



Combining Strategies for Leadership Development of Engineering Students

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Work In Progress: Combining Strategies for Leadership Development of Engineering Students

Abstract

This work in progress reports an intervention to develop leadership skills in engineering undergraduate students. A methodology based on a cognitive apprentice framework was implemented, where coaching, Peer-Led Team Learning (PLTL), cooperative learning, reflection, and self-assessment are combined to train peer leaders from different engineering programs. Students in the PLTL Peer Leaders initiative are low-income academically talented students (LIATS) from a Hispanic Serving Institution (HSI). Early results analyzing post workshop reflections and self-assessment of peer leaders were used to identify changes in leadership skills of peer leaders. This paper reports on the methodology employed and early results from students' reflection and self-assessment.

Introduction

This work in progress describes the implementation of a Peer-Led Team Learning (PLTL) model for students participating in the Program for Engineering Access, Retention, and LIATS Success (PEARLS) which works with low-income academically talented students (LIATS) studying engineering at a Hispanic Serving Institution (HSI). In PLTL, student leaders create and deliver workshops to raise levels of competencies of participating students using cooperative learning, reflection, and peer-to-peer instruction. PLTL was originally developed to focus on teaching technical skills [2], but, in our initiative, it was modified to teach soft skills, such as teamwork, leadership, effective communication, among others. Peer leaders were selected among volunteer students.

A program for LIATS was recently established in the College of Engineering to address the differences between the performance of low-income students when compared with the general engineering population. A cohort of ninety-two (92) students, ranging from 1st. to 3rd. year of study participate in the program. The purpose of this program is to increase retention and improve graduation rates of students from economically disadvantaged communities as well as from underrepresented minority groups. An integrated model, based on Lent's et al. Social Cognitive Career Theory [1], combines several strategies that include faculty mentoring, communities of learners, reflection, apprenticeship, peer-led team-learning, and cooperative learning to target attrition and improve graduation rates.

Peer-Led Team Learning

The Peer-led Team Learning model [2] was created to address retention and enhance in-depth knowledge of students in chemistry courses. In PLTL student leaders are trained to teach other students the core or fundamental concepts in a course. Students who have done well in previous courses are selected to be peer leaders and to run weekly workshops on fundamental topics in a course. Leaders are trained in pedagogy, teaching strategies, cooperative learning, and active learning and collaborate closely with faculty members in the creation and delivery of the

workshops. Peer leaders keep a reflective journal to discuss what worked well and what did not work at the sessions. Entries are posted after each session [2].

Essential elements of the PLTL model are: (1) a peer leader must run weekly workshops; (2) the faculty teaching the course is closely involved in the creation of the workshops and in supervising leaders; 3) peer leaders are students who have successfully completed the course in the previous semester and are well-trained; 4) workshop materials should be challenging and encourage active learning in cooperative learning groups [3]; 5) small group size, space, and teaching should promote learning; 6) the institution should support these pedagogies at all levels [2].

The literature has shown that the use of PLTL increased participant student achievement, attitude, and self-concept [4], increased performance in the course [5], as well as improved critical thinking skills [6]. On the effect of PLTL on peer leaders, literature has shown deepened knowledge of subject matter [7, 8, 9], improved communication skills [7, 9], increased academic performance [5, 8, 10], increased critical thinking skills [5], increased confidence and perseverance [7, 5, 11], and appreciated intellectual diversity [8, 12]. It also shows that leaders self-evaluate as having improved leadership skills [9]. Despite this, we have found little evidence on how core leadership skills are developed under PLTL and we wanted to understand the effect on the peer leaders.

Research questions: How are core leadership competencies developed by PLTL? Which leadership model best describes peer leaders gains in leadership skills?

We intend to explore which leadership model best describes the development of core leadership competencies of peer leaders. So far, the analysis of narrative and self-evaluation have been used to identify patterns. However, we are still initiating the evaluation of leadership models that best describes the leadership gains of peer leaders based on their reflection's narratives.

Implementation of PLTL at the PEARLS Program

The selection of peer leaders was done by an open call for participation. Ten (10) engineering students, from different engineering programs, answered the call to serve as peer leaders without any compensation, volunteering their time and effort. All were selected to be trained as peer leaders. Training was held for two days. On day one, peer leaders were trained on cooperative learning [3], working with diverse teams, creating active learning activities, and asking questions. They were given a set of possible, difficult situations to train them on how to react to challenges. The next day, faculty members were trained on PLTL, and the peer leaders who were trained the previous day practiced by training faculty in a formal workshop.

