The Difference between Teams with No Female Students and Teams with Female Students for Peer Evaluation Behavior in Engineering Education

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Abstract

Engineers are spending a lot of time with teamwork and collaboration. Hence, teamwork skills are increasingly valued by many companies, and many college engineering courses require their students to do group projects. Peer evaluation is a way to assess the quality of teamwork, but this assessment might be influenced by many factors. For instance, since we have less female engineering students than male students, many teams might be presented without female students. This paper examines whether there is difference in peer rating results between teams that have female students and teams that do not. This study would select the data from a first-year engineering course. As a result of this study, teams with women have somewhat more improvement in the quality of peer evaluation, but the difference was not substantial.

Keywords

Teamwork, Gender, CATME, Engineering, Education

1. Literature Review

Nowadays, since teamwork activities increase geometrically in industry and education (Lawler et al., 2001; Cordes et al.,1995; Loughry et al., 2007), teamwork is recognized as an important skill in almost all disciplines. Hence, effectively working in teams is a very important ability for candidates who are seeking jobs, and recruiters keep evaluating this ability (Alsop, 2002; NACE, 2011; Wayne Calloway School of Business and Accountancy, 2004; Loignon et al., 2017). According to the Job Outlook survey performed by the National Association of College and Employers (2011), the "ability to work in a team structure" was the most important skill that recruiters are looking for in college graduates (Loughry et al., 2013). In addition to the work organizations' emphasis on teamwork, the Accreditation Board of Engineering and Technology (ABET) also requires institutions to demonstrate teamwork skills development in their education (Honor, 2012).

However, the characteristics of each team member might affect the effectiveness of teamwork. There are various dimensions to examine team member traits; for instance, Jackson et al. (1995) and Harrison et al. (1998) recommended to analyze demographics information (e.g. gender, age, education and tenure) (Kang et al., 2006). Instructors should be careful about female students in teams and consider them when they want to form teams or analyze the peer evaluation result (Beigpourian & Ohland, 2019). So, in this study we would like to know whether

putting women in the teams will affect the quality of peer evaluation because peer evaluations can develop teamwork skills (Loignon et al., 2017). Specifically, peer evaluations create a sense of responsibility within teammates, and motivate teammates to show good team skills and contribute to the teamwork (Hernandez, 2002; Millis & Cottell, 1998; Loughry et al., 2013). The process of completing peer evaluations could also help improving teamwork skills, as students would learn which behaviors are important while working in teams. Moreover, teammates' feedback is valuable for student learning (Ohland et al., 2012). Hence, peer evaluations are commonly used in many college courses and industries to evaluate team members (Loignon et al., 2017; Bono & Colbert, 2005; Dai et al., 2010; Smither, et al., 2005). In this study, we used a newly developed web-based system called CATME (Comprehensive Assessment of Team Member Effectiveness) to accomplish the peer evaluations (Ohland et al., 2012).

CATME system is a widely used teamwork system that devotes to improve teamwork quality. The idea started in 2003 and in October 2005, the first web-based tool, CATME Peer Evaluation was set up (Loughry et al., 2013). Until 2018, CATME is used by over 8000 instructors in different fields within more than 2000 institutions (Ferguson et al., 2018). All CATME peer evaluations evaluate students based on 5 dimensions including Contributing, Interacting, Keeping, Expecting, and Having (Ohland et al., 2012).

CATME has embedded Team-maker algorithm to form teams, which considers the effect of women Layton et al., 2010). All female students are paired with other underrepresented members (female students and all male students who are not "white, non-Hipanic"), usually with another female that has a different race (Layton et al., 2010). We then compared the peer evaluation behaviors of them with the teams that only had male students, in order to know whether there is a difference between them by analyzing the peer evaluation results. This leads to our specific research question of this paper: Is there any difference between teams without female students and teams with female students for peer evaluation behavior in teams?

2. Methodology

Our participants are from a first-year engineering course in a mid-western public university. We collected data using CATME (comprehensive assessment of team member effectiveness) peer evaluation, which is a web-based peer evaluation tool (Ohland et al., 2012). In this study, we used two different interventions. Intervention 1 has teams with no female students, and intervention 2 has teams with female students. We had 154 teams with no female students and 94 teams with female students in this study. There are four students in each group, and each student finished three peer evaluations during the semester.

