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What Do Students Experience as Peer Leaders of Learning Teams?

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ABSTRACT

In a course for engineering freshmen, peer leaders facilitated optional study sessions, which implemented peer-led team learning workshops. Some leaders were paid teaching assistants, but most were undergraduate volunteers. To understand the experiences of the peer leaders, we asked them to keep weekly reflective journals. By performing a basic qualitative analysis of fourteen journals from two semesters, we developed a description of the experience of leading peer-led team learning workshops over the course of the semester. At the beginning of the semester, the leaders were apprehensive about teaching and concerned with correctly answering students' questions. As the semester progressed, the leaders were often frustrated with the difficulty of teaching, and the leaders tried new ways of encouraging student participation. At the end of the semester, the leaders reported that they increased self-confidence, developed an appreciation for intellectual diversity, and gained an increased interest in teaching.

Key Words: Peer-led team learning, qualitative analysis, reflective journals

INTRODUCTION

In peer-led team learning (PLTL) (Gosser et al. 2001), permanent learning teams of six to eight students meet weekly for 90 to 120 minutes to collaborate on difficult, open-ended problems. The

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problems emphasize conceptual understanding of lecture topics, and their solutions require the effort of the entire team. Students work actively on these problems and are not provided worked examples. The learning teams are facilitated by a peer leader, typically an undergraduate student who recently completed the course. The peer leader serves as a facilitator, not as a content expert. The role of the leader is to guide the team's efforts. The leader helps the students develop their solutions, understand the concepts, and justify their problem solving techniques.

While PLTL is intended to promote the learning of the participating students, PLTL sessions are an important experience for another group of students: the peer leaders. Many PLTL leaders are undergraduates who recently completed the course. For these students, serving as a PLTL leader is their first college teaching experience, as well as an early collegiate leadership experience.

When we implemented PLTL in an introductory engineering course, we asked the peer leaders to keep weekly reflective journals. Using these journals, we performed a basic qualitative analysis (Merriam 2009). We sought a rich, descriptive understanding of the experience of serving as a PLTL leader. By better understanding the experiences and teaching conceptions of the PLTL leaders, course instructors can maximize the benefits to peer leaders.

Cooperative learning pedagogies have been implemented in a wide variety of contexts, and prior work has shown the cognitive and affective benefits of cooperative learning (Felder & Brent 2007; Millis & Cottell 1997; Prince 2004). PLTL is a particular form of cooperative learning involving permanent, peer-led student teams. Courses in biology (Born, Revelle, & Pinto 2002), chemistry (Tien, Roth, & Kampmeier 2002), computer science (Horwitz et al., 2009; Utschig & Sweat 2008), and engineering (Drane, Micari, & Light 2014; Loui & Robbins 2008; Foroudastan 2009; Pazos et al. 2007; Loui et al. 2013) have implemented PLTL. Generally PLTL sessions replace discussion or recitation sessions, although the PLTL sessions have sometimes been implemented in addition to the normal course sessions.

Whereas these previous studies identified the benefits to participating students, some prior work has identified the benefits to the peer leaders themselves. Gafney and Varma-Nelson (2007) and Hug, Thiry, and Tedford (2011) evaluated the effects of PLTL leadership by surveying a large number of former peer leaders. Surveyed leaders reported that they increased their content knowledge, understood different learning styles, and gained confidence and patience. Although valuable, surveys only partially capture the experience of being a peer leader. The surveys do not help us understand the challenges and experiences the leaders faced in individual sessions. Tien, Roth, and Kampmeier (2004) had PLTL leaders keep journals, which were used to assess the effectiveness of a training course for peer leaders. Previous work by Micari, Streitwieser, and Light (2006) and Streitwieser and Light (2010) investigated the benefits to peer leaders as well as the changes in their teaching styles. They found that the experiences of the peer leaders resembled the experiences of graduate

teaching assistants, and that many peer leaders tended to move from teacher-centered to learner-centered styles of teaching. These previous studies did not address how the experience of leading PLTL sessions influenced the development of the peer leaders and how program organizers could best support the leaders.

PLTL workshops are similar to Supplemental Instruction (SI) workshops (Stone & Jacobs 2006), which also focus on solving difficult problems. Unlike PLTL leaders, however, SI leaders are typically paid undergraduate and graduate teaching assistants who serve as content experts and teach prepared lessons. Stout and McDaniel (2006) found that SI undergraduate leaders improved their mastery of course content, enhanced their communication and leadership skills, and developed professionally.

