121st ASEE Annual Conference & Exposition
Indianapolis, IN
June 15-18, 2014
Paper ID #8864

Informal Peer-Peer Collaboration, Performance, and Retention for First Semester Engineering Students

Nora Honken, University of Louisville

Nora Honken holds degrees in industrial engineering from Virginia Tech and Arizona State University. She will receive a PHD in Education Leadership, Foundations and Human Development from the University of Louisville in May 2014. She has held positions in engineering and management for Axxess Technologies, Varian, Amoco and Corning, and has taught in industry, at community college and at the graduate and undergraduate levels. Her research interests include engineering student performance and retention, and how to best teach work skills throughout the engineering curriculum.

Dr. Patricia A Ralston, University of Louisville

Dr. Patricia A. S. Ralston is Chair of the Department of Engineering Fundamentals at the University of Louisville. She also has an associate appointment in Chemical Engineering. Dr. Ralston teaches undergraduate engineering mathematics and is currently involved in educational research on the effective use of Tablet PCs in engineering education, the incorporation of critical thinking in undergraduate engineering education, and retention of engineering students. Her fields of technical expertise include process modeling, simulation, and process control.

©American Society for Engineering Education, 2014

Informal Peer-to-Peer Collaboration, First Semester GPA and First Year Retention

Introduction

A tremendous amount of research has been conducted on the benefits of collaborative learning. College students can participate in multiple types of collaborative learning, including required in-class activities, required out-of-class project work, organized formal study groups, and informal peer-to-peer collaboration on homework and studying.

Within the literature the terms collaborative learning and cooperative learning have both been used to classify these types of learning activities. Some authors use the terms interchangeably, while others consider them on a continuum with cooperative learning being the most structured and collaborative learning the least structured.[1] For the purpose of this paper, we refer to structured in-class or out-of-class group activities as formal collaboration and voluntary peer-to-peer student initiated activities as informal collaboration.

Background Literature

The majority of the research on collaboration has focused on teacher initiated formal collaboration as part of course design. Definitive reviews have established that formal collaborative learning techniques can positively influence students' achievement and persistence in science, technology, engineering and math (STEM) fields.[2, 3, 4] Intentionally incorporating collaborative activities into course design has been shown to foster social integration which has been related to retention.[5,6]

A meta-analysis of 500 studies of college students' academic performance in STEM showed a positive relationship between structured collaborative learning and achievement and retention.[7] The study also indicated that this type of collaborative learning might have a positive impact on students' attitudes towards the subject matter.

Studies on collaborative learning have been conducted specifically with underrepresented groups of students to determine the effects on achievement and retention. In a study of African-American students majoring in math and science at the University of California-Berkeley, the five-year retention rate for students who participated in collaborative learning workshops was 65%, compared to 41% for non-participants.[8] These findings were replicated in a 5-year longitudinal study of underrepresented Latino students enrolled in mathematics, science or engineering programs at California Polytechnic State University, Pomona. This study revealed that fewer than 4% of Latino students who participated in formal out-of-class collaborative learning sessions withdrew or were academically dismissed, compared to 40% of the students who did not participate in the program.[9]

Studies have also investigated the relationship between informal collaboration and achievement. Two recent studies involving only engineering students[10] presented a convincing case for the relationship between informal collaborative learning and improved confidence and academic achievement. Collaborative learning strategies investigated in these studies included "sharing ideas with peers, obtaining helpful feedback from other students, and working together to help each other understand the material, learn new things and complete assignments".[11] The results from these two studies concluded that students' self-reported collaborative learning strategies were associated with increased self-efficacy for learning course material and academic achievement, and students who received a B reported higher levels of collaboration then students who earned an A or C. Female in the study reported greater use of informal collaborative learning strategies than did male students.