2.1 Dimensions of Peer Evaluations

CATME includes five dimensions for peer evaluations which measures the amount of contribution of students in team (C dimension), how much students interact with each other (I dimension), how team members keep team on track by planning and organizing teamwork (K dimension), the expected quality (E dimension), and having relevant knowledge, skills, and abilities (H dimension).

2.2 Social Relations Model

To find out peer rating behavior differences between these two interventions, we used Social Relations Model (SRM) to compare the rating differences between these two interventions. SRM is a method section that analyzes

the peer ratings within teams using rater variance, target variance, and relationship variance (Greguras, Robie, & Born, 2001). Social Relations Model analyzes the rating results using three variance components: Rater Variance, Target Variance, and Relationship Variance (Back & Kenny, 2010). For having high peer evaluation quality, we expect to have lower Rater Variance which means students are not giving same rating to all team members. We also expect to see higher target variance which shows team member rated similarly by all other team members. In addition, Relationship Variance shows whether the ratings are based on personal interactions or interactions that are experienced by the whole team.

3. Results

For the analysis section, we first ran the SRM analysis for ADA (across all five dimensions), and then SRM for each individual dimension.

Table 1. ADA SRM Analysis Table

	Rater			Target			Relationship		
	PE1	PE2	PE3	PE1	PE2	PE3	PE1	PE2	PE3
No Female	61.5%	44.6%	31.7%	12.3%	19.6%	30.8%	26.2%	35.9%	37.5%
Female	60.0%	47.4%	35.6%	10.9%	17.8%	35.4%	29.2%	34.9%	28.9%

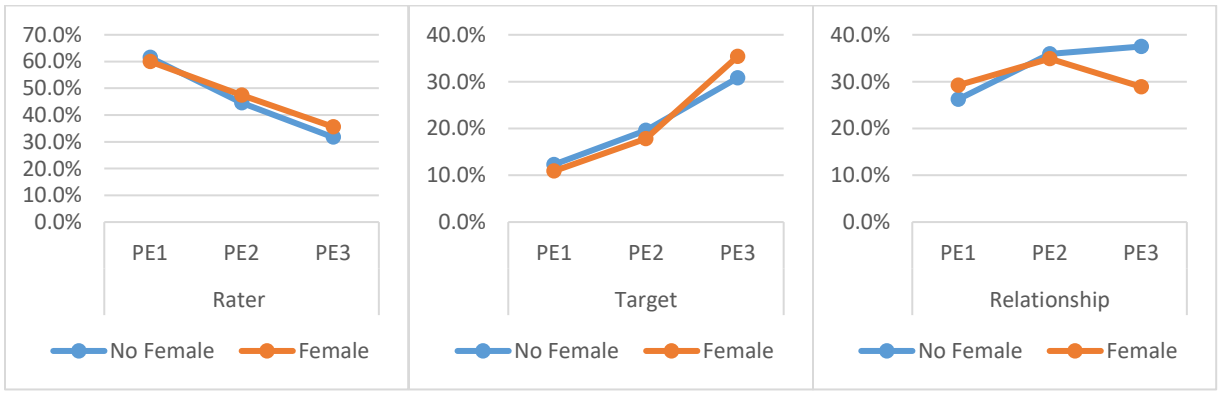

Figure 1. ADA SRM Analysis Graph

According to Table 1 and Figure 1, in ADA SRM Analysis, both interventions show a decreasing trend in rater variances across peer evaluations. This shows that while more teamwork is done, members in both interventions tend to give more different ratings to different teammates. Also, teams with female students have slightly higher rater variance for peer evaluation 2 and 3, which means that members in teams with female students slightly tend to rate their teammates more similarly across semester. However, the difference is small.

For target variance, all teams show an increasing trend across peer evaluations. This shows that while more group work is done, members in both types of groups tend to receive more similar ratings from different teammates. Both

types of groups don't show a significant difference in target variance between each other and have a similar size of target variance for all three peer evaluations. Specifically, the teams with female students are 1.4% higher for peer evaluation 1, 1.8% higher for peer evaluation 2, and 4.6% lower for peer evaluation 3.

For relationship variance, the teams with only male students increase across peer evaluations, while teams with female students don't show an obvious trend across peer evaluations. Specifically, compared to peer evaluation 1, the relationship variance for no-female teams are 9.7% higher in peer evaluation 2, and 11.3% higher in peer evaluation 3. This indicates that while more teamwork is done, the teams with only male students tend to rate each other based on personal interactions more, while teams with female students don't show an obvious change in rating behavior across peer evaluations from this aspect.