Afterwards, leaders met with the PLTL coordinator to decide on the subject matter to cover in the PLTL workshops. The two selected subjects were *Resume Building* and *Creation of E-portfolios*. They had already received a training on resume building and the creation of e-portfolios, and the goal was to help other LIATS to complete theirs. Two planning sessions were held previous to each session to decide on logistics, contents, and practice. Then all the students participating in the PEARLS Program were equally distributed among the ten peer leaders.

Training the leaders was done using a cognitive apprenticeship framework, as it works well with PLTL [13, 14]. PLTL is rooted in Vygotsky's zone of proximal development [2]. Here the PLTL coordinator models behaviors for the PLTL leader to follow, providing possible scenarios, practicing cooperative learning elements and using vocabulary according to context. The role of the PLTL coordinator is to observe the group interaction while allowing students to generate their own knowledge on how to teach the concepts and will intervene only when needed.

After each training session, peer leaders were asked to write a two-page reflection on what worked and did not work in their groups, in planned activities, and logistics. There was no time limit for the reflection. According to Mezirow [15], reflective thinking is considered a learning tool that promotes higher thinking skills and deep learning among adults. Prompt questions were the following: 1) How was the process to create the session? What worked and what did not work? 2) How was the participation in the session? What worked and what did not work? 3) How was the delivery of the session? What worked and what did not work? 4) How was teamwork of the PLTL leaders? Communication? What worked and what did not work? 5) Did you learn something, developed some skills? Others? 6) General comments.

The implementation of the PLTL initiative started during the 2019 Fall Semester and will continue for the five-year extension of the program. We will be able to eventually answer the research questions as the students continue to participate in the program. In this work in progress, we report the initial findings from a one-semester experience.

Methodology and Early Results

Nine out of ten leaders participated in the reflection process. Content analysis of the narratives written by PLTL leaders were analyzed to find common themes among respondents. For the first session, 'difficulties for accommodating to each other's work styles' emerged as a common theme. Presentation skills were improved, communication improved, and leaders expressed that they learned about teamwork and how to mentor others. They were not effective in convening the students; therefore, few students attended sessions. Difficulties in planning and finding available rooms was a hurdle commonly reported among the leaders. This hinted at difficulty on managing ambiguity. For the second session, leaders were more comfortable with each other and with teamwork, and group dynamics improved, as well as student's attendance. Leaders expressed that sessions were more successful, and there was an increase of ideas exchange. Engagement of students in the sessions emerged as a common topic. They reported having improved their mentoring, planning, and communication skills.

The first model of leadership we have applied to map peer leaders' narratives was Goleman's emotional intelligence leadership model. Goleman [16, 17] defines five dimensions of emotional intelligence (EI) that impact leadership skills: self-awareness, self-regulation, motivation, empathy, and social skills. Persons who improve those five aspects present better teamwork, improved time management, and increased motivation. We wanted to identify if there were positive changes in peer leader's behavior from conducting the first two PLTL sessions. After each session, peer leaders wrote their reflections. Before the third workshop, a self-assessment questionnaire was completed by peer leaders. In the self-assessment questionnaire of peer leaders, a retrospective pre-post technique was used to explore perceived change in Goleman's

leadership dimensions. The assessment technique employed collects the data in a posttest, but asks for pre-test data as well, to eliminate the impact of response shift bias [18].

Eight (8) of ten leaders filled out the emotional intelligence self-assessment questionnaire. This questionnaire includes 23 statements representative of Goleman's dimensions. For each item, peer leaders were asked to assess how they felt 'Before' and 'After' participating in the PLTL experience. They were asked to use the following scale: 1 = Poor, 2 = Need improvement, 3 = Adequate, 4 = Good, and 5 = Very good.

Table 1: Items with the highest and lowest mean score differences

Item	Mean before PLTL	Mean after PLT	Difference
I trust myself	2.50	3.75	1.25
I recognize how to reinforce and the development of the members of my team.	2.63	3.75	1.13
I have persistence in attaining my goals despite of obstacles	2.75	3.75	1.00
I have a commitment with a task, group or organization.	3.88	4.00	0.13
I am sensible and I understand the perspective of other persons	4.13	4.25	0.13
I recognize diversity as an opportunity	4.38	4.5	0.13

Conclusion

This work in progress presents an early analysis of how leadership skills emerge when combining Peer-Led Team Learning (PLTL), cooperative learning, reflection, and a cognitive apprenticeship model to develop peer leaders participating in a LIATS program. The combination of these methodologies show early progress in the development of leadership competencies described by Goleman in his emotional intelligence model [16]. Before participating in the program, PLTL leaders reported having poor or very little confidence in themselves as leaders, and, from the PLTL experience, they self-described as sure of themselves and motivated to reach set goals.

