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AC 2011-2331: A CROSS-NATIONAL INVESTIGATION OF CONFIDENCE IN ABET SKILLS AND KOLB LEARNING STYLES: KOREA AND THE UNITED STATES

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A Cross-National Investigation of Confidence in ABET Skills and Kolb Learning Styles: Korea and the United States

Abstract

In this paper, we examine confidence levels in ABET skills and Kolb learning style preferences in lower division students in project-based design courses offered at the University of California at Berkeley and the Korea Advanced Institute of Science and Technology. With data obtained from online surveys, we compared confidence in ABET-related engineering and design skills by country and gender. We used the learning styles defined by David Kolb's Experiential Learning Theory, for its strong connection with design processes as well as learning. Kolb's model defines four learning styles, which are each highlighted in different stages of design.

The results highlight national and gender differences in students' perception of their development in ABET-related skills. The American students rated themselves higher in creativity, teamwork, ethics, facility with tools of engineering practice, and in recognizing global impact. The Korean students assessed their skills higher in design, problem solving, and communication skills. There was no statistically significant difference in leadership or analytical skills. However, in spite of apparent national differences, the students follow similar gender patterns. The men were more confident in technical and analytical skills, while the women were more confident in communication and teamwork skills. As such, both cultures could benefit from interventions that build skills and confidence in each area.

Introduction and Literature Review

Recent reports from the National Academies stress the importance of preparing engineers to be successful in a global, multidisciplinary workforce[1,2,3]. In addition to strengthening traditional skills related to analysis and experimentation, accreditation for engineering education through ABET[4,5,6,7] requires students to demonstrate advances in creativity and practical ingenuity, design capabilities, communication skills, leadership, ethics, and professionalism. This stems from the belief that these skills lead to success inside and outside of the classroom, and also provide a foundation for engaging in life-long learning and real-world problem-solving.

This paper discusses students' confidence in these skills in two lower division college populations from research universities in Korea and the United States. We build on previous research for educating effective engineers[8,9], and hope to provide insight into these crucial "flat world" skills[10] within the context of gender, nationality, and learning styles.

In addition, we explore the correlation between learning styles and confidence levels in ABET-related skills using David Kolb's Experiential Learning Theory. Although there are many excellent tools available for classroom use of learning or cognitive styles tests (e.g., Herrmann Brain Dominance Instrument[11,12], Index of Learning Styles[13,14], Big Five Personality Test[15,16]), we used the Kolb tool because of its accessibility for research, shorter length questionnaire and the ability to benchmark against prior work. Having fewer questions was particularly important, as we needed to translate the survey into the Korean language to administer in Korea.

The Kolb model is based on the idea that "knowledge is created through the transformation of experience"[17,18], and is built on two axes. The vertical axis represents how one thinks about things, while the horizontal axis represents how one acts on things. The end of each axis corresponds to a cognitive or behavioral extreme: Concrete Experience versus Abstract Conceptualization, and Reflective Observation versus Active Experimentation. Most people develop strengths at one end of each axis. Learning styles are determined by which combination of approaches each individual trends towards: accommodating, diverging, assimilating, and converging (Figure 1).