Stump and colleagues[12] recognized that their study designs did not allow for a clear idea as to the nature of the collaborative activities students self-reported. They suggested that future studies should examine ways to cultivate, support and extend informal collaborations for engineering students. Their studies involved mostly students in junior level courses, versus the current study which involved first-year engineering students. Informal collaboration of freshmen students might have a stronger relationship with overall retention since academic achievement in the early semesters of the engineering curriculum has been linked to retention.[13]

Purpose

In light of these previous results, the purpose of this study was to investigate the relationship between performance of students in their first semester of engineering school and the frequency of informal, student initiated, peer-to-peer collaboration on homework and studying for tests. The study also investigated the relationship between informal, peer-to-peer collaboration and first year retention. It is clear from past research that academic performance and retention of engineering students is a complex issue with confounding variables, but since the goal of the study was to determine if informal collaboration should be recommended to all students, no covariates were investigated.

The research questions were as follows:

1. Is there a difference in the average first semester GPA for the engineering students who report different levels of collaboration on their homework?
2. Is there a difference in the average first semester GPA for the engineering students who report different levels of collaboration on studying for tests?
3. Is there a difference in the peer collaboration patterns of males and females?
4. Is there a difference in the retention rate for the engineering students who report different levels of collaboration on their homework?
5. Is there a difference the retention rate for the engineering students who report different levels of collaboration on studying for tests?

Research Design

Procedure

Data for this IRB approved study was gathered on a survey administered to first-time full-time students in an Introduction to Engineering course, which is a required course for all freshman engineering students. The survey was administered through email in week 13 of fall 2012 semester and was part of a larger research effort to improve engineering student retention and performance. Students were given class time to complete the survey and no rewards or credit towards the class were given for participating in the study.

Participants

The participants in this study were all first-time, full-time engineering students in the fall 2012 freshman cohort at the J. B. Speed School of Engineering at the University of Louisville. Three hundred-fifty-three students completed the survey for an 82% participation rate. Seven-nine of the participants were female (22%) and 274 were male (78%). The gender distribution in the study was identical to the gender distribution in the cohort, which had a slightly higher percentage of females than the national population of engineering students.[14] The participants were 85% Caucasian, which was identical to the percentage in the cohort. No other ethnic group represented more than 4% of the participants or the cohort. The ethnic distribution of the participants was more heavily Caucasian than the ethnic distribution in the national population of engineering students.[15] The average ACT composite score for the participants was 28.5 (SD = 3.13) and approximately 40% of the students had a weighted high school GPA of 4.0 or above.

Since the response rate was lower than 85%, missing data was analyzed to determine if any threats to internal validity existed. There was not a significant difference between the average GPA between participants, 2.84 ($SD = .87$) and the entire cohort, 2.71 ($SD = .98$), $t(781) = 1.942$, $p = .053$. But since the p value was low, the GPAs of the participants and non-participants were investigated further. The average first semester GPA for students who participated in the survey, 2.84 ($SD = .87$), was statistically significantly different from the GPA for students who did not participate in the study, 2.16 ($SD = 1.24$), $t(428) = 4.58$, $p < .001$(t-test for unequal variances). The group who did not participate in the study had a higher percentage of students with lower GPAs and less than half the percentage students with GPAs between 3.5 and 4.0 (see Figure 1). This has been a common occurrence with research we have conducted with other cohorts.

