 for each, indicating no multicollinearity problem. The Durbin–Watson value of 1.911 was closer to 2, showing no correlation among residuals, in support of regression model validity.

All these results support Hypothesis 3: soft skills will have a positive effect on attitudes toward integration, and Hypothesis 4: empathy will have a positive effect on attitudes toward integration.

5. Discussion

This study sought to investigate attitudinal differences respecting integration, soft skills and empathy among engineering students in Korea by gender. It also aimed to examine the relationships among attitudes toward integration, soft skills and empathy as well as the effects of soft skills and empathy on attitudes toward integration. The main study findings follow.

First, regarding gender attitudinal differences regarding integration, soft skills and empathy, statistically significant differences were found in the three variables' sub-scales. Concerning gender attitudinal difference toward integration, men scored higher than women. This is consistent with a previous study [11]. Also, the finding on gender differences in soft skills, that men scored significantly higher in accuracy, versatility, and dependability than women, contradicts the results from [27]. Both of these results on gender gaps can be explained by previous reports on the engineering field's characteristics [46,47], where a significant number of women experience identity confusion and difficulties in career progress due to the male-dominant culture (e.g., collective-mindedness, men-centric education, task-orientation). In fact, many integrated curricula in engineering education, such as capstone design or imaginary engineering, are provided based on task types in which diverse students work together to design, perform, or solve problems. In this process, if women students experience discomfort in team activities without being able to play a leadership role due to a lack of gender-sensitive attitudes from engineering professors or fellow male students, or their own inner conflicts, they have difficulties in achieving or experiencing self-efficacy, resulting in poor attitudes toward integration. Considering these difficulties for women engineering students, it is necessary to increase their interest and self-efficacy by facilitating repeated experiences of success or curiosity through diverse integrated curriculum-based activities. Also, this study's finding of gender difference in empathy is consistent with numerous previous studies [27,67–69]. According to those, women were more empathetic than men, which was confirmed in the current study. Nowadays, engineering design encompasses many activities, and user-participation processes make new demands. So, engineering education should foster an environment suitable for further development of engineering students' empathy by incorporating empathy into the teaching of more technical outcomes (e.g., in order to fully incorporate clients' needs) [32]. In this vein, for example, co-creation workshops between engineering students and user representatives as a learning experience focusing on the user's needs have been identified as appropriate for user-centered design education [34]. Certainly, further disaggregation analyses for other related factors simultaneously would be informative. Accordingly, the present study's findings on engineering students' gender attitudinal differences on integration, soft skills and empathy can contribute to generalizing the previous studies' conclusions.

Second, regarding the correlations among attitudes toward integration, soft skills, and empathy, positive ones were found for most of the three variables' sub-factors. As there have been only a few studies directly or indirectly dealing with correlations among these three variables, it is difficult to directly compare them with the current study. However, based on prior studies [28,29,31,32,34,35], we can predict that the higher a student's soft skills, the more positive the attitudes toward integration. Also, the higher one's empathy, the more positive the attitudes toward integration. With an integrated curriculum being an effective way of enhancing diverse 21st century competences including soft skills and empathy [3,23], a student's attitudes toward integration are closely related to soft skills and empathy. Therefore, it is necessary to embed soft skills training into hard skills, which is an effective method of achieving both a preferred pedagogy and enhanced soft skills [29]. Through enhanced soft skills as well as empathy, attitudes toward integration can be expected to be enhanced.

Third, this study investigated the effects of engineering students' soft skills and empathy on their attitudes toward integration, with soft skills and empathy having a considerable effect on attitudes toward integration as well as its sub-factors. Notwithstanding the paucity of studies directly examining the relationships among attitudes toward integration, soft skills, and empathy, the current results on the effects of both soft skills and empathy on attitudes toward integration, at least, are congruent with the literature [11]. In light of the current study's results, soft skills need to be further enhanced. Also, the current findings on the effects of soft skills and empathy on attitudes toward integration are supported by several similar studies examining the social skills/empathy [35,66] and empathy/engineering [32,63,68] relationships. Thus, it can be stated that to enhance attitudes toward integration, soft skills as well as empathy need to be reinforced. Few studies have empirically investigated whether there are significant effects of soft skills as well as empathy on attitudes toward integration. The conclusions of this empirical study respecting the positive impacts of soft skills and empathy on attitudes toward integration will help to foster a better educational environment for attitudinal improvement regarding integration.

This study's findings are of limited generalizability to all undergraduate students majoring in engineering, because its sample was drawn from only three large Korean universities' undergraduates. Future studies need to be conducted with larger and more extensive samples for better generalizability to more students and further expansion of the parameters of the engineering education environment. Also, future research needs to employ a mixed-method research design in order to support the present findings with stronger and more concrete evidence. Finally, future studies need to examine more and different variables possibly related to attitudes toward integration. In these ways, more appropriate means of improving engineering students' attitudes toward integration, soft skills, and empathy can be explored in return for more convincing conclusions.

6. Conclusions

It is evident from the current findings that engineering students' attitudes toward integration are related to both soft skills and empathy. Therefore, to bring about positively changed attitudes toward integration, methods that can improve soft skills and empathy while remaining relevant to the curriculum need to be considered. Overall, our findings highlight the general importance of engineering students' attitudes toward integration and contribute to the body of research on such attitudes' close relationship to soft skills and empathy.

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