Table 2. Individual Dimension C Table

		Rater			Target			Relationship		
		PE1	PE2	PE3	PE1	PE2	PE3	PE1	PE2	PE3
C	No Female	50.6%	31.3%	23.2%	17.2%	29.6%	41.6%	32.2%	39.2%	35.2%
	Female	52.1%	33.2%	21.0%	18.5%	32.6%	44.7%	29.4%	34.3%	34.3%

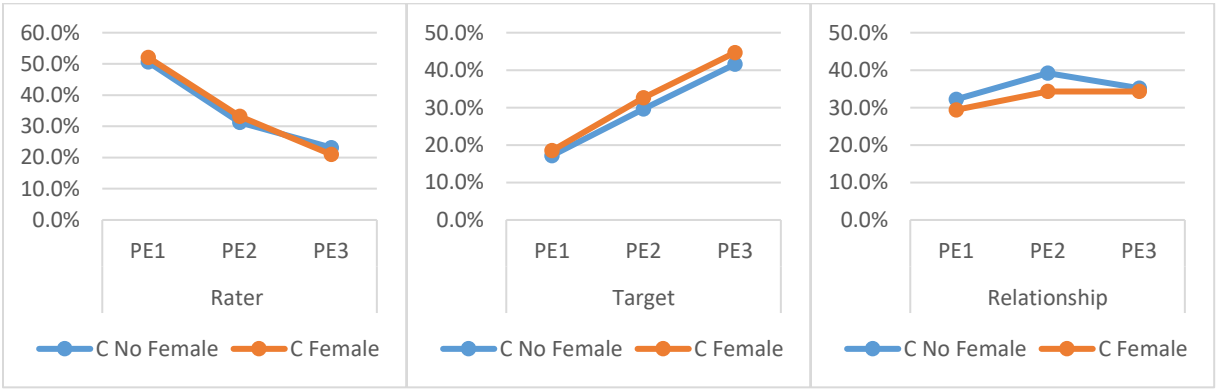

Figure 2. Individual Dimension C Graph

According to Table 2 and Figure 2, in dimension C, the teams with no female students show the same trend of change in rater variance across peer evaluations compared to the teams with female students. Specifically, both rater variances decrease across semester. This means that as members in both interventions work with each other longer, they tend to give different team members more different ratings. No significant difference is found in the size of rater variances between female groups and no female groups. For the target variance, both interventions also show similar trends of change, since they all increase across peer evaluations. This means that the members tend to receive more similar ratings as more teamwork is done together. Overall, teams with female students have slightly higher target variances, which means that members in these groups tend to receive slightly more similar ratings, but no obvious difference is found between two types of groups. For relationship variance, both interventions don't show an obvious trend and only varies slightly across peer evaluations. However, the teams with female students have lower relationship variances than teams with only male students for all three interventions. This shows that the

members in the teams with only male students tend to rate their teammates based on personal interactions that may not be experienced by others in the team more.

Below, we provided the tables and graphs for other dimensions. Specifically, Table 3 and Figure 3 are for Dimension I, Table 4 and Figure 4 are for Dimension K, Table 5 and Figure 5 are for Dimension E, Table 6 and Figure 6 are for Dimension H.

Table 3. Individual Dimension I Table

		Rater			Target			Relationship		
		PE1	PE2	PE3	PE1	PE2	PE3	PE1	PE2	PE3
I	No Female	55.8%	43.8%	40.1%	11.5%	9.5%	16.5%	32.7%	46.7%	43.4%
	Female	58.1%	44.6%	36.7%	8.1%	14.2%	23.8%	33.8%	41.2%	39.5%