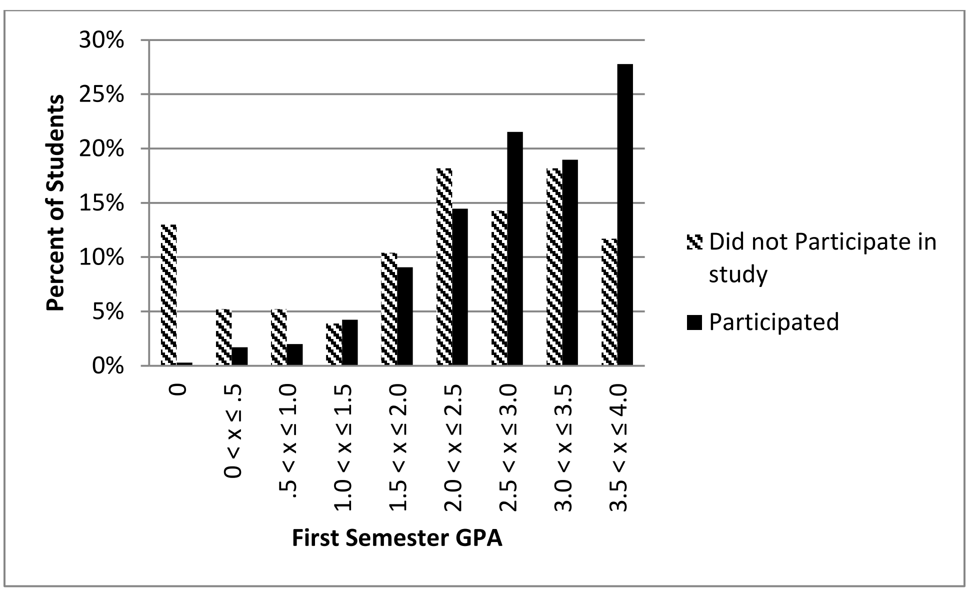

Figure 1. Distribution of First Semester GPA for Students Who Did and Did Not Participate in the Study

Measurements

The degree of homework and study collaboration was estimated by the students' responses to the following two questions: 1) *This semester, how frequently did you study for tests with classmates?* 2) *This semester, how frequently did you work on homework with classmates?* The available responses were 1) *Never*, 2) *At least once, but less than ½ of the tests (homework*), 3) *For about half of the tests (homework)*, 4) *For more than half of the test (homework), but not all*, 5) *Always.* The responses were treated as categorical and were intended to only measure a general idea of collaboration level.

Analysis

Independent t-tests were performed to determine if there was a difference in first semester GPA for students with different collaboration levels. Logistic regression was used to determine if the likelihood of retention was different for students with different levels of collaboration. Collaboration level was treated as categorical and the response of *Never* was used as the reference variable. The variable STATUS was set to "1" for students who were retained in engineering after one year and STATUS was coded as "0" for students who left the university or switched majors. All analyses were performed in SPSS version 20.

Results

Table 1 shows the percentage of male, female and all students who selected each response for each of the two collaboration questions. The most frequent response for the question on study and homework collaboration was *At least once, but less than half*. Approximately 6% of the students reported never doing homework or studying with other students. Fourteen percent of the students reported both studying and doing homework together over 50% of the time. Three percent reported always studying and always doing homework together. Females were twice as likely as males to select *Always* for collaborating on homework, but were almost twice as likely as males to select *Never* for studying with others for tests.

Table 1. Response to Collaboration Questions by Gender

		Never	At least once, but less than half	About half	More than half, but not always	always
Homework	Females	14%	38%	20%	18%	10%
	Males	12%	43%	22%	18%	5%
	All	12%	42%	22%	18%	6%
Study for tests	Females	20%	29%	22%	18%	11%
	Males	11%	43%	21%	15%	10%
	All	13%	40%	21%	16%	10%

Collaboration and GPA

The average first semester GPA for all the students who participated in the study was 2.84 (*SD* = .87). There was no significant difference in the average GPA or standard deviation of GPAs for female students, 2.86 (*SD* = .86), and male students, 2.83 (*SD* = .87). The following sections summarize the differences in the average GPA for students with different levels of study and homework collaboration.

Study Collaboration

The average first semester GPA for students in the five categories of study collaboration (see Table 2 and Figure 2) were all within .14 of each other. The box plot shows major overlap in the ranges of GPA for all five categories. Independent *t*-tests showed that the average GPA was not significantly different for students with different responses to the study collaboration question.

