Experiences of international and domestic students in the first two years of undergraduate engineering programs

Irene B Mena, Pennsylvania State University, University Park

Irene B. Mena has a B.S. and M.S. in industrial engineering, and a Ph.D. in engineering education. Her research interests include first-year engineering and graduate student professional development.

Dr. Thomas A. Litzinger, Pennsylvania State University, University Park

Thomas Litzinger is Director of the Leonhard Center for the Enhancement of Engineering Education and a Professor of Mechanical Engineering at Penn State, where he has been on the faculty since 1985. He received his Ph.D. in Mechanical and Aerospace Engineering from Princeton in 1986. His work in engineering education involves teaching and learning innovations, curricular change, faculty development, and assessment. He also teaches and conducts research in combustion and thermal sciences. He is Fellow of ASEE and ASME, and he serves as an Associate Editor of Advances in Engineering Education. He can be contacted at tal2@psu.edu.

Dr. Sarah E Zappe, Pennsylvania State University, University Park

Dr. Sarah Zappe is Research Associate and Director of Assessment and Instructional Support in the Leonhard Center for the Enhancement of Engineering Education at Penn State. She holds a doctoral degree in educational psychology emphasizing applied measurement and testing. In her position, Sarah is responsible for developing instructional support programs for faculty, providing evaluation support for educational proposals and projects, and working with faculty to publish educational research. Her research interests primarily involve creativity, innovation, and entrepreneurship education.

Experiences and perceptions of international and domestic students in the first two years of undergraduate engineering programs

Introduction

Increasing numbers of students from outside the U.S. are matriculating into undergraduate engineering programs. National data published recently in ASEE PRISM[1] show that the percentage of international undergraduate engineering students rose from 5.32% in 2007 to 8.56%. Data at individual institutions vary substantially from the national averages with some reporting that more than 20% of their first-year undergraduate engineering students are international. Many of the international students come from countries whose educational systems are quite different than those in the U.S. Consequently, these students may encounter difficulty because they are not accustomed to the type of learning environments that exist in the U.S. Highly interactive courses such as design courses with team projects can be a particular challenge for some international students.

In a review of research on international students and their adjustment to college in English-speaking countries, Andrade[2] discusses two bodies of literature – studies of adjustment issues that international students encounter and studies of the links between adjustment and academic achievement. She defines adjustment as related to the "fit between students and the academic environment" (p. 134). She reviews four studies of adjustment issues. Not surprisingly, all of the studies show that international students encounter adjustment challenges that go beyond those experienced by domestic students. For non-native English speakers, language skills can be a major challenge causing students to have difficulty taking notes, participating in class, and working with their peers. Andrade also summarizes findings related to professors' perceptions of international students. Professors attributed lack of participation to cultural differences, whereas the students themselves attributed it to poor language skills. She also reports that international students often preferred to work independently rather than in groups.

The work reviewed by Andrade[2] appears to be characteristic of much of the research on international students. It focuses on adjustment issues and relationships to academic achievement. In engineering education, participation of international students in active learning activities, including project and problem-based learning, is also a major source of concern. Unfortunately, the literature on the participation of international students in pedagogies of engagement is very limited. Zhao, Kuh and Carini[3] assert that "relatively little is known about the extent to which international students are satisfied with the experience, interact with peers and faculty members, and participate in a variety of other educationally purposeful activities (p. 211)."

Zhao et al.[3] use data from the National Survey on Student Engagement to identify similarities and differences in engagement, satisfaction, and self-reported learning gains. In the analysis, effects of the students' major were not investigated. International students were found to report higher levels of academic challenge, which was based on items related to effort, amount of work, and higher cognitive processes. Somewhat surprisingly, international students reported greater

levels of participation in active and collaborative learning and in interactions with faculty members. International students and domestic students provided similar ratings of "supportive campus environment," but the international students reported slightly lower satisfaction with their education. Effect sizes for these sets of items were in the range of 0.l4 to 0.27.