Another related approach is peer tutoring, which does not usually involve permanent learning groups. Peer tutoring is typically defined as one-on-one interaction between a peer tutor and a student. Peer tutoring programs have been implemented in many subjects and many contexts (Topping 1996). These programs have been effective at improving student attitudes and performance. Beasley (1997) and Roscoe and Chi (2007) studied the benefits of peer tutoring for the tutor. Tutors can show improved mastery of topics, better study habits, and stronger interpersonal relationships. Peer tutoring, however, differs fundamentally from structured approaches such as PLTL and SI, in which permanent groups meet to work on special problems.

Researchers have rarely used reflective journals to analyze the benefits to peer leaders. For the peer leaders, the potential benefits of reflective journaling include enhancing personal development, encouraging self-discovery, and promoting critical thinking (Hiemstra 2001). Using journals, leaders can learn from their experiences through retrospective reflection (Boud 2001). Reflective thinking allows the leaders to identify important events and analyze the significance of these events. For education researchers, weekly entries in journals provide data about how participants' experiences may change over time.

Using electronic journals, this study aims to describe the experience of leading PLTL teams in an introductory engineering course. With weekly entries, the electronic journals enable us to trace the development of the peer leaders across the semester. Due to the reflective nature of journal writing, we can investigate the significance of the PLTL experience for the peer leaders. Specifically, we seek to understand what events the leaders experienced during the sessions, what actions the leaders took, and how the leaders interpreted what occurred during PLTL sessions—in short, how the experience of leading PLTL sessions can influence the development of the peer leaders.

Unlike previous work by Tien, Roth, and Kampmeier (2004), we do not use the journals to assess specific learning outcomes. Our study also differs from previous studies of PLTL leaders, called "facilitators," at Northwestern University by Micari, Streitwieser, and Light (2006) and by Streitwieser

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and Light (2010). Whereas Micari, Streitwieser, and Light gathered data from facilitators through retrospective interviews, focus groups, and surveys, we used reflective journals to collect the self-reported experiences of the peer leaders. Journals can be more effective at capturing the leader's feelings and experiences contemporaneously. Whereas the facilitators at Northwestern received either course credit or a small stipend, the leaders in our program were mostly volunteers. Finally, our program was implemented at a large public university rather than a private one. The results of our study thus complement previous studies of the experiences of PLTL leaders. By analyzing the responses in the reflective journals, we are better able to offer guidance to program organizers based on the specific experiences of peer leaders throughout the semester.

In designing this study, we followed a scholarship of teaching and learning (SoTL) process (McKinney 2010; Savory, Brunett, & Goodburn 2007). We did not start with a theoretical or conceptual framework such as teaching self-efficacy (DeChenne, Enochs, & Needham 2012). Instead, as in other SoTL studies, we collected and analyzed the reflective journal entries that the peer leaders wrote as standard academic assignments.

IMPLEMENTATION OF PLTL

Beginning in Fall 2007, we implemented PLTL in a gateway course for freshmen (first-year students) majoring in electrical and computer engineering or in general engineering (systems engineering). Approximately 250 students enroll each semester. The course introduces a broad range of electrical and computer engineering topics, including circuits and digital systems. The topics covered in lecture are directed towards the design of an autonomous vehicle in the laboratory (Uribe et al. 1994). We implemented PLTL in our course using optional workshops called "supervised study sessions" (SSS). Since our PLTL sessions were optional for students, our implementation resembles that of Munkeby, Drane, & Light (2005). Students who signed up for the PLTL sessions were assigned to permanent learning teams of six to eight students.

Teams met for ninety-minute workshops on Sunday afternoons or evenings. During the PLTL sessions, each team cooperatively solved difficult problems that were selected by the course instructors. These problems were more difficult than most routine homework problems: their solution required understanding of basic concepts and integration of several ideas. For each problem, the students collaborated to solve a problem at the chalkboard, and the leader facilitated the team effort. The peer leaders encouraged all students to participate, and they continually asked questions to probe students' understanding of fundamental concepts. A full description of our implementation can be found in our companion paper assessing the benefits of PLTL to participating students (Loui et al. 2013).

Peer leaders were recruited before the semester began. A few peer leaders were graduate or undergraduate teaching assistants, who were paid to hold office hours and to grade exams, but the majority were undergraduate volunteers. These volunteers were recruited from students who had excelled in a previous offering of the course. After the first semester of our PLTL implementation, the undergraduate volunteers were drawn largely from previous participants in the PLTL program.