Table 2. Average GPA for Different Levels of Collaboration in Studying for Tests

	GPA		
	M	(*SD*)	*n*
Never	2.84	(.98)	45
At least once, but less than half of the tests	2.80	(.91)	141
For about half the tests	2.80	(.82)	75
For more than half of the test, but not all	2.94	(.78)	56
Always	2.88	(.82)	35

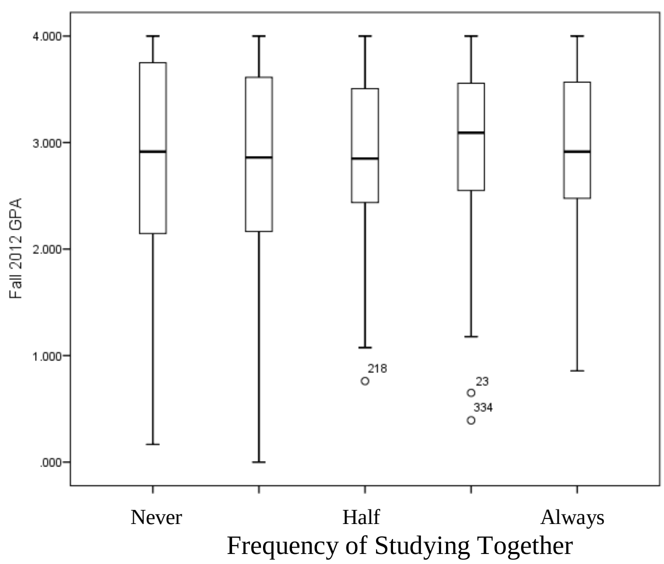

Figure 2. Box Plot of First Semester GPA for Different Levels of Study Collaboration

Homework Collaboration

The average first semester GPA for the five categories of homework collaboration ranged from 2.53 to 2.96 (see Table 3 and Figure 3). Individual *t*-tests showed a significant difference between the average GPA for students who responded *Always* and *At least once, but less than half*, $t\,(166) = -2.13$, $p = .034$, but not for any other two categories.

Table 3. Average GPA for Different Levels of Collaboration on Homework

	GPA		
	M	(*SD*)	*n*
Never	2.70	(.70)	43
At least once, but less than half of the tests	2.96	(.87)	147
For about half the tests	2.76	(.89)	77
For more than half of the test, but not all	2.84	(.71)	64
Always	2.53	(1.03)	21

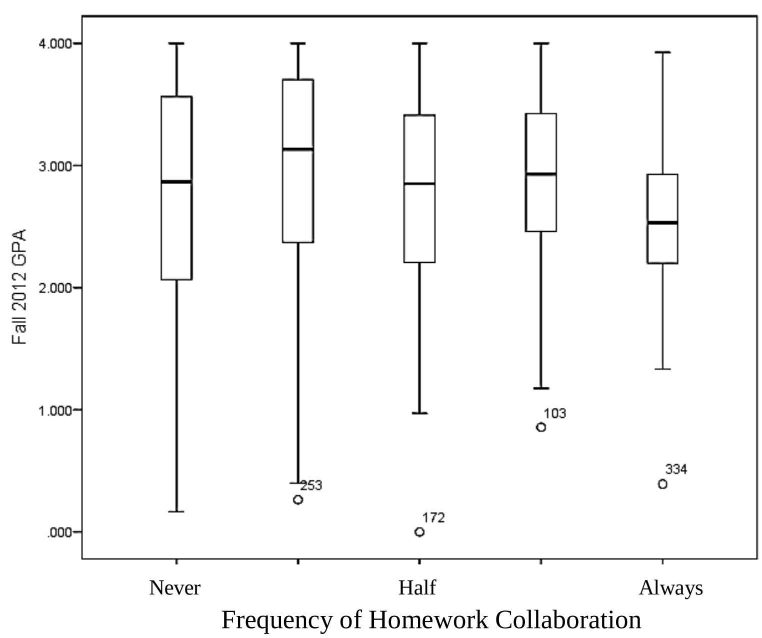

Figure 3. Box Plot of First Semester GPA for Different Levels of Homework Collaboration

Collaboration and Retention

The first year retention in engineering rate for the 2012 cohort was 70%, which was down from the previous four years. Unlike past cohorts at our university, males had a higher retention rate in engineering (72%) than did females (67%). The retention rate for the 352 students who completed the survey questions on collaboration (74%) was slightly higher than the cohort rate. Tables 4, 5 and 6 display the retention rates for each level of study and homework collaboration. There is a separate table for male, female and all students.