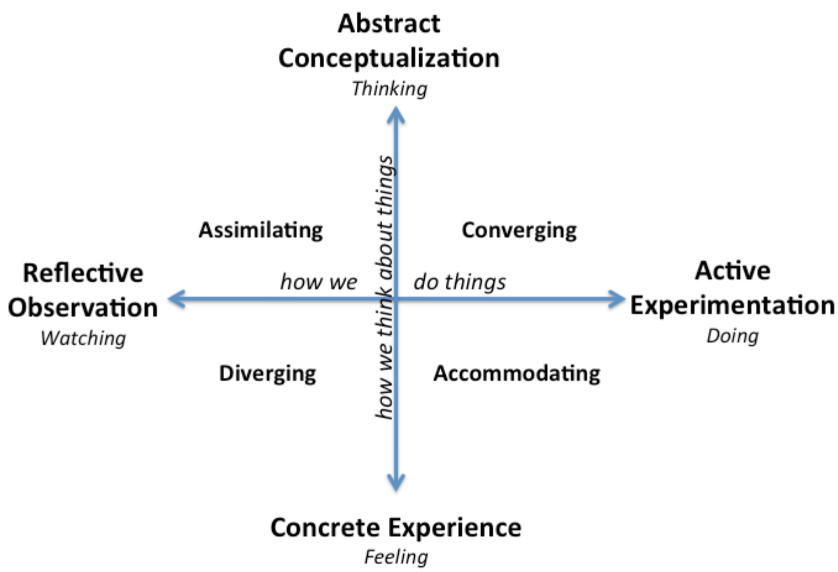

Figure 1: Learning Styles

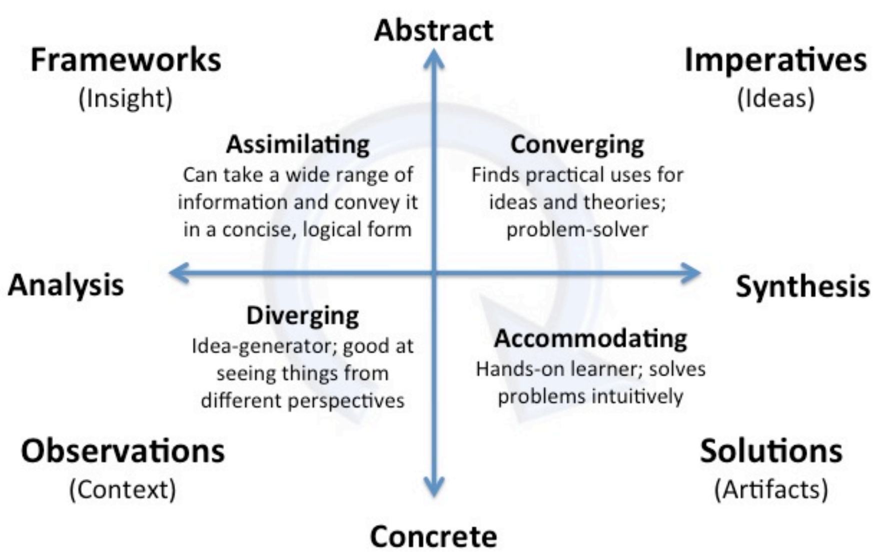

Figure 2: Learning Styles and the Design Process[19]

We focus on learning styles because of their relation to innovation as a learning process. Designers must move fluidly between concrete and abstract worlds, and use both analysis and synthesis to create new designs. For instance, they may begin with observations, then build frameworks, settle on a list of imperatives, and finally reach the design solution (Figure 2). It is important to note that the best results are obtained when the students iterate through this cycle (i.e., the four quadrants) multiple times. As such, successful design teams must collectively demonstrate all four learning styles in the design process[19].

Survey Populations and Methods

Most of the data were gathered from design courses at research universities in Korea and the United States. The Korean data are from "ED100: Introduction to Design and Communication," a freshman-level course offered at the Korea Advanced Institute of Science and Technology (KAIST). ED100 is a required course for all freshmen at KAIST, regardless of major, and focuses on the fundamentals of conceptual design and critical thinking[20]. Although students do not declare majors in their freshman year, over 50% of the students at KAIST eventually graduate with a B.S. degree in computer science or engineering. (In contrast, only 24% of B.S. degrees granted in Korea are related to engineering[7].)

The data from the United States are from lower division students in "E10: Introduction to Engineering Design and Analysis", a course offered at the University of California at Berkeley that teaches freshmen about engineering design, analysis, and practice[21,22]. E10 is split into three parts over the semester. Our data are collected from students participating in the six-week module entitled "Sustainable Human-Centered Design". Both ED100 and E10 are project-based courses, with teams of four to six members each. The projects are open-ended, real-world design challenges that allow students to explore a wide range of ideas in their design solutions. Although both courses are compulsory, ED100 is required for all freshmen while E10 is open to the campus but only required for engineering students. As a result, the ED100 students are expected to have a wider range of disciplinary interests. Table 1 shows the number of students from each class that participated in the study. Note that the percentage of female students in ED100 is somewhat higher than that of E10 (33% versus 25%).

Table 1: Breakdown of Course Participants

	E10			ED100	
	Spring 2008	Spring 2009	% by Gender	Fall 2010	% by Gender
Women	45	34	25%	133	33%
Men	129	108	75%	274	67%
Total	174	142	100%	407	100%

The data were gathered from surveys that were administered at the beginning of the semester to the E10 students in Spring 2008 and Spring 2009 and to the ED100 students in Fall 2010. We included additional data related to Kolb learning styles collected over a range of ages from UC Berkeley in Fall 2010 and Spring 2011. Survey question topics cover standard demographics (gender, ethnicity, and discipline), Kolb learning styles, and past experiences with engineering or design (such as shop classes, CAD, sewing, design competitions, and engineering-related programs). Students were also asked to assess their strengths in design and engineering skills. The exact wording of the question was: "Based on your experiences and education thus far, please perform a self-assessment of how much you possess these traits”. The list of skills that followed is based on the learning outcomes as defined by ABET[4] (which sets accreditation standards for American programs) and ABEEK[5] (Accreditation Board for Engineering Education in Korea)[*]:

- Analytical skills
- Creativity and practical ingenuity
- Ability to develop designs that meet needs, constraints, and objectives
- Ability to identify, formulate, and solve technical problems
- Communication skills
- Team skills
- Leadership and management skills
- Ethics and professionalism
- Recognizes need for an ability to engage in life-long learning
- Ability to design and conduct experiments, analyze, and interpret data
- Ability to learn and use the techniques and tools used in engineering practice
- Ability to recognize the global, economic, environmental, and societal impact of engineering design and analysis
- Ability to understand other cultures and engage in international collaboration.

This list builds on the learning outcomes that overlap in ABET and ABEEK criteria. In performing the cross-national analyses, we drew comparisons only for those skills on which both student groups self-rated. In the remainder of the paper, we will present the results of the survey and discuss possible implications.

Cross-National Comparison of Confidence in ABET-Related Skills

Table 2 presents the average self-confidence ratings of engineering skills for the ED100 (Korean) and E10 (American) student groups using a 5-option Likert scale (High, Medium High, Neutral, Medium Low, Low). Eight of the ten skills showed statistically significant differences between the two populations. The highest value in each category that has a significant difference is shown in bold. The Spring 2008 and Spring 2009 data from the E10 students were combined. Overall, the E10 students ranked themselves higher than the ED100 students did in six out of ten skills, with five skills showing statistical significance ($p \leq 0.05$).

A closer examination of the results reveals this dichotomy is probably heavily influenced by the academic and cultural backgrounds of each sample. There is a higher percentage of engineering students in the E10 population. Approximately half of the ED100 students will choose non-engineering disciplines, so it is expected that they would be less confident in using “engineering practice” techniques and in understanding the impact of “engineering design and analysis.” However, when asked about technical skills, the ED100 students were more confident than the E10 students. They self-rated higher in their ability to “formulate and solve technical problems”

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[*] We expect that the students were unaware that these skills were related to the ABET and ABEEK criteria as we never made the connection to them explicitly.

Table 2: Average Confidence in Engineering Skills - ED100 (Fall 2010), E10 (Spring 2008, Spring 2009)

	Average Confidence		p
	ED100	E10	
Strong analytical skills	3.967	3.922	0.251
Creativity and practical ingenuity	3.46	**3.713**	**0.0007**
Develop designs that meet needs, constraints, and objectives	**3.569**	3.459	**0.0492**
Identify, formulate, and solve technical problems	**3.649**	3.4	**0.0032**
Good communication skills	**3.804**	3.547	**0.0017**
Good team skills	3.797	**3.95**	**0.028**
Leadership and management skills	3.633	3.641	0.467
Strong ethics	3.753	**4.243**	**0.0008**
Use the techniques and tools used in engineering practice	3.265	**3.883**	**0.0042**
Recognize the global impact of engineering design and analysis	3.188	**3.519**	**0.0056**

Table 3: Confidence in Engineering Skills by Gender – ED100 (Fall 2010), E10 (Spring 2008, Spring 2009)
BOLDED numbers represent statistical significance in each gender (E10 versus ED100)

	Men			Women		
	ED100	E10	Δ	ED100	E10	Δ
Strong analytical skills	4.044	4.271	0.227	3.811	3.5	0.311
Creativity and practical ingenuity	3.529	**4.042**	0.513	3.318	**3.75**	0.432
Develop designs that meet needs, constraints, and objectives	3.571	3.771	0.2	3.565	3.667	0.102
Identify, formulate, and solve technical problems	3.755	3.75	0.005	3.432	3.417	0.015
Good communication skills	**3.707**	3.458	0.249	**4**	3.583	0.417
Good team skills	3.725	3.75	0.025	**3.947**	3.833	0.114
Leadership and management skills	3.566	3.625	0.059	3.773	3.833	0.06
Strong ethics	3.714	**3.958**	0.244	3.833	**4.417**	0.584
Use the techniques and tools used in engineering practice	3.313	**4.146**	0.833	3.167	**4**	0.833
Recognize the global impact of engineering design and analysis	3.165	**3.583**	0.418	3.237	**3.75**	0.513