Each semester, new peer leaders attended a mandatory half-day training seminar. This seminar introduced the fundamentals of the PLTL model, explaining the leaders' role and incorporating a mock PLTL session. The seminar also provided practical guidance for the new leaders, as well as a forum for leaders to discuss problems that they anticipated.

After selecting leaders, we assigned each leader to a learning team and placed two teams in each classroom. Whenever possible, we paired each new, inexperienced leader with a leader who had previously led PLTL teams. Although the teams shared a room, each worked separately at separate chalkboards. Peer leaders were responsible for administrative duties, such as recording student attendance.

To support the peer leaders, a graduate teaching assistant or course instructor conducted weekly enrichment meetings. The weekly meetings were devoted to overviews of ideas about college teaching (Roth, Goldstein, & Marcus 2001), such as Perry's model of student intellectual development (Felder & Brent 2004; Perry 1999) and Grow's model of self-directed learning (Grow 1991). These meetings also provided an opportunity to distribute materials, to review the key concepts, and to discuss any problems that the leaders were having. Another resource for the peer leaders was their fellow leaders. Because experienced and inexperienced leaders were paired, each new leader had a potential mentor.

Additionally, we provided a suggested structure for PLTL sessions, and a set of activities to help leaders throughout the semester. We recommended that the leaders assign students to standard roles: one student would serve as a chalkboard scribe while two students served as designated questioners. The other students would then solve the problems. These roles would rotate with each problem. Leaders were encouraged to adapt this structure to fit their teams. We also provided leaders with a team charter exercise for the beginning of the semester and a plus-delta exercise for the middle of the semester (Smith 2007). These exercises were intended to help peer leaders improve team cohesion and communication.

Overall, our implementation of PLTL differed from most PLTL implementations. Due to scheduling constraints, we implemented PLTL workshops as optional sessions. Unlike other PLTL implementations, a majority of our leaders were volunteers. We surmised that motivated volunteers could make excellent leaders and could serve as role models for students.

METHODS

Electronic Journals

In the spring and fall semesters of 2008, we encouraged the peer leaders to keep reflective journals, writing for 15 to 30 minutes after each session. The prompts suggested that they consider how the session went, what met and what did not meet their expectations, and what would they do differently at the next session. For the final journal entry, we provided the leaders with the following prompts:

- In what ways did the supervised study sessions meet your initial expectations? In what ways did they differ?
- In what ways did leading the sessions benefit you?
- How has your understanding of teaching and learning changed? What aspects of your understanding have not changed?
- How did leading the sessions affect your understanding of the technical material (circuits, digital systems, etc.)? For what reasons? Please give specific examples.
- What do you still want to learn more about teaching and leadership?
- How might your experiences as a session leader affect your future studies and career?

We chose these prompts primarily to enable the peer leaders to learn from their experiences, and only secondarily to gather data for research purposes. Although most prompts were worded neutrally, one prompt suggested that the peer leaders had benefited from the sessions. The specific wording of these prompts may have influenced the responses.

Before collecting the leaders' journals, we received approval from the local Institutional Review Board (IRB #08262). We informed the peer leaders about the research goals of keeping journals, and leaders who elected to submit journals were assumed to have consented. Leaders submitted their journals to a third party who removed all identifying information.

In Spring 2008, seven of twelve peer leaders submitted reflective journals. In Fall 2008, six of thirteen peer leaders submitted complete journals, and one submitted an incomplete journal. In the following sections, leaders from Spring 2008 are identified as Leaders 1 to 7, and Fall 2008 leaders are identified as Leaders 8 to 14.

In Spring 2008, out of twelve leaders, three were women, and three were international students. In Fall 2008, out of thirteen leaders, three were women, and five were international students. In each semester, approximately half of the peer leaders already had experience leading PLTL workshops. Because the journals were submitted anonymously, we do not know which journals correspond to which students.

Basic Qualitative Analysis

We seek to construct a detailed description of the experiences of peer leaders in an introductory engineering course. Specifically, we hope to understand what events and behaviors the leaders experienced, what actions the leaders took, and how the leaders interpreted what occurred during the PLTL sessions.

The authors of this paper were closely tied to the course. One author served as an undergraduate teaching assistant, and another served as a graduate teaching assistant; both also served as peer leaders of learning teams. One of the authors was a faculty member who taught the course lecture sections in the fall semesters, introduced the PLTL model to the course, and regularly taught the PLTL training sessions.

