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THE EXPERIENCE OF PEER LEADERSHIP AND ITS IMPACT ON STEM SUCCESS

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How do Peer Leaders view their leadership experience? A survey was administered during the Spring 2013 semester to current and former peer leaders at New York City College of Technology ("City Tech") of the City University of New York (CUNY). The survey examined peer leaders' perseverance and retention in their science, technology, engineering, or mathematics (STEM) disciplines, and their views on how the facilitation experience had impacted their personal and leadership growth and skills.

It is not a common practice for many college students to hold leadership positions related to their STEM fields. In a higher education institution, the opportunity to lead may exist typically in student officer positions for STEM-focused clubs. However, a Peer Leadership program provides the unique prospect of leading in an academic setting. A Peer Leader encourages collaborative learning in a workshop setting that complements an undergraduate course, usually in a STEM discipline. Few studies have been conducted on the impact of peer leadership on students who are or have been peer leaders. Gafney and Varma-Nelson (2007) surveyed former leaders (1995-2003) from 11 institutions (n=119 respondents) through an online survey. Two responses, "participating in workshops" and "acting as a Peer Leader" were ranked as "most productive learning experiences" (p. 538). The long-term impact of serving as Peer Leaders was "increased… confidence in entering science-related careers and made them more effective as they interacted with people in a wide range of situations" (p. 538). A study of 15 respondents at the University of Texas, El Paso, found that Peer Leaders agreed that their "leadership and communications skills had improved because of the experience" and furthermore, the experience increased their interest in teaching as well as preparing them for various STEM careers(Dominguez, Salazar, Narayan, & Becvar, 2013). As one Peer Leader noted, "Workshops give peer leaders opportunities as undergraduates, often reinforced for several years, that students at other universities do not receive until they are in graduate school."

Amaral and Vala (2009) conducted a study of Peer Leaders ("mentors") who helped remedial students during lecture time in an introductory chemistry course. This study examined the benefits to Peer Leaders as *students* in terms of their cognition of science content. These peer mentors led discussions during the class with a group of at most six students. The authors "examined the relationship between mentoring and the achievement gains of the *mentors* using grades in subsequent subject-matter courses and the retention of the mentors in these courses" (p. 631). Results showed that 104 peer mentors

persisted in higher-level courses. Alberte, Cruz, Rodriguez, & Pitzer (2013) examined the "boost" in peer leaders' academic performance and found that Peer Leaders, current and past, outperformed their peers who were taking the same course in biology.

Another instructional model that uses students as peer leaders is Supplemental Instruction (SI). In a study by Stout & McDaniel (2006), SI leaders stated that leading sessions fostered better understanding of course content, improved their communication skills (written and verbal) and interpersonal skills, as well as their skills in networking with faculty, and developing teamwork strategies. The experience also increased their self-confidence. In a phenomenological study, Lockie & Van Lanen (2006) reported that the leadership position made SI leaders (N=44) more aware of the diversity of student learning needs. The student leaders also reported having enriched academic and interpersonal experiences, and they had developed a better relationship with faculty.

The common benefits of a peer leadership experience from these studies can be summarized as1) a deeper learning of course material (enriching academic experiences); 2) impactful interaction with students and faculty (enriching interpersonal experiences, networking with faculty); 3) improved communication skills; and 4) increased self-confidence.

Background

New York City College of Technology ("City Tech") is the designated college of technology within the City University of New York system. As a comprehensive college designated as a Hispanic Serving Institution, City Tech offers both Associate and Bachelor degree programs. Since 2007, there have been peer-led workshops for students in designated mathematics courses; however, mandatory participation was not required. While all the workshops were initially "free-standing" without a direct connection to a particular instructor or section, it was not until 2010 that two mathematics sections had time scheduled for mandatory workshops. Additionally, a one-credit course was implemented in 2008 for training first-time peer leaders. During the 2007-2013 period, formal meetings ("prep") with faculty to discuss course content with the Peer Leaders were not instituted. Instead, a set of workshop modules designed by faculty were provided to the Peer Leaders (see Liou-Mark, Dreyfuss, Yuen-Lau, Lu, Scott, Young, & Younge, 2013 for a complete history of PLTL at City Tech).