Table 4. Retention in Engineering Rates for All Students by Response on Collaboration Questions (n = 352)

	Study for Tests		Homework	
	% retained	*n*	% retained	*n*
Never	67%	45	63%	43
At least once, but less than ½ of the tests (homework)	72%	141	75%	147
For about half of the tests (homework)	69%	75	69%	77
For more than half of the test (homework), but not all	82%	56	81%	64
Always	89%	35	86%	21

Table 5. Retention in Engineering Rates for Males by Response on Collaboration Questions (n = 273)

	Study for Tests		Homework	
	% retained	*n*	% retained	*n*
Never	66%	29	66%	32
At least once, but less than ½ of the tests (homework)	71%	118	74%	117
For about half of the tests (homework)	72%	58	75%	61
For more than half of the test (homework), but not all	91%	42	84%	50
Always	92%	26	85%	13

Table 6. Retention in Engineering Rates for Females by Response on Collaboration Questions (n = 79)

	Study for Tests		Homework	
	% retained	*n*	% retained	*n*
Never	67%	16	55%	11
At least once, but less than ½ of the tests (homework	74%	23	77%	30
For about half of the tests (homework)	59%	17	44%	16
For more than half of the test (homework), but not all	57%	14	71%	14
Always	78%	9	88%	8

Logistic regression models were run, using data from all participants, to determine if the likelihood a student would be retained in engineering after one year was statistically different for students with different levels of collaboration on homework and studying. The results using the data from the question on study collaboration showed that overall the difference was not significant, but there was a significant difference between students who reported *Never* and those who reported *Always*. Based on the odds ratio confidence intervals (see Table 7), a student who always studied with peers was between 1.2 to 13 times more likely to be retained in engineering after one year than a student who never studied with peers.

Table 7.   Logistic Regression Results for Study Collaboration

	B	S.E.	Wald	df	Sig.	Exp(*B*)	95% CI Exp(*B*)
Overall study variable			7.801	4	.099		
At least once	.233	.367	.403	1	.526	1.262	[.615, 2.593]
About half	.123	.403	.092	1	.761	1.130	[.513, 2.492]
More than half	.833	.471	3.129	1	.077	2.300	[.914, 5.788]
Always	1.355	.618	4.800	1	.028	3.875	[1.153, 13.018]

Note: Response of *Never* was reference variable

The results of the analysis using the homework collaboration data (see Table 8) showed the overall variable of homework collaboration was not significant. There was, however, a significant difference in the likelihood of retention between students who never collaborated on homework and students who indicated they had collaborated on more than half of their homework assignments (but not all). Students who indicated they had collaborated on more than half of their homework assignments were between 1.1 and 6.2 times more likely to be retained than students who indicated they never collaborated on homework. The difference in the likelihood of being retained was not significant between students who responded *Never* and *Always*. This is due to the high standard error, which is due in part to the low number of students who responded *Always*.

Table 7. Logistic Regression Results for Homework Collaboration

							95% C.I. for EXP(*B*)	
	B	S.E.	Wald	df	Sig.	Exp(*B*)	Lower	Upper
Overall homework variable			6.940	4	.139			
At least once	.566	.368	2.364	1	.124	1.762	.856	3.626
About half	.269	.400	.452	1	.501	1.309	.597	2.867
More than half	.943	.450	4.401	1	.036	2.568	1.064	6.198
Always	1.269	.699	3.295	1	.070	3.556	.904	13.989

Note: Response of *Never* was reference variable

Discussion

This study was inspired by results of an ongoing study investigating retention and performance of students in the Engineering Fundamentals department at the J. B. Speed School of Engineering at the University of Louisville. In that study, students who collaborated more frequently in high school were more likely to be retained in engineering after one year.[16] Those results led the researchers to question the potential benefits of peer-to-peer voluntary study and homework collaboration in college, and whether such informal collaboration should be recommended to all students as a way to help increase performance or retention. Since the goal of this study was to determine if informal collaborative work should be recommended to all students, no other variables, such as intelligence, were investigated.