Context of the study and research questions

The College of Engineering at a mid-Atlantic research university has initiated a longitudinal study of undergraduate students' experiences, perceptions, and beliefs. This longitudinal study has been using quantitative and qualitative methods to better understand the undergraduate engineering experience and how the University is preparing engineering students. A component of this longitudinal study is learning about the experiences of international students in the College of Engineering.

The College of Engineering at the mid-Atlantic University has experienced an increase in the fraction of international students that parallels national trends. In 2007, the percentage of first-year engineering students from outside the U.S. was 3.2%; by 2012, it had risen to 10.7%. Because of the increasing enrollment of international students and because of increasing numbers of first-year students, up by nearly 30% between 2007 and 2012, the College of Engineering was interested in answering the following research questions: (1) what are some differences in international and domestic students' reported perceptions and attitudes at the beginning of their first year of engineering?, and (2) what are some differences in international and domestic students' reported perceptions and attitudes, specifically regarding their learning experiences, at the end of their second year of engineering?

Methods

Data for this study was collected using two surveys: one sent to first-year students in the fall 2011 semester, and one sent to second-year students in the spring 2013 semester. The students who completed the surveys were all part of the same cohort of students beginning their engineering studies in the fall 2011 semester.

Both surveys were created to answer questions specific to our longitudinal study. Therefore, instead of using existing surveys, we created our own instruments.[4] The steps we followed to create our first-year survey, which are the same steps we followed to create our second-year survey, are described in Mena, Zappe, and Litzinger.[5]

The first-year survey had the goal of learning about incoming students' confidence in their abilities to become engineers, perceptions of the engineering profession, reasons for choosing engineering, commitment to major, global awareness, creativity, and leadership. The survey consisted of 42 items related to these areas of interest.

The second-year survey had the purpose of learning about students' experiences in and perceptions of their courses and learning environment during their first two years of engineering. The second-year survey consisted of 38 items that asked students about their confidence in their abilities to become engineers, commitment to major, learning environment, and creativity.

For both surveys, a five-position Likert scale was used. The responses ranged from strongly agree to strongly disagree.

The first-year survey was sent to all 2766 first-year engineering students at the University in the fall 2011 semester. A total of 665 students (77% male, 23% female; 93% domestic, 7% international) completed the survey. The second-year survey was sent to the same group of 2766 first-year students from the fall 2011 semester, as it was expected that these students would be second-year students at that point. Questions were included at the start of the survey to determine if the students were still University students in the College of Engineering. A total of 488 students (71.5% male, 28.5% female; 92% domestic, 8% international) completed the survey.

The data for both surveys were analyzed to learn about item means and distributions by gender and international status. Next, an item analysis was conducted on our predetermined scales to ensure that these scales had a strong internal consistency (see results below). Finally, t-tests were conducted on each of the subscales, for both surveys, to determine any significant differences in experiences or perceptions between international and domestic students.

Results

In this section, we describe results from the first-year survey and from the second-year survey.

First-year survey

Our first-year survey consisted of seven scales:

1) Self-efficacy: This scale consisted of eight items, all related to students' perceived levels of self-efficacy. It had the goal of revealing students' levels of confidence in their abilities to succeed in engineering.
2) Knowledge of the engineering profession: The five items in this scale asked students about their perceptions of engineering, specifically with respect to the skills and activities that characterize engineering work.
3) Motivation: The five items in this scale asked students about their reasons for wanting to become engineers.
4) Commitment to engineering: This scale, consisting of seven items, had the goal of learning about students' engineering identity, or the extent to which they saw themselves as engineers and as part of the engineering community, and their commitment to engineering.
5) Global awareness: The seven items in this scale asked students about their willingness to engage in various types of global and international activities.
6) Creativity/innovation: Through this scale, consisting of three items, we sought to learn about students' perceptions of their own creativity and creative abilities.
7) Leadership: Through this scale, consisting of three items, we sought to learn about students' perceptions of their leadership abilities and their interests in undertaking leadership roles.