The Peer Leaders at City Tech have demonstrated professional and scholarly growth and many expressed interest in attending graduate school, a direction that had not originally been in their plans. In discussing their plans after graduation, it became clear that the experience of leading workshops had made an impact on their educational attainment. To better understand the impact of the Peer Leader experience at City Tech, a survey was designed and administered in the Spring 2013 term. Institutional Review Board approval at City Tech was obtained to conduct the study.

Study Participants and Methodology

The four-page survey form was sent via email to 89 current and former City Tech Peer Leaders who had peer-led from Fall 2007 through Spring 2013. The email explained the purpose of the study, and a consent form to participate in the study was provided. The completed survey forms were returned to a neutral third party who deleted any identifiable information. Responses were returned over a four-week period with encouragement from two subsequent emails sent within the same four week period to those

who had not responded (as tracked by the neutral third party). Of the total of 89 Peer Leaders, 36 responded, giving a 40% return rate. Of the 36 respondents, 27 were continuing in their degrees and nine (9) had graduated.

For this study, all Peer Leaders (first-time and experienced) who served in the Spring 2013 semester are categorized as "Current Peer Leaders." For five respondents, this was their first semester as a peer leader. Those Peer Leaders who had graduated from City Tech prior to the Spring 2013 semester are considered as "Graduated Peer Leaders" (n=9).

Survey Instrument

A survey was designed with three components: 1) demographic information, 2) word association, and 3) impact of the experience. The questionnaire used was piloted with 19 Peer Leaders at the University of Houston-Downtown (Houston, Texas) in early March 2013, and wording was revised before it was administered in late March 2013 at City Tech.

The first section of the survey requested demographic information: major, number of credits completed and/or degree attained, number of semester(s) as Peer Leader, courses led, gender, ethnicity, and language spoken at home. An additional question for graduates asking for their current status was requested. They were asked whether they were working, in graduate school, or teaching, and if so, whether they were still involved in STEM fields.

The second section involved word associations, with 44 words or phrases listed. These were descriptions or attributes of the phenomenon of "leading" from a study of 22 peer leaders by Dreyfuss (2012). The list of words or phrases originated from the question: "What three words would you use to describe your experience of leading a workshop?" A Likert scale was used for each descriptor, from 1 representing "strongly disagree" to 5 representing "strongly agree," and space for comments was provided for each word or phrase.

The third section examined the impact of the peer leading experience through 24 statements compiled by Peer Leaders over the years. Similarly to the second section of the survey, a Likert scale of 1-5 was also used, and space was provided for any additional comments.

Results

Demographic Information

Of the total 36 respondents to the survey, 19 were female (53%), and 16 were male (44%), and one respondent did not answer this question (Table 1). Sixteen respondents (44%) are the first in their family to attend college (Table 2). For 14 respondents (39%), the primary language spoken at home is more often a language other than English (Table 3). Those languages include Spanish, Chinese, Bengali, Haitian Creole, Serbian, French, Yoruba, and Hokkien (a Chinese dialect). English is the primary language for ten of the respondents (27%), while English and another language are spoken at home by 12 respondents (33%).

Table 1. Current Peer Leaders and Graduates – Gender

Gender	Current Peer Leaders	Graduated Peer Leaders
Male	16 (59%)	3 (33%)
Female	11 (41%)	3 (33%)

Table 2. Current Peer Leaders and Graduates – First in Family to Attend College

	Current Peer Leaders		Graduated Peer Leaders	
	Yes	No	Yes	No
First in family to attend college	14 (52%)	13 (48%)	2 (22%)	7 (78%)

Table 3. Current Peer Leaders and Graduates - Language Spoken at Home

	Current Peer Leaders			Graduated Peer Leaders		
	English only	English and another language	Other language only	English only	English and another language	Other language only
Language spoken at home	7 (19%)	9 (25%)	11 (31%)	3 (8%)	3 (8%)	3 (8%)

Responses showed that 11 (41%) Peer Leaders currently enrolled as students have already obtained an Associate's degree, and they are working toward completing a Bachelor's degree. Three (3) of the respondents already have a Bachelor's degree or are taking science and mathematics courses in preparation for a new career. Of the 27currently enrolled as undergraduates, six (22%) are currently also working, either on or off campus. Over 80% of the Peer Leaders stated that they are interested in attending graduate school.