The analysis showed a potential negative relationship between always collaborating on homework with other students and first semester GPA. This must be taken with caution as the average GPA for the students who responded *Always* to homework collaboration, although the lowest of any group, was only statistically different than the average GPA of the students who responded *At least once but less than half*.

The results of the current study showed no evidence of a relationship between the frequency of study collaboration and first semester GPA. This is in contrast to the results reported by Stump and colleagues[17] who found that informal collaborative strategies was a significant predictor of course grade (n = 150).

In the current study, females were more likely than males to respond *Always* to working with others on all their homework assignments, but were also more likely to respond *Never* to studying for tests with others. The percentage of females who always did homework together (10%) was twice as high as the percentage of males who always did homework together (5%). However, the percentage of females who never studied for tests with others (20%) was almost twice as high as the percentage of males who never studied together (11%). In the study by Stump and colleagues,[18] females were more likely to collaborate with their fellow students.

The results of the logistic regression analysis showed the amount of informal peer-to-peer collaboration is not a significant variable in explaining student retention when no other variables are considered. There was evidence that students who responded they never studied with peers were less likely to be retained than students who reported they always studied for tests with peers. There was also evidence that students who never collaborated on homework were less likely to be retained than students who collaborated on more than half of their homework. All of these relationships need to be studied further with larger sample sizes.

It is interesting that students who selected *Always* for collaboration on homework, had the lowest average GPA, but the highest retention rate for the cohort (although neither were significantly different from all other categories). This raises some interesting questions such as whether informal peer-to-peer collaboration can help maintain interest for some students when their performance drops, or if the social benefits of collaboration help give some students a sense of belonging that contributes to the student's decision to stay in engineering. These questions would have to be answered with future research that was qualitative in nature.

There are many reasons collaborating informally (without structured assistance from the instructor) on homework or studying for tests might not positively contribute to academic performance; just working together doesn't guarantee success.[19] Students may not assume proper roles in collaborative settings[20] and they might lack common goals.[21] First year engineering students may not be able to properly engage in beneficial cognitive steps such as questioning and elaborating on another's ideas which are effective help-seeking behaviors,[22] but may instead be focused on getting an answer and turning in the homework assignment.

Limitations, Conclusions and Future Research

When considering the results of this study, the limitations must also be considered. The participants in this study were in one cohort of engineering students all from the same university and were less ethnically diverse then the general population of college students. It is up to the reader to determine based on the information given about the participants if the results might apply to their students. In the future, the study could be expanded to include a more ethnically diverse group of students.

The 18% of students who did not take the survey had a higher percentage of students in the lower GPA range and a lower percentage of students in the 3.5 to 4.0 range. Thus, students with lower GPAs were underrepresented in the study and the students in the higher range were overrepresented. Also when looking specifically at females, the number of participants in the study was only 79 and the number of responses for each category of collaboration was relatively low. A study with a larger sample of female students would add credence to the results of this study.

This study was correlational; thus no cause and effect could be determined from the results. The values for collaboration were gathered on a survey that asked students to characterize their collaboration in terms of frequency of collaborations based on all homework and tests. As with all surveys, it is unknown how accurately the answers reflect actual collaboration levels and if students' responses were influenced by current collaboration activities. Also the measures of collaboration were based on the answer to one question; future validation on this measure is needed.