Table 4: Confidence in Engineering Skills by Class -
ED100 (Fall 2010), E10 (Spring 2008, Spring 2009)
BOLDED numbers represent statistical significance in each class (men versus women)

	ED100			E10		
	Men	Women	Δ	Men	Women	Δ
Strong analytical skills	**4.044**	3.811	0.233	**4.271**	3.5	0.771
Creativity and practical ingenuity	3.529	3.318	0.211	4.042	3.75	0.292
Develop designs that meet needs, constraints and objectives	3.571	3.565	0.006	3.771	3.667	0.104
Identify, formulate, and solve technical problems	**3.755**	3.432	0.323	**3.75**	3.417	0.333
Good communication skills	3.707	**4**	0.293	3.458	**3.583**	0.125
Good team skills	3.725	**3.947**	0.222	3.75	**3.833**	0.083
Leadership and management skills	3.566	**3.773**	0.207	3.625	**3.833**	0.208
Strong ethics	3.714	3.833	0.119	3.958	**4.417**	0.459
Use the techniques and tools used in engineering practice	3.313	3.167	0.146	4.146	4	0.146
Recognize the global impact of engineering design and analysis	3.165	3.237	0.072	3.583	3.75	0.167

and also to "develop designs that meet needs." The lower confidence of ED100 students in their "creativity and practical ingenuity" and stronger confidence in communication skills by students in ED100 is interesting and deserves further study.

Confidence in ABET Skills by Gender

Table 3 presents how all students ranked their engineering and design skills by gender, comparing the ED100 men versus E10 men and ED100 women versus E10 women. The numbers in bold represent the highest confidence for each category that was statistically significant. There is a striking similarity in how the American and Korean students rate themselves within each gender category, showing the same patterns of confidence as in Table 2. For every category but teamwork and analytical skills, the class would collectively self-report more or less confident. For instance, with "creativity and practical ingenuity", the American students self-rated themselves higher than the Korean students in both the male and female groups.

The most marked differences were in the categories relating to engineering practice and in "creativity and practical ingenuity" – both the E10 men and women self-rated higher than the ED100 men and women ($p \leq 0.05$). These results are consistent with ED100 having a mix of engineering and non-engineering students and therefore less defined engineering skills, as well as the Korean self-perception of being "non-creative." Surprisingly, the ED100 men and women rank themselves higher than the E10 men and women in communication skills. In fact, this is the only category where the ED100 men rank above the E10 men. The women show more variability, with ED100 women ranking above the E10 women in analytical skills, in their ability to form and solve technical problems, and in teamwork, although only the teamwork is statistically significant.

Table 4 presents how all students assess their engineering and design skills by class, comparing the ED100 men versus women and E10 men versus women. The bolded numbers represent the highest confidence for each category that was statistically significant.

In spite of the national differences described previously, both populations show similar gender differences. The men ranked higher than the women in their analytical skills, their ability to identify and solve technical problems, and their ability to use engineering techniques and tools. However, women were more confident in understanding the global impact of engineering design and analysis, and also self-rated higher in their communication skills, team skills, and leadership skills. These patterns highlight the perceived "hard" and "soft" skill sets often attributed to men and women.

Engineering Experience and Culture

In the survey, students were also asked to report what engineering or design related experiences they had prior to entering college. Figure 3 presents the data for the E10 (American) and ED100 (Korean) students. No additional details were provided on specific areas within each course. From the results, it appears that many more American students engage in these extracurricular activities than the Korean students. Additionally, the American students seem to have a more dominating presence even in the activities that show significant involvement by Korean students. We note that Korean students' time in the classroom leaves very little opportunity for extracurricular activities and thus their participation is very much tied to curricular activities.