To conduct our analysis, we adopted a post-positivist epistemological perspective, seeking an accurate description of the PLTL experience for the peer leaders. To describe the experience of PLTL leaders, we performed a basic qualitative analysis (Merriam 2009) on the fourteen journals. As Merriam (2009) states, "qualitative researchers conducting a basic qualitative study would be interested in (1) how people interpret their experiences, (2) how they construct their worlds, and (3) what meaning they attribute to their experiences. The overall purpose is to *understand* how people make sense of their lives and their experiences."

Two authors conducted the initial analysis of the electronic journals. To begin the analysis, we independently read through the leaders' journals in detail. Each author highlighted passages of interest. After this first reading, we then highlighted specific statements corresponding to student behaviors, leaders' actions, and leaders' interpretations and understanding. Independently, each author generated a list of students' behaviors, leaders' actions, and leaders' interpretations and understandings of the PLTL sessions. Each author then summarized the lists into statements and categories. Next, the authors met to compare the category lists. After in-depth discussion, the categories were combined into an agreed upon list. This list formed a coding table for the electronic journals.

Using this combined table, the authors again independently highlighted journal quotations corresponding to the different categories. The authors then met to check the codings, discussing and resolving discrepancies as necessary. The final inter-coding agreement was above 90%. The third author then independently read the journals and independently assessed the coding. The assessment by the third author was to improve the credibility and dependability (internal validity and reliability) of our analysis, consistent with our post-positivist orientation. For the second stage, the authors used the coding to create frequency counts of phenomena.

RESULTS

The qualitative analysis of the electronic journals revealed the difficulties and challenges faced by the peer leaders throughout the semester. Using the weekly entries in the electronic journals, we

were able to chart a typical path of development for the peer leaders. Finally, the reflective nature of the journals allowed us to explore the self-identified benefits to the peer leaders.

In the Beginning

Leading a PLTL session was an early leadership and teaching opportunity for many PLTL leaders. Initially they were unsure of how their role as a leader in the PLTL model would work in practice. They were concerned with their perceived inadequacies as a teacher and as a content expert.

Leader 11, Week 1

This being my first session, I was a bit nervous about handling it.

Leader 3, Final Entry

I was originally afraid to make a mistake or lead the students in the wrong direction.

In these example quotations, the leaders expressed their initial concerns: telling students the correct answers and avoiding mistakes.

Leaders were also concerned about how they would be perceived by the students.

Leader 5, Final Entry

This semester I was a freshman just like the students. They were actually surprised when they learned this about me and I wonder if it affected their perception of me (maybe negatively?). Next semester this will no longer be the case . . . Is this good or bad?

The leaders wanted to be perceived as reliable sources of knowledge because the leaders did not yet fully understand their roles in practice. The leaders were familiar with the PLTL model through either their previous experience or the leader training session. In practice, however, the leaders were apprehensive about working with a new team and unsure about how to work with this new group. In the authors' experience with the leader training workshop, most new leaders were concerned about what to do if a student asked a question that that they could not answer, and they were also worried that they might direct the students to solve a problem incorrectly.

The initial concerns of peer leaders resembled the concerns of new graduate teaching assistants (Nyquist & Wulff 1996). Graduate teaching assistants focused initially on their ability to answer questions and to control a classroom. Despite having different backgrounds from graduate teaching assistants, PLTL leaders expressed similar concerns. This finding confirms a finding of Micari, Streitwieser, and Light (2006), who also found that PLTL leaders expressed concerns that mirrored those of graduate teaching assistants.

Difficulties During the Semester

As the semester progressed, leaders faced a variety of challenges, some anticipated and some unanticipated. Even though students were expected to attend every PLTL session, the sessions had

fluctuating attendance. Attendance was affected by external factors such as exams, the weather, and even Super Bowl Sunday (as the sessions were held on Sunday afternoons and evenings).

Leader 9, Week 4

The low attendance spell continues. I feel like this semester's group is a lot less cohesive than last semester's . . . I don't have a reason for this—it doesn't seem like I'm doing anything differently.

The leaders reported poor student preparation and participation. All leaders encountered uncooperative and unprepared students. Some students did not participate in the team problem solving. Some students refused to work with the team and instead worked individually.

Leader 7, Week 5

The study sessions tonight were a bit frustrating . . . it was obvious that, in addition to ignoring my questions, most of the students had not taken time to prepare for the sessions.

Leader 8, Final Entry

I joined [the PLTL sessions] when I took [the course]. At first, I thought I can apply what my supervisor [previous peer leader] at that time did to my group . . . but I cannot do it in my group. I tried several times, but it fails, they don't really like to do [work at the chalkboard].