Of those currently enrolled, almost half of the students are majoring in Applied Mathematics, and a third in Engineering Technology majors. There were a total of ten different majors: from the School of Arts and Sciences: Applied Mathematics, Chemistry Technology, Computer Science; from the School of Technology and Design: Computer Systems Technology, Mechanical Engineering Technology, Electrical Engineering Technology, Civil Engineering Technology, Computer Engineering Technology, Architectural Technology; and from the School of Professional Studies: Accounting. Ninety six percent of the Peer Leaders are STEM majors (Table 4).

Of the nine respondents who have graduated, eight (8) received a Bachelor's degree in a STEM field and one received a Bachelor's degree in a related field (Architectural Technology) (Table 4). All nine are currently working, with six engaged in STEM fields and three of them as teachers. Half of them are in graduate school, and they are pursuing their advanced degrees in a STEM field. Two former peer leaders had already completed their Master's degrees in a STEM area.

Table 4. Number of respondents by majors, degrees, and work in STEM fields

	Current Peer Leaders (N=27*)			Graduated Peer Leaders (N=9)		
	School of Arts & Sciences	School of Technology & Design	School of Professional Studies	Bachelor's Degree Attained	Graduate School	Workforce
Majors	Applied Math: 13 (48%) Computer Science: 1 (3%) Chemical Tech: 1 (3%)	Engineering Technology: 6 (22%) Computer System Technology: 2 (7%) Architectural Technology: 1 (3%)	Accounting: 1 (3%)	STEM field: 8 (89%) Architectural Technology: 1 (11%)	Attending: 5 (56%) Completion of Master's degree: 2 (22%)	STEM field: 6 (67%) Teachers in STEM field: 3(33%)

* two respondents did not respond

More than half (55%) of the Peer Leaders started leading in either their freshmen or sophomore years (Table 5). As a requirement, students must have succeeded in Pre-Calculus (MAT 1375) before they can apply to be a Peer Leader. New Peer Leaders are initially required to facilitate in either Fundamentals of Mathematics (MAT 1175), covering topics in intermediate algebra and geometry, or College Algebra and Trigonometry (MAT 1275).

Table 5.Number of Credits Earned when Students First Served as Peer Leaders

Number of credits when first became a Peer Leader(N=36)	Number of Peer Leaders starting in that year	Current Peer Leaders	Graduated Peer Leaders
Freshman (0-30 credits)	11 (30%)	7 (26%)	4 (44%)
Sophomore (31-59 credits)	9 (25%)	8 (30%)	1 (11%)
Junior (60-89 credits)	2 (5%)	2 (7%)	0 (0%)
Senior (90-120+)	6 (17%)	4 (15%)	2 (22%)
No answer	8 (22%)	6 (22%)	2 (22%)
Total (responding to that question)	36	27	9

The majority of the Peer Leaders have led workshops for the series of foundational mathematics courses, specifically MAT 1175 and MAT 1275 (Table 6).