It is clear from the plethora of research on academic performance and retention of engineering students that these issues are very complex. Although others have concluded that collaboration helps academic performance, the analysis in this study does not support such a conclusion when collaboration is measured by self-reported frequencies of voluntary study and homework collaboration. The study does indicate the need to investigate further whether voluntary peer-to-peer collaboration can have an impact on retention. It is clear that before recommendations on informal collaboration can be made for all students, more research needs to be completed to determine the type of students who benefit most from collaboration and how to support students so that they collaborate most effectively in informal situations like studying for tests and doing homework together.

References

1. Barkley, E. F., Cross, K. P. & Major, C. H. (2005). Collaborative learning techniques: A handbook for college faculty. San Francisco: Jossey – Bass.
2. Bowen, C. W. (2000). A quantitative literature review of cooperative learning effects on high school and college achievement. *Journal of Chemical Education, 77*(1), 116–119.
3. Prince, M. (2004). Does active learning work? A review of the research. *Journal of Engineering Education, 93*(3), 223–231.
4. Springer, L., Stanne, M. E., & Donovan, S. S. (1999). Effects of small-group learning on undergraduates in science, mathematics, engineering, and technology: A meta-analysis. *Review of Educational Research, 69*(1), 21–51.
5. Tinto, V. (1993). Leaving college: Rethinking the causes and cures of student attrition (2nd ed.). Chicago: University of Chicago Press.
6. Braxton, J. M., Sullivan, A. S., & Johnson, R. M. (1997). Appraising Tinto's theory of college student departure. In J. C. Smart (Ed.), Higher education: Handbook of theory and research (volume 12), 107-164. New York: Agathon.
7. Cooper, J. L. (1997). New evidence of the power of cooperative learning. *Cooperative Learning and College Teaching, 7*(3), 1-2.
8. Treisman, U. (1992). Studying students studying calculus: A look at the lives of minority mathematics students in college. *College Mathematics Journal, 23*(5), 362-372.
9. Bonsangue, M. V. (1993). The effects of calculus workshop groups on minority achievement in mathematics, science, and engineering. *Cooperative Learning and College Teaching, 3(3)*, 8-9.
10. Stump, G.S., Hilpert, J.C., Husman, J., Chung, W., and Kim, W., (2011). Collaborative Learning in Engineering Students: Gender and Achievement, *Journal of Engineering Education*, *100*(3), 475-497.
11. Stump, et al. (2011). op. cit. pg. 476
12. Stump, et al. (2011). op. cit.
13. Jackson, L. A., Gardner, P. D., & Sullivan, L. A. (1993). Engineering persistence: Past, present, and future factors and gender differences. *Higher Education, 26*(2), 227–246.
14. National Science Foundation. (2013). Women, minorities and persons with disabilities in science and engineering (table 2-9 undergraduate enrollment in engineering programs by sex, race/ethnicity, citizenship and enrollment status: 1999-2009) (NSF report number NSF_13-304). Arlington, VA: National Science Foundation. Retreived from http://www.nsf.gov/statistics/wmpd/2013/pdf/tab2-9.pdf
15. National science Foundation. (2013). op. cit.
16. Honken, N. B., & Ralston, P. (2013). Freshman engineering retention: A holistic look. *Journal of STEM Education: Innovations and Research*, *14*(2), 29-37.
17. Stump, et al. (2011). op. cit.
18. Stump, et al. (2011). op. cit.
19. Barron, B. (2003). When smart groups fail. *The Journal of the Learning Sciences, 12*(3), 307–359.
20. Salomon, G., & Globerson, T. (1989). When teams do not function the way they ought to. *International Journal of Educational Research*, *13*(1), 89–99.
21. Slavin, R. E. (1996). Research on cooperative learning and achievement: What we know, what we need to know. *Contemporary Educational Psychology, 21*(1), 43–69.
22. Webb, N. M., & Mastergeorge, A. (2003). Promoting effective helping behavior in peer-directed groups. *International Journal of Education Research*, *39*(1–2), 73–97.