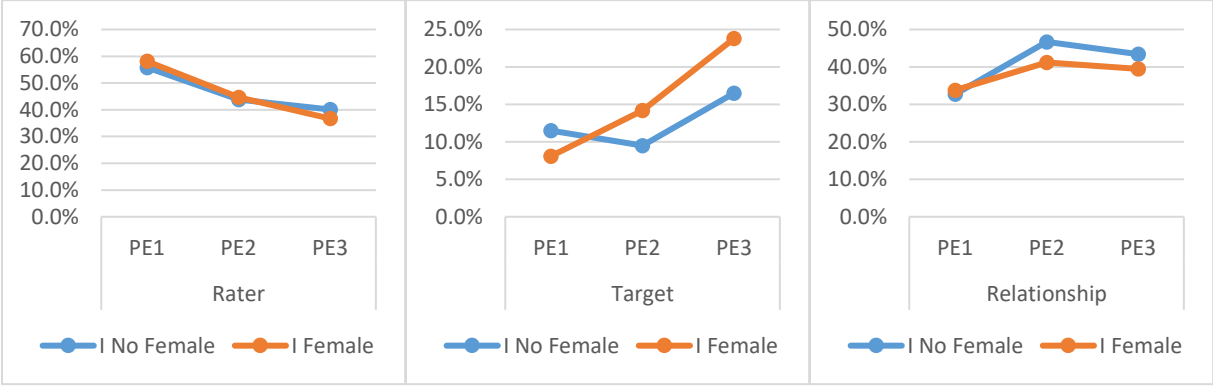

Figure 3. Individual Dimension I Graph

Table 4. Individual Dimension K Table

		Rater			Target			Relationship		
		PE1	PE2	PE3	PE1	PE2	PE3	PE1	PE2	PE3
K	No Female	65.1%	48.3%	35.2%	9.4%	13.5%	21.4%	25.5%	38.2%	43.4%
	Female	64.8%	47.4%	37.2%	5.5%	11.2%	27.1%	29.7%	41.4%	35.7%

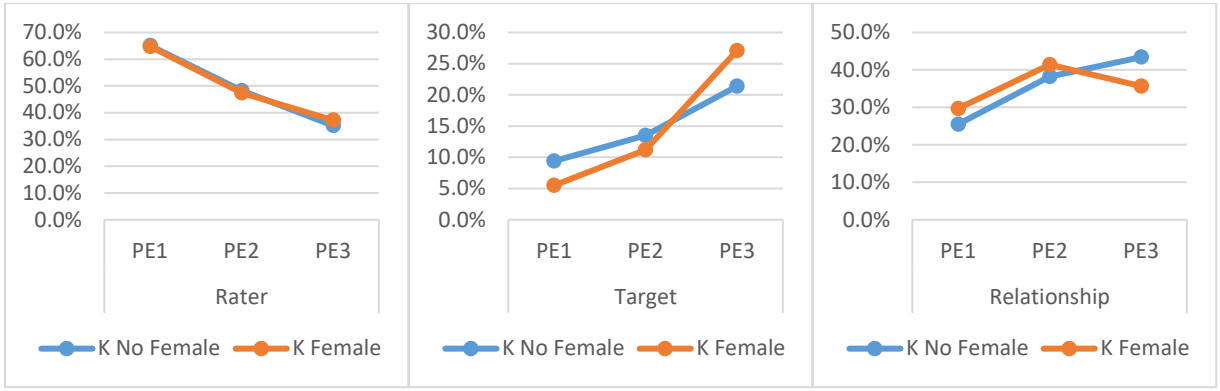

Figure 4. Individual Dimension K Graph

Table 5. Individual Dimension E Table

		Rater			Target			Relationship		
		PE1	PE2	PE3	PE1	PE2	PE3	PE1	PE2	PE3
E	No Female	67.9%	52.0%	41.1%	6.3%	7.9%	17.4%	25.8%	40.1%	41.5%
	Female	66.0%	60.6%	41.4%	4.7%	8.2%	23.1%	29.3%	31.2%	35.5%