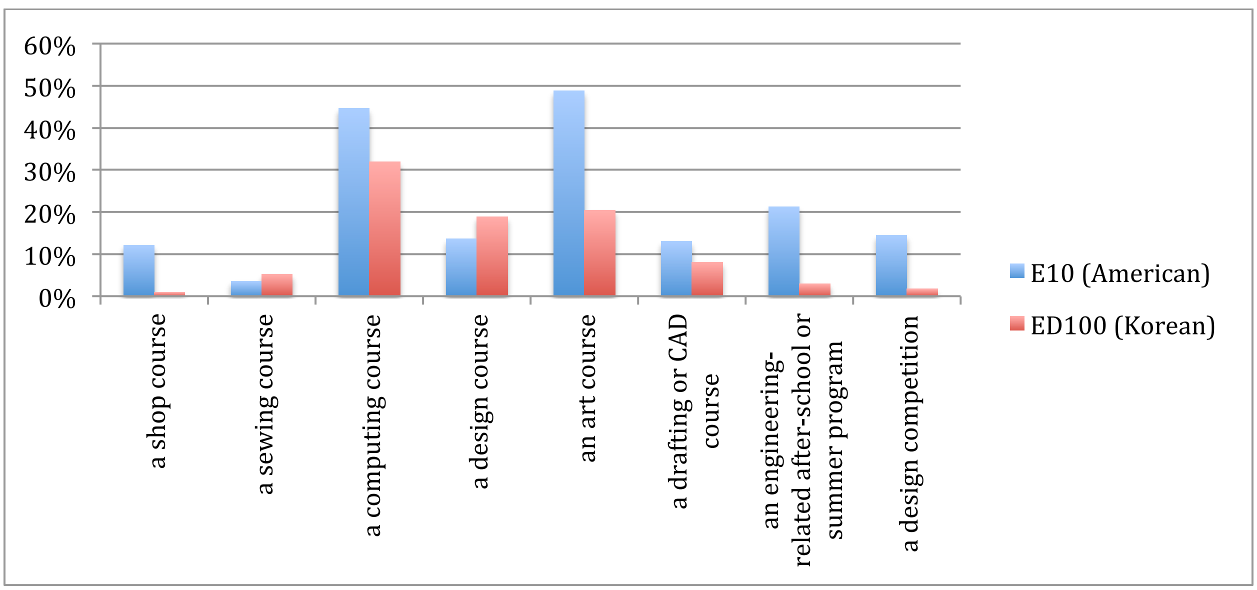

Figure 3: Previous Engineering and Design Experiences - E10 (Spring 2008, Spring 2009), ED100 (Fall 2010)

Separately, Korean students reported heavy participation in math and science competitions, which is associated with coursework: 46% and 55%, respectively. We do not have data on how many American students participated in these competitions because those questions were not included in their survey. However, we note that the level of American student participation in computing and art courses is similar to the level of Korean participation in math and science competitions: 45% and 49%, respectively. Thus, this data may reflect differences in the types of opportunities that are available to the students in each country.

This difference in extracurricular activities may explain the students' assessment of their skills. The American students rank higher in "creativity and practical ingenuity" – skills possibly nurtured through artistic endeavors. Conversely, they rate lower in their ability to "identify, formulate and solve technical problems" than the Korean students who focus on early math and science development.

Kolb Learning Styles and Confidence in ABET Skills

Figure 4 shows the makeup of learning styles from ED100 and from a population of upper division and graduate students engaged in multidisciplinary design courses at UC Berkeley. Unfortunately, learning style preferences were not originally collected for UC Berkeley students in E10. The literature suggests that learning styles do not change significantly at the college level and thus we do not expect large differences due to a one or two year separation in age.