We were able to provide early answers to the question: How are core leadership competencies developed by PLTL? But the question: Which leadership model best describes peer leaders gains in leadership skills? will remain the focus of future inquiries during the five-year extension of the program. Peer leaders will continue to provide workshops to the participants of the PEARLS program as we continue to explore which patterns surface and which theories of leadership best describe their behavior as leaders.

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References

- [1] R. W. Lent, S. D. Brown, and G. Hackett, G., "Social cognitive career theory", *Career choice and development*, vol. 4, pp. 255-311, Oct 2002.
- [2] D. K. Gosser, M. Cracolice, J. A. Kampmeier, V. Roth, V. S. Strozak, and P. Varma-Nelson *Peer-led team learning: A guidebook*. Upper Saddle River, NJ: Prentice Hall, 2001.
- [3] D. W. Johnson, R. T. Johnson, and K. A. Smith, *Active learning: cooperation in the college classroom*. Edina, MN: Interaction Book Company, 1991.
- [4] J. Y. Chan and C. F. Bauer, "Effect of peer-led team learning (PLTL) on student achievement, attitude, and self-concept in college general chemistry in randomized and quasi experimental designs", *Journal of Research in Science Teaching*, vol. 52, no. 3, pp. 319-346, Mar 2015.
- [5] A. E. Dreyfuss, and A. Fraiman, "Peer-Led Team Learning: an Active Learning Method for the 21st Century", in *Proceedings of ICERI 2015 Conference*, Seville, Spain, 16th-18th November 2015.
- [6] I. J. Quitadamo, C. J. Brahler, and G. J. Crouch, "Peer-led team learning: A prospective method for increasing critical thinking in undergraduate science courses", *Science Educator*, vol. 18, no. 1, 2009.
- [7] V. Roth and L. Tien, "The impact of the PLTL experience on Workshop leaders: An investigation", in *The Workshop project newsletter. Progressions: Peer-led team learning*, vol. 1, no. 3, p. 1, 2000.
- [8] B. A. Robbins, E. C. Johnson, and M. C. Loui, "What Do Students Experience as Peer Leaders of Learning Teams?", *Advances in Engineering Education*, vol. 4, no. 4, 2015.
- [9] S. Hug, H. Thiry, and P. Tedford, "Learning to love computer science: Peer leaders gain teaching skill, communicative ability and content knowledge in the CS classroom", in *Proceedings of the 42nd ACM technical symposium on Computer science education*, Mar 2011, pp. 201-206.
- [10] J. L. Alberte, A. Cruz, N. Rodriguez, and T. Pitzer., "The PLTL leader boost", in *Proceedings of the Peer-led Team Learning International Society Inaugural Conference*, May 2012.
- [11] L. Gafney, and P. Varma-Nelson, P., "Evaluating peer-led team learning: A study of long-term effects on former workshop peer leaders", *Journal of Chemical Education*, vol. 84, no. 3, pp. 535, 2007.
- [12] E. C. Johnson and M. C. Loui, "Work in progress - how do students benefit as peer leaders of learning teams?" in *2009 39th IEEE Frontiers in Education Conference*, San Antonio, TX, USA, 18-21 Oct 2009, pp. 1-2.
- [13] A. Ghefaili, A., "Cognitive apprenticeship, technology, and the contextualization of learning environments", *Journal of Educational Computing, Design & Online Learning*, vol. 4, no. 1, pp. 1-27, 2003
- [14] A. Collins, J. S. Brown, J. S. and A. Holum, "A. Cognitive apprenticeship: Making thinking visible", *American educator*, vol. 15, no. 3, pp. 6-11, 1991.

- [15] J. Mezirow, J., *Fostering critical reflection in adulthood*. San Francisco: Jossey-Bass Publishers, 1990.
- [16] D. Goleman, "What Makes a Leader?", In *Harvard Business Review on Leadership*, Harvard Business Press, 2017.
- [17] Goleman, D., "Leadership that gets results", *Harvard business review*, vol. 78, no. 2, pp. 4-17, 2000.
- [18] Geldhof, G. J., Warner, D. A., Finders, J. K., Thogmartin, A. A., Clark, A., & Longway, K. A. "Revisiting the utility of retrospective pre-post designs: the need for mixed-method pilot data", *Evaluation and program planning*, vol. 70, pp. 83-89, 2018.