Table 6.Mathematics Courses in which Peer Leaders Served

Course	Freestanding (Optional)	Current Peer Leaders	Graduated Peer Leaders	Embedded (Mandatory)	Current Peer Leaders	Graduated Peer Leaders
MAT 1175: Fundamental of Mathematics	10	8	2	17	14	3
MAT 1275: College Algebra & Trigonometry	13	9	4	15	12	3
MAT 1375: Precalculus	10	7	3	1	1	

Course	Freestanding (Optional)	Current Peer Leaders	Graduated Peer Leaders	Embedded (Mandatory)	Current Peer Leaders	Graduated Peer Leaders
MAT 1475: Calculus I	7	6	1			
MAT 1575: Calculus II	7	5	2	3		3
MAT 2675: Calculus III	5	5				
MAT 2572: Probability & Mathematical Statistics I	3	3				
MAT 1180: Mathematical Concepts &Applications	1	1				
MAT 0650: Elementary Algebra	1					

The PLTL program at City Tech has expanded to include other STEM courses, including Chemistry, Biology, and Statics (Strength of Materials, in the Civil Engineering/Construction Management department). These workshops are not yet fully embedded in these courses (Table 7).

Table 7.Other Courses (Chemistry, Statics, Biology) in which Peer Leaders Served

Course	Freestanding (Optional)	Current Peer Leaders	Graduated Peer Leaders	Embedded (Mandatory)	Current Peer Leaders
CHEM 1101: General Chemistry I	2	1	1		
CHEM 2223: Organic Chemistry I	1	1			
CHEM 2323: Organic Chemistry II	1	1			
CMCE 1104: Statics I				1	1
BIO 1101: Biology I	1	1			

The number of semesters a student served as a Peer Leader averaged three semesters. However, the range varied from one semester (current semester) to eight semesters with a delayed graduating time. Approximately half of the respondents (18) served for two or more semesters continuously from their first semester on. It can also be said that 50% served with intermittent breaks due to the pressure of other commitments, but returned to being a Peer Leader later in their academic studies.

Word Association

The second section of the survey form focused on words and phrases that were used to describe the experience of leading by former Peer Leaders (Dreyfuss, 2012). The Peer Leaders in that study were first asked what three words described their experience of leading a workshop group. The list of 44 words or phrases was grouped in this study into categories based on commonalities: Self-actualization (personal development) (18 questions); leadership (9 questions); rewards (8 questions); and feelings (9 questions).

Respondents strongly agreed with 16 of the 18 words regarding self-actualization. The strongest agreement of words describing the peer leading experience were the following: Responsibility (4.60), helpful (4.55), motivation (4.44), and leadership (4.44). Respondents found leading to be satisfying (4.38), challenging (4.36), satisfactory (4.33), self-exploratory (4.32), enlightening (4.32), where punctuality (4.32) and enthusiasm (4.32) were important. They also found confidence (4.29), insight (4.18), courage (4.14),

strength (4.14), and excellence (4.00) to be important (Table 8). The words describing *leading* had used either a noun or adjectival form.

Table 8. Ranking of Self-actualization Descriptors (18 questions)

Word or phrase	Mean response* (n=36)	Current Peer Leaders	Graduated Peer Leaders
responsibility	4.60	4.68	4.38
helpful	4.55	4.65	4.25
motivation	4.44	4.50	4.13
leadership	4.44	4.60	4.14
satisfying	4.38	4.36	4.50
challenging	4.36	4.52	3.86
satisfactory	4.33	4.46	3.63
self-exploratory	4.32	4.60	3.50
enlightening	4.32	4.46	3.86
punctuality	4.32	4.38	4.13
enthusiasm	4.32	4.36	4.25
confidence	4.29	4.38	4.00
insightful	4.18	4.48	3.86
courage	4.14	4.23	3.86
strength	4.14	4.23	3.86
excellence	4.00	4.12	3.63
authority	3.64	3.77	3.25
strictness	3.51	3.61	3.14

* Scale of 1= strongly disagree to 5=strongly agree

The two words receiving the lowest aggregate scores, denoting weaker agreement were authority (3.64) and strictness (3.51). These two descriptors speak to an authoritarian "leadership" aspect of being a Peer Leader. These attributes may be needed under some circumstances as suggested by the values over 3.5.

The word associations for self-actualization attributes suggest that working as a Peer Leader improves one's self-value, ranked as a sense of responsibility, helpfulness, motivation, and even punctuality. These attributes may be said to help shape Peer Leaders into valuable candidates in the fast-paced working environment where team-working skills are valuable and appreciated.