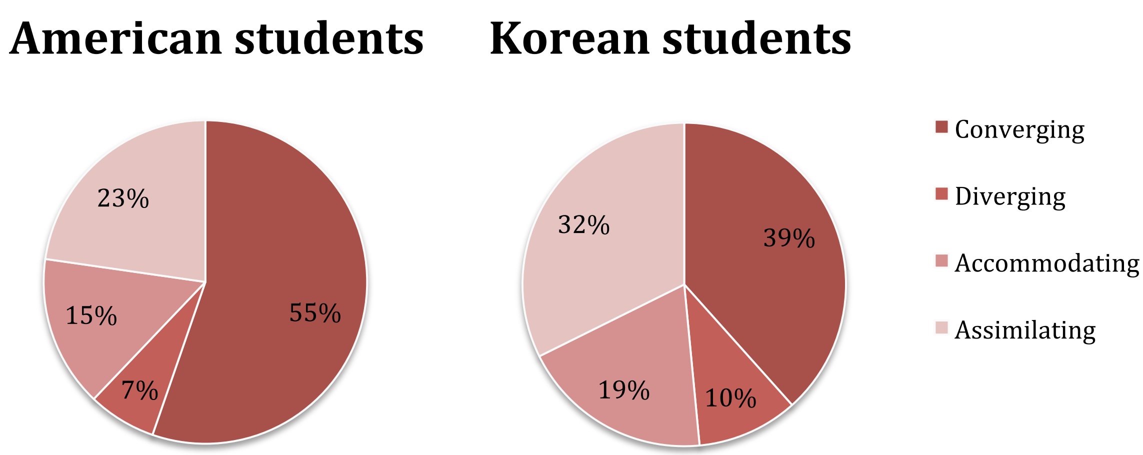

Figure 4: Breakdown of Learning Styles

We observe that the breakdown of learning styles is similar between the two national data sets. The largest difference is the percentage of convergers (55% versus 39%) and assimilators (23% and 32%) respectively for the American versus Korean students. Since the difference between convergers and assimilators occurs on the analysis-synthesis axis, the differences in the learning style distributions may be partially explained by the fact that the Korean education system generally emphasizes analysis, sometimes to the exclusion of synthesis. In the ED100 end-of-semester student survey (which was conducted separately from the surveys discussed in this work), 331 out of 413 respondents (80.1%) reported never taking a design class or working on a design project before. Thus, these students may have had little or no opportunity to develop those skills or have their learning style be influenced by them.

Only the ED100 (Korean) dataset includes the ABET confidence and the Kolb learning style questions in the same sample. Table 5 presents the results by learning style for the ED100 (Korean) students in Fall 2010. Learning style data had not been captured for the E10 (American) students and is therefore not included in this table.

Table 5: Confidence in Engineering Skills by Learning Style
ED100 (Fall 2010)

	Diverging	Converging	Assimilating	Accommodating
Strong analytical skills	3.73	**4.06**	**4.03**	3.77
Creativity and practical ingenuity	3.23	3.49	3.34	**3.68**
Develop designs that meet needs, constraints, and objectives	3.6	3.67	3.46	3.7
Identify, formulate, and solve technical problems	3.53	**3.71**	3.66	3.58
Good communication skills	3.77	**3.96**	3.55	**4.02**
Good team skills	3.73	**3.94**	3.58	**3.86**
Leadership and management skills	3.67	3.75	3.34	**3.91**
Strong ethics	3.6	3.68	3.81	3.61
Design and conduct experiments, and analyze and interpret data	3.47	3.68	3.66	3.25
Use the techniques and tools used in engineering practice	3.33	3.27	3.22	3.19
Recognize the global impact of engineering design and analysis	3.13	3.27	**3.93**	3.46

These results show the expected behavioral trends for the various learning styles. Accommodators are quick to take initiative and carry out plans[23,24], and self-rate themselves higher in leadership and management skills ($p \leq 0.0001$). Convergers, on the other hand, are generally strongest at problem-solving and filtering through many options to set clear objectives[24]. Unsurprisingly, they assess their analytical skills to be the strongest among all other skills. Students with the converging learning style score well in their ability to "analyze and interpret data" ($p=0.001$); data processing is typically associated with assimilators[24] with a very similar high correlation.

There are also unexpected patterns. People who demonstrate the diverging learning style are typically best at brainstorming and conceiving new ideas[24]. However, this is not reflected in a correlation with "creativity and practical ingenuity" skills, with accommodators ranking highest (p=0.013). Divergers have broad, cultural interests and are able to connect needs with the people[23,24], but this is not reflected in their confidence in "developing designs that meet needs". The lack of statistical significance may be due, in part, to the relatively small number of student divergers in the population.

Conclusion

This paper has explored the variations in confidence in engineering-related skills among freshman design students in Korea and the United States, under the subtexts of gender and learning style. The students followed a creative, iterative design cycle in their respective courses, resulting in innovative outcomes at the end. The results showed striking differences in confidence levels that may be due to national differences. The American students rated themselves higher in creativity, team skills, ethics, facility with tools of engineering practice, and in recognizing global impact. The Korean students assessed their skills higher in design, problem solving, and communication skills. There were no statistically significant differences in leadership or analytical skills. However, we must question whether the national differences may also be due, in part, to the difference in disciplinary aspirations in each group. The Korean students were taken from all disciplines as students at KAIST do not declare majors until their sophomore year, whereas most of the American students had already declared engineering as their major. In the future, once the Korean students have declared their major, we will redo the analyses to identify the national versus disciplinary contributions to the differences.

In spite of (what may be) national differences, the students still follow the same gender patterns. The men are more confident in technical and analytical skills, while the women feel stronger in communication and teamwork skills. As such, both cultures may benefit from interventions designed to build confidence in each area, perhaps in the form of continuous feedback on their work – reflecting on what works and amending the mistakes[25]. By providing a forum for students to develop and sharpen their respective skills, they can gain the confidence to successfully face future design challenges and reach the best solutions possible.

Acknowlegments

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