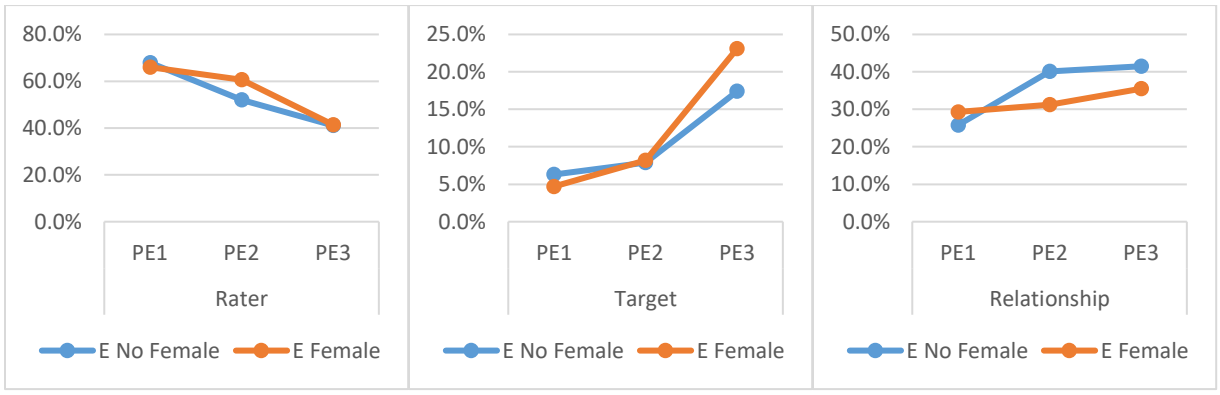

Figure 5. Individual Dimension E Graph

Table 6. Individual Dimension H Table

		Rater			Target			Relationship		
		PE1	PE2	PE3	PE1	PE2	PE3	PE1	PE2	PE3
H	No Female	48.9%	37.1%	25.2%	15.2%	25.7%	34.2%	35.9%	37.2%	40.6%
	Female	45.6%	36.0%	27.8%	16.3%	22.5%	39.5%	38.1%	41.5%	32.7%

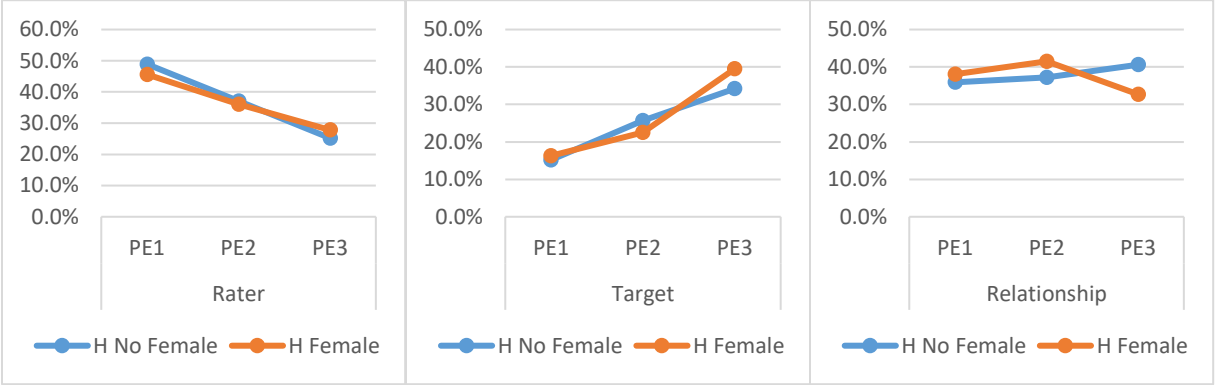

Figure 6. Individual Dimension H Graph

4. Discussion

For the overall ADA SRM Analysis, both interventions show an increasing trend in target variance and a decreasing trend in rater variance. This is a good and logical trend of change. Since when teammates do more work together, they tend to know each other and differentiate between different teammates better. Also, since teammates tend to know each member better, each teammate tends to receive a more similar rating from all other teammates. Among the two types of groups, the female groups have slightly higher rater variance, However, the difference was very small indicating that there is almost no difference in peer rating behavior between teams with no female students and teams including at least one female student.

We found some additional results from SRM individual dimension analysis. For dimension C, teams with only male students tend to have higher relationship variances, which means that their ratings are based on personal interactions more in dimension C. For dimension I, teams including female students have higher target variances except for the first review and increased across peer evaluations, while teams with only male students have lower target variances and didn't change obviously across peer evaluations. This means members in teams with female students tend to receive more similar ratings compared to male groups and across peer evaluations; overall, teams with female students show a better performance in rating in dimension I. Teams with only male students tend to have higher relationship variances, which means that their ratings are based on personal interactions more in dimension I.

For dimension K, in target variance, teams with female students have higher variance than teams with only male students only in the third peer evaluation. This shows that when most groups projects are done, the members in teams with female students tend to know each other well as they rate each teammate much more consistently than

before, but members in teams that only contain male students tend to know each other more quickly. For dimension E, the data indicates that teams with female students tend to rate their teammates a little more similarly and receive slightly more similar ratings in peer evaluation 2 and 3. For dimension H, not much significant results could be found in ratings between female groups and no-female groups in all three variances across three peer reviews.