Appendix A lists all the items belonging to each scale in the first-year survey.

Item analyses were conducted on our scales to determine the internal consistency of each scale. Table 1 presents the coefficient alpha values for each of the scales. The values all exceed the minimum of 0.5 suggested by Tuckman[6] for instruments that assess attitudes and preferences.

Table 1: Reliability for first-year survey scales

Scale	Cronbach's Alpha
Self-efficacy	0.72
Knowledge of the engineering profession	0.67
Motivation	0.61
Commitment to engineering	0.83
Global awareness	0.87
Creativity/innovation	0.61
Leadership	0.82

Independent-samples t-tests were used to compare international versus domestic students' responses on these scales. There were significant differences in the following two scales:

a) Creativity/innovation, with $t(609)=2.74$ and $p=0.006$
b) Global awareness, with $t(55)=-7.81$ and $p=0$

There were no significant differences in the remaining scales. The means, standard deviations (SD), and t-test results for each scale are summarized in the table below.

Table 2: First-year survey scale means, standard deviations, and t-test results

Scale	Mean*	SD	t	Degrees of freedom	p
Self-efficacy	D=28.91 I=28.54	D=4.13 I=4.31	0.54	609	0.59
Knowledge of the engineering profession	D=21.11 I=21.26	D=2.28 I=2.14	-0.39	611	0.7
Motivation	D=20.60 I=19.88	D=2.36 I=1.99	1.892	612	0.06
Commitment to engineering	D=27.63 I=27.20	D=4.11 I=3.70	0.644	604	0.52
Global awareness	D=25.92 I=30.10	D=5.04 I=3.11	-7.81	54.5	0
Creativity/innovation	D=11.34 I=10.46	D=1.91 I=2.28	2.74	609	0.006
Leadership	D=12.03 I=11.50	D=2.07 I=1.89	1.59	612	0.11

*D=domestic students; I=international students

The results indicate that in their first year of engineering, there are no significant differences between domestic and international students' reported levels of self-efficacy, knowledge of the

engineering profession, motivation to study engineering, commitment to engineering, or leadership. There are significant differences in their reported levels of global awareness and creativity. The effect size of the difference in mean for global awareness is greater than one, which represents a large effect. For the creativity/innovation scale, the effect size is in the medium range.

Table 3 presents the mean responses rescaled to a maximum value of 5, which would represent strong agreement with the statements in the scale. The lowest mean responses for domestic students occurred on the self-efficacy, global awareness and creativity/innovation scales. For international students, the lowest mean responses were on the creativity/innovation, self-efficacy, and leadership scales.

Table 3: Rescaled mean scores for first-year survey

	Rescaled Mean - Domestic	Rescaled Mean - International
Self-efficacy	3.61	3.57
Knowledge of the engineering profession	4.22	4.25
Motivation	4.12	3.98
Commitment to engineering	3.95	3.89
Global awareness	3.70	4.30
Creativity/innovation	3.78	3.49
Leadership	4.01	3.83

Second-year survey

Our second-year survey consisted of seven scales:

1) Learning environment: This scale consisted of nine items. These items asked students about their satisfaction with their courses, including the quality of teaching, opportunities for working with other students, and the helpfulness of the feedback they receive.
2) Relationships and support/supportive environment: This scale, consisting of seven items, sought to learn about students' relationships with instructors and students, and their perceptions of how supportive their instructors were.
3) Value: The four items in this scale asked students about their perceptions of the value of the topics covered in their courses, specifically regarding how interesting, challenging, and relevant to their future careers they considered these topics to be.
4) Self-efficacy: Similar to the self-efficacy scale used in the first-year survey, this five-item scale had the goal of revealing students' levels of confidence in their abilities to succeed in engineering and in their courses.
5) Creativity: This three-item scale had the goal of learning about students' perceptions of whether and how their courses were preparing them to be creative.
6) Commitment to engineering: This scale, consisting of seven items, was the same one used in the first-year survey. It had the goal of learning about students' engineering identity and commitment to engineering in their second year of engineering.