Respondents agreed strongly with five of the word or phrases describing leadership attributes (Table 9). The words receiving the highest aggregate scores, denoting strongest agreement were the following: Teamwork (4.64), communication (4.55), guide (4.42), preparation (4.20), and adaptability (4.17). These attributes of working as a team, communicating, serving as a guide, being prepared, and being able to adapt all point to interaction as the focus of the workshop session. They also promote teamwork, communication and adaptability skills, providing a baseline experience for serving as a leader in other environments.

Other responses are autonomy (3.93), acting as catalyst (3.85), acting with "different faces* (3.50), and acting as older sibling (3.41). What is interesting about the last three phrases is that these are metaphors for the experience of leading by Peer Leaders (Dreyfuss, 2012), and there appeared to be some understanding of the sense of the metaphor by better than average responses. However, these metaphors need a better sense of attributes to define the experience, as well as testing Peer Leaders' understanding of these metaphors as defining their experiences.

Table 9.Ranking of Leadership descriptors (9 questions)

Word or phrase	Mean response* (n=36)	Current Peer Leaders	Graduated Peer Leaders
teamwork	4.64	4.77	4.25
communication	4.55	4.65	4.25
guide	4.42	4.50	4.14
preparation	4.20	4.30	3.86
adaptability	4.17	4.27	3.86
autonomy	3.93	4.08	3.43
acting as a catalyst	3.85	3.73	3.50
acting with different "faces"	3.50	3.63	3.13
acting as older sibling	3.41	3.73	2.50

* 1= strongly disagree to 5=strongly agree

Respondents agreed strongly with six of the words or phrases regarding perceived benefits or rewards (Table 10). The words receiving the highest aggregate scores, denoting strongest agreement were the following: Sharing (4.61), knowledge (4.58), educational (4.55), experience (4.50), patience (4.50), and informative (4.41). This list also mixes noun and adjectival forms. The themes of interaction and deeper learning are evident, as Peer Leaders must promote sharing of knowledge while knowing the material to steer the discussion through hints and questions. Leading is itself an educational process, as each experience provides a more complete picture of what needs to be done. Leaders also learn deeper content, the processes of leading, how to develop patience, and how to provide space for students' willingness to share their thinking. And since leaders are not supposed to teach, "being didactic" received a lower rating, although it is still sturdy as a practice. The word associations for rewards suggest that working as a Peer Leader is a meaningful job, that the leader can share his/her knowledge benefiting both the leaders and students.

Table 10. Ranking of Perceived Benefits (Rewards) descriptors (8 questions)

Word or phrase	Mean response* (n=36)	Current Peer Leaders	Graduated Peer Leaders
sharing	4.61	4.73	4.25
knowledge	4.58	4.69	4.25
educational	4.55	4.65	4.25
experience	4.50	4.61	4.13

Word or phrase	Mean response* (n=36)	Current Peer Leaders	Graduated Peer Leaders
patience	4.50	4.58	4.25
informative	4.41	4.54	4.13
expectation	3.90	4.12	3.5
being didactic	3.68	3.67	3.75

* 1= strongly disagree to 5=strongly agree

Respondents agreed strongly with five of the words regarding emotional descriptors of the experience of peer leading (Table 11). The words receiving the highest aggregate scores, denoting strongest agreement were the following: Exciting (4.42), interesting (4.38), enjoyable (4.29), fun (4.26), and new (4.00). These attributes of the experience of peer leading are surprisingly positive, denoting an unusual and encouraging experience.

The words receiving the lowest aggregate scores, denoting weaker agreement, were the following: frustrating (2.85), difficult (2.82), scary (2.55), and confused (2.52). There was not a denial that other emotions can be at play, and these dimensions should be probed to determine where the situations causing these feelings arise.