5. Conclusion

There is a need for having more women in engineering. Having more women brings more diversity for engineering which can result in more diversity of ideas. However, to have more diversity in teams, the team members should work constructively together. One way for having constructive collaboration is conducting peer evaluations in teams. Peer evaluations can help engineering students to get feedback from teammates and improve their performance in the teams. In this study, we were interested about whether putting women in teams will change the peer rating behavior or not, and if there is change it is for better or worse. So, we analyzed the peer evaluation in first-year engineering classroom. Although teams with female students improved slightly comparing to teams with no female students, there was not significant difference between the behavior of them. This also confirms the validity of CATME peer evaluation system and Team-maker system, since from the peer evaluation results, all groups are formed in a fair way and the teamwork quality is assured.

6. Limitations and future studies

In this study, we chose the sample solely from a first-year college engineering course. Next time, we could also try to take the sample from a higher-level engineering course and compare the results between them. Some difference is expected to be found, as coursework might have more diverse format and all students will be more familiar with the format of college courses and the field of engineering. Another important factor to consider is the team size. In the sample of this study, all teams contain 4 members. When the team size becomes different, the effect of female students in groupwork might differ. Finally, in this study, teams with female students had a different number of female students. The number of female students in each female team might affect the behavior of female students in teamwork as well.

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Biographies

Chuhan Zhou is a junior undergraduate student and Research Assistant in Engineering Education at Purdue University. He is currently majoring in Applied Statistics and minoring in Economics. He is interested in topics regarding data analysis and probability modeling. Chuhan has worked in CATME since 2018 and is currently conducting research regarding the CATME peer evaluation system, with a specific focus on how demographics might affect teamwork behaviors.

Sunjae Choi is a senior undergraduate student and Research Assistant in Engineering Education at Purdue University. He is majoring in Computer Information Technology and minoring in Economics. Based on his major, he is interested in data analytics. He has previously conducted research with Discovery Park at Purdue University regarding the effects of online anxiety on cyber-secure behavior and cyber-hygiene. He currently works in the CATME project as a Summer Research Intern.

Behzad Beigpourian is a Ph.D. student and Research Assistant in Engineering Education at Purdue University. He earned his master's in Structural Engineering from Shahid Chamran University in Iran, and his bachelor's in Civil Technical Teacher from Shahid Rajaee Teacher Training University in Iran, Tehran. He has been official Technical Teacher at Ministry of Education in Iran from 2007 to 2018, and received many certificate in education such as Educational Planning, Developing Research Report, and Understanding School Culture. Mr. Beigpourian currently works in the CATME project, which is NSF funding project, on optimizing teamwork skills and assessing the quality of Peer Evaluations.

Siqing Wei received both bachelor's and master's degrees in electrical and Computer Engineering from Purdue University. He is currently pursuing Ph.D degree in Engineering Education at Purdue University. After years of experience of serving a peer teacher and a graduate teaching assistant in first year engineering courses, he is a research assistant at CATME research group studying the existence, causes and interventions on international engineering teamwork behaviors, the integration and implementation of team-based assignments and projects into STEM course designs and using mixed-method, especially natural language processing to student written research data, such as peer-to-peer comments. Siqing also works as the technical support manager at CATME research group.

Daniel M. Ferguson is CATME Managing Director and the recipient of several NSF awards for research in engineering education and a research associate at Purdue University. Prior to coming to Purdue he was Assistant Professor of Entrepreneurship at Ohio Northern University. Before assuming that position he was Associate Director of the Inter-Professional Studies Program [IPRO] and Senior Lecturer at Illinois Institute of Technology and involved in research in service learning, assessment processes and interventions aimed at improving learning objective attainment. Prior to his University assignments he was the Founder and CEO of The EDI Group, Ltd. and The EDI Group Canada, Ltd, independent professional services companies specializing in B2B electronic commerce and electronic data interchange. The EDI Group companies conducted syndicated market research, offered educational seminars and conferences and published The Journal of Electronic Commerce. Dr. Ferguson is a graduate of Notre Dame, Stanford and Purdue Universities, a special edition editor of the Journal of Engineering Entrepreneurship and a member of Tau Beta Pi.

Matthew W. Ohland is Professor of Engineering Education at Purdue University. He has degrees from Swarthmore College, Rensselaer Polytechnic Institute, and the University of Florida. His research on the longitudinal study of engineering students, team assignment, peer evaluation, and active and collaborative teaching methods has been

supported by the National Science Foundation and the Sloan Foundation and his team received Best Paper awards from the Journal of Engineering Education in 2008 and 2011 and from the IEEE Transactions on Education in 2011 and 2015. Dr. Ohland is an ABET Program Evaluator for ASEE. He was the 2002–2006 President of Tau Beta Pi and is a Fellow of the ASEE, IEEE, and AAAS.