Appendix B lists all the items belonging to each scale in the second-year survey.

Item analyses were conducted on our scales to determine the internal consistency of each scale. Table 4 shows the coefficient alpha values for the scales in the second year survey. All lie above the value of 0.5 suggested by Tuckman[6].

Table 4: Reliability for second-year survey scales

Scale	Cronbach's Alpha
Learning environment	0.72
Relationships and support/supportive environment	0.81
Value	0.72
Self-efficacy	0.77
Creativity	0.74
Commitment to engineering	0.84

Independent-samples t-tests were used to compare international versus domestic students' responses on these scales. There were no significant differences in any of the scales. The means, standard deviations (SD), and t-test results for each scale are summarized in Table 5.

Table 5: Second-year survey scale means, standard deviations, and t-test results

Scale	Mean*	SD	t	Degrees of freedom	p
Learning environment	D=32.03 I=31.42	D=4.73 I=4.55	0.71	403	0.48
Relationships and support/supportive environment	D=23.16 I=24.18	D=3.41 I=3.15	1.65	408	0.10
Value	D=11.03 I=10.71	D=2.21 I=2.21	0.82	411	0.42
Self-efficacy	D=18.38 I=18.24	D=3.52 I=3.27	0.23	411	0.82
Creativity	D=9.80 I=9.71	D=2.37 I=2.36	0.22	409	0.82
Commitment to engineering	D=27.57 I=27.94	D=4.46 I=4.20	-0.45	406	0.65

*D=domestic students; I=international students

The results indicate that in their second year of engineering, there are no significant differences between domestic and international students' perceptions of the learning environment, relationships, value, self-efficacy, creativity, or commitment to engineering.

Table 6 presents the mean responses for the second-year survey rescaled to a maximum value of 5, which would represent strong agreement with the statements in the scale. The lowest mean for any scale in the second-year survey is for the value scale, which asks students about whether

their courses are challenging and interesting and whether they are able to see how the courses relate to their major and future career. The mean score of approximately 2.7 indicates that, on average, the students disagree with items in this scale.

The mean responses for the self-efficacy and commitment to engineering scales are quite similar to those in the first-year survey. For creativity/innovation, however, the mean response is lower on the second-year survey compared to the first-year survey for both domestic and international students.

Table 6: Rescaled mean scores for second-year survey

	Rescaled Mean - Domestic	Rescaled Mean - International
Learning environment	3.56	3.49
Relationships and support/supportive environment	3.31	3.45
Value	2.76	2.68
Self-efficacy	3.68	3.65
Creativity	3.27	3.24
Commitment to engineering	3.94	3.99

Conclusions and future work

In this paper, we looked at a group of students' perceptions and beliefs their first year of engineering, and later their second year of engineering. Using independent-samples t-tests, we compared the responses of international versus domestic students, and found that in the first-year survey, there were no significant differences in any of the scales, except for creativity/innovation and global awareness. There were no significant differences in any of the scales in the second-year survey.

The differences in global awareness in the first-year survey are not unexpected. The global awareness questions were related to openness to international experiences, which in the international students' case, they were not only open to these experiences, they were in fact already living these experiences. Our sample of domestic students included those students who were interested in international experiences, and those who were not. Our sample of international students were all students who evidently chose to pursue international experiences, as they were all currently engaged in their own study abroad experience. As such, it is not surprising that the international students scored significantly higher on the global awareness scale.