Table 11 .Ranking of Emotional (Feelings) descriptors (9 questions)

Word or phrase	Mean response* (n=36)	Current Peer Leaders	Graduated Peer Leaders
exciting	4.42	4.27	4.00
interesting	4.38	4.46	4.13
enjoyable	4.29	4.36	4.13
fun	4.26	4.32	4.13
new	4.00	4.07	3.75
frustrating	2.85	2.65	3.5
difficult	2.82	2.80	2.86
scary	2.55	2.38	3.13
confused	2.52	2.61	2.25

* 1= strongly disagree to 5=strongly agree

Impact of the Experience of Leading

The statements regarding the impact of the experience were developed by taking selected statements from an end-of-term survey instrument used at City Tech to query Peer Leaders about their experience (see Dreyfuss, Liou-Mark, Bonhomme, & Joseph, 2013).The statements that received strong agreement are presented in Table 12 and the weakest agreement in Table 13.

Table 12. Statements with the Strongest Agreement ranking regarding the impact of the experience of leading

Question Number	Statement	Mean Response* (n=36)
Q. 3	I am motivated to learn more	4.47
Q. 21	I enjoy sharing my knowledge with others	4.40
Q. 12	I enjoy working with teammates	4.38
Q. 4	I understand concepts better	4.36
Q. 5	I have looked at problems from different points of view	4.35
Q. 7	I communicate more comfortably with other peer leaders	4.35
Q. 2	I communicate more comfortably with other students	4.32

* 1= strongly disagree to 5=strongly agree

Table 13. Statements with the Weakest Agreement ranking regarding the impact of the experience of leading

Question Number	Statement	Mean Response* (n=36)
Q. 6	I changed my major	2.11
Q. 19	My career goals have changed	2.83
Q. 15	I'm interested in being a teacher	3.74
Q. 23	I confirmed my choice of major	3.74

* 1= strongly disagree to 5=strongly agree

Peer Leaders are motivated to learn more, understand, and implement concepts and theories. The longer-term impact on Peer Leaders is that they have gained effective communication skills, including the enjoyment of sharing their knowledge with others. These students have not changed their STEM majors, instead confirming their choice of major. Moreover, an interest "in being a teacher" was agreed to favorably.

Discussion

The findings presented in this study profile Peer Leaders who have overcome seeming disadvantages. These include being in the first generation of their family to attend college, and learning and leading in a language not spoken at home. Almost all the respondents are majoring in either Applied Mathematics or an area of Engineering Technology. They have strong mathematical backgrounds, some possibly formed by schooling in another country. Because many began to serve as Peer Leaders in their first or second year of college, there is a continued positive and energetic emotional connection with the position.

With nearly equal numbers of women and men serving as Peer Leaders, it is notable that women Peer Leaders are staying in STEM fields, and the majority (81%) of current Peer Leaders plan to go to graduate/professional school.

The word associations in the four categories of attributes of leading were favorably agreed to by the respondents. The experience challenges the students to envision themselves as a leader and tests how willing are they to take responsibility, to be helpful, and to motivate other students within the structure of the workshop program. The responses suggest that these attributes are sustained from practice and can be valuable in other team-working contexts where such group facilitation skills are valuable and appreciated. This longer-term impact is demonstrated in that Peer Leaders note that they have gained effective communication skills and enjoyed sharing their knowledge with others. This also has the effect of reinforcing their choice of a STEM major. The impact of leading suggests a development of "deep learning" (Marton & Säljö, 1976), as Peer Leaders are motivated to learn more, understand better, and find ways to implement concepts and theories.

Conclusion

Armala and Vala (2009) recommended that "Programs that encourage student leadership should be considered an important aspect of any undergraduate science curriculum" (p. 633). At the 2013 Peer-Led Team Learning International Society Conference, the authors with other City Tech Peer Leaders presented these survey findings. In preparation for their presentation the Peer Leaders agreed on this concluding statement:

> *As Peer Leaders, we found leading PLTL workshops not only helpful with our academics but also with our self-confidence and communication skills. This is important because despite today's technology, social and communication skills are slowly decreasing. As Peer Leaders acquire more experience, they become more comfortable with their role and want to expand to other opportunities. They also receive long-term benefits, such as support to continue with their STEM fields through graduation, and to gain experience in the STEM areas.*

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