While international students scored significantly higher on the global awareness scale, domestic students scored significantly higher on the creativity/innovation scale. The students completed this survey the first few weeks of their very first semester. The international students' responses could be the result of their initial perceptions of the differences between their previous and their current learning environments. In a paper looking at international students in an Australian university, Edgeworth and Eiseman[7] write that the Western educational practices could be "problematic": "Critical thinking, evidence-based writing, tutorial discussion, group

work, case studies, oral presentations, and having to give opinions are all new experiences for international students that do not align with their prior educational experience" (p.9). Perhaps international students' initial reactions to these new environments result in their having perceptions of being less prepared than they actually are in certain areas, which may include creativity and innovation. Future studies can focus on determining if and how these differences in perceptions change as international students progress through their studies – it may be that after becoming more and more adjusted to the (possibly) different educational practices and learning environments, their perceptions of their creativity and innovation will be comparable to domestic students' perceptions.

Besides the significant differences in the global awareness and creativity/innovation scales in the first-year survey, there were no other significant differences between international and domestic students. This suggests that our first-year students begin their engineering studies with overall the same perceptions, attitudes, and expectations, regardless of international status.

The second-year survey, focusing mostly on the learning environments in the first- and second-year courses, resulted in no significant differences between international and domestic students in any of the scales. This is somewhat surprising, as previous research has indicated differences in certain aspects of the educational experience. For example, in Zhao et al.'s[3] study, compared to domestic first-year students, international first-year students had higher scores in student-faculty interaction, and lower satisfaction scores.

The fact that there were no significant differences in any of the second-year survey scales suggests that when it comes to learning environment, instructor support, and certain perceptions, the students at our University seem to be experiencing their first two years of engineering in similar ways, regardless of international status. Certainly, international students' overall undergraduate experiences will be different in many ways. For example, as a result of their acculturation process, they may experience stressors such as language and sociocultural stressors, among others[8], which domestic students will not have to deal with. However, our survey, which focused on only one part of the undergraduate experience, indicated that there were no significant differences between international and domestic students in the specific areas we looked at.

There were some limitations to this study. Due to the nature of survey research, issues of non-response, or a refusal of certain individuals to complete the survey, can be common. This affects our results in that those who refuse to participate may have "different attitudes and behaviors from those who do co-operate" (p.95)[9]. It may be possible that due to non-response, our participating international and domestic students may not be accurately representing the international and domestic students at the University.

The results presented in this paper are part of a longitudinal study in which surveys will be administered to cohorts in their first, second, and third years of engineering. Future research will include comparing international and domestic students' experiences from various cohorts in their first, second, and third years of engineering. Additionally, we will be able to track students from one cohort from their first to their third year, in order to determine if and how international and domestic students' perceptions change over time.

List of references

1.Yoder, B. L. (September 2013). The Global Campus. *PRISM*. 018-019.
2.Andrade, M. S. (2006). International Students in English-Speaking Universities: Adjustment Factors. *Journal of Research in International Education*. 5(2): 131-154.
3.Zhao, C., Kuh, G. D., & Carini, R. M. (2005). A Comparison of International Student and American Student Engagement in Effective Educational Practices. *The Journal of Higher Education*. 76(2): 209-231.
4.Creswell, J. W. (2008). *Educational Research*. Upper Saddle River, New Jersey: Pearson Education, Inc.
5.Mena, I. B., Zappe, S. E., & Litzinger, T. A. (2013). Examining the Experiences and Perceptions of First-Year Engineering Students. *Paper presented at the American Society for Engineering Education Conference & Exposition.* Atlanta, GA, June 24, 2013.
6.Tuckman, B.W. (1999). *Conducting Educational Research*, 5th ed., Fort Worth, TX: Harcourt Brace Publishers.
7.Edgeworth, K., & Eiseman, J. (2007). Going Bush: International Student Perspectives on Living and Studying at an Australian Rural University Campus. *Journal of Research in Rural Education*. 22(9): 1-13.
8.Smith, R. A., & Khawaja, N. G. (2011). A Review of the Acculturation Experiences of International Students. *International Journal of Intercultural Relations.* 35: 699-713.
9. Sapsford, R. (1999). *Survey Research*. Sage Publications.

Appendix A: First-year survey scales and items

Self-efficacy
I sometimes wonder if I have the skills to be a successful engineer.
I have doubts that I will be successful in my undergraduate engineering program.
I sometimes wonder if engineering is the career for me.
I can work well with people from other disciplines.
I can work well with people from different countries.
I am good at developing creative solutions to problems.
I am good at communicating my ideas to others.
I am good at solving problems that I've never encountered before.

Knowledge of the engineering profession
Successful engineers need to be creative.
Successful engineers work well in teams with people from different disciplines.
Successful engineers need to be effective communicators.
Engineers need to consider the ethical implications of their work.
Engineers often work in teams with members from other countries.

Motivation
I want to be an engineer because I am good at math and science.
I want to be an engineer because I am good at solving problems.
I want to be an engineer because engineering will provide me with a good, high-paying job in the future.
I want to be an engineer because I want to help people/society.
I want to be an engineer because engineers are innovative.

Identity
Being an engineering student is an important part of my self-image.
I have a strong sense of belonging to the engineering student community.
I am happy that I am going to be an engineer.
I am proud that I will be an engineer.
I feel that engineers have made valuable contributions to society.
I think engineers are viewed negatively by others.
I fit in well with the other engineering students.

Commitment to major
I believe I have chosen the right major.
I am happy so far with my intended engineering major.

Global awareness
I am open to international experiences.
I would be willing to accept a job outside the United States.
I would like to work with people from different countries.
I would like to practice engineering in a global context.
I would like to have a study abroad experience.

I would like to have a work abroad experience.
I would like to work with people from different disciplinary fields.

Creativity/innovation
I doubt that I can develop novel solutions to problems.
I enjoy finding creative solutions to problems.
I wonder if I am a creative person.

Leadership
I see myself as a leader.
I would like to assume a leadership position within a team or group.
I hope to assume a leadership position within professional societies or service activities.

Appendix B: Second-year survey scales and items

Learning environment
I am satisfied with the quality of teaching in my classes.
My overall experience in my classes has been positive.
I feel comfortable participating in my classes.
The size of my classes makes it harder for me to learn.
The written feedback on projects/papers is helpful to my learning.
The written feedback on exams is helpful to my learning.
My classes provide opportunities for students to get to know each other.
In my classes, students are given time to work with each other.
In my classes, students help each other succeed.

Relationships and support/supportive environment
My instructors are available if I need to talk to them.
I feel comfortable going to my instructors' office hours.
If I don't understand something in one of my courses, I ask the instructor for help.
If I don't understand something in one of my courses, I ask other students for help.
My instructors want students to succeed.
My instructors want students to learn.
My instructors are willing to help students.

Value
The topics in my classes are challenging.
The topics in my classes are interesting.
I can see how my courses connect to my intended major.
My instructors help me understand how the courses I'm taking will be useful in my future career.

Self-efficacy
If I study for my classes, I know I can learn the material.

Compared to other students, I am doing poorly in my classes.
I believe I can do well in my classes.
I sometimes wonder if I have the skills to be a successful engineer.
I have doubts that I will be successful in my undergraduate engineering program.

Creativity
My courses allow me to be creative.
My courses have helped me become more creative.
Developing innovative solutions to problems is emphasized in my classes.

Commitment to engineering
I am happy so far with my intended engineering major.
I am happy that I am going to be an engineer.
I fit in well with the other engineering students.
I sometimes wonder if engineering is the career for me.
I believe I have chosen the right major.
I have a strong sense of belonging to the engineering student community.
I am proud that I will be an engineer.

Other
My main concern in my classes is getting a good grade.
My main concern in my classes is understanding the course material.
I want to do well in my classes because it is important to show my ability to potential employers.