These difficulties caused some leaders to doubt the effectiveness of their methods. In the excerpt above, Leader 9 was unsure which action (or inaction) produced low attendance. Leader 7 expressed concern over student preparation when students ignored the leader's review questions. Leader 8 found that the same techniques did not work with a new group.

As the leaders encountered these challenges, they realized that their initial concerns were less relevant. These challenges did not arise because the leaders did not understand the technical material. As the semester progressed, the leaders were more concerned with motivating students, encouraging groups to cooperate effectively, and ensuring all students benefited. The leaders took different approaches to try to address these challenges.

Leader 8 took a hands-off approach and allowed the students to decide the format of the PLTL sessions. This leader found that the team did not feel comfortable working together, and the leader was unable to get the students to volunteer suggestions. Students would often work individually on the problems then compare solutions.

Leader 8, Final Journal Entry

They don't really like to [work at the chalkboard]. I think they are too shy and think that they have to finish what they have in the handout first before coming up [to the chalkboard] (although I told them that it's not necessary).

The leader allowed the students to work individually because students were reluctant to collaborate. According to the PLTL model, however, this format did not maximize student benefit. Struggling students were not able to observe the thinking that goes into solving the problems, and

successful students did not enhance their own conceptual knowledge by explaining problem solv-ing methods to others.

Leader 5 took a didactic approach, responding directly to student questions and even solving problems for the students. Leader 5 reported the disadvantages of this approach during the PLTL session just before the second course exam.

Leader 5, Week 6

I noticed that when I'm explaining how a problem is done the students don't really stop and ask questions because they're busy copying down the correct work rather than trying to understand why the correct answer is what it is. Asking them questions like "why is this right?" or "where should I go from here?" is probably a good way to do it from now on.

This leader described an extreme example of the direct approach. The leader essentially ignored the PLTL model and told the students how to solve problems. The leader noticed the difference in approaches and decided to focus on facilitating group work after week 6. In other meetings, leaders reported that students were unable to begin any of the problems for a given PLTL session, so the leaders had to intervene by directing the students. Experimenting with different methods helped leaders find a balance between helping struggling students directly and encouraging the students to work as a team.

Leader 7 explored both acting directly to answer questions and allowing students to struggle towards their own solutions. In week 5, Leader 7 reported an effective compromise between the two approaches.

Leader 7, Week 5

A few students continually turned to ask questions [of me]. I reminded them that I was just here to supervise, and they should ask their fellow team members. These students still seemed reluctant to speak up in front of the group. I tried to ease the situation by asking one of the students to explain to the group how they went about doing the problem. The timid students seemed more likely to ask follow up questions than to pose an initial question.

Leader 7 exemplified the PLTL model, taking action to improve communication between students and to encourage student collaboration. Leaders needed to explore different methods in order to understand how the PLTL model can work in practice. For many leaders taking the direct approach, an alternative would be to employ the ideas of cognitive apprenticeship (Collins, Brown, & Newman 1989). In cognitive apprenticeship, the leader would begin a session by working through a problem with the students, explaining the thought process to solving the problem. For subsequent problems, the leaders would take a decreasingly active role, as they guided the student' efforts to solve the problems. By the end of the session, the students would be able to approach the problems on their own, with the leader serving as a facilitator. Experimenting with different ways to manage teams was an important part of developing as a peer leader.

The End of the Semester

In the last few weeks of the semester and during the final journal entries, the leaders began to express explicitly or demonstrate implicitly how they understood and interpreted their experiences leading PLTL sessions.

Recognizing limitations and increased self-confidence

Although the peer leaders need not serve as content experts, they should have mastered the material in order to provide meaningful guidance and to understand students' different approaches to solving technical problems. In addition to technical knowledge, leaders should possess strong communication and interpersonal skills to ensure the team collaborates effectively. Ten leaders reported that their own technical knowledge or interpersonal skills were limitations during at least one team meeting.

Leader 5, Week 11

I couldn't answer the students' questions. I was poorly prepared for this study session because of an important exam . . . this was poor planning on my part . . .

Leader 3, Week 8

I feel like some work could be done discussing/solidifying this concept, or at least clearing it up. I myself feel like I never truly learned this concept, and I made that clear to the students.

These leaders faced their personal limitations and admitted their faults in front of the team. The leaders discovered first-hand, however, that recognizing their limitations was not disastrous. The leaders simply admitted the limitation and continued leading the session. This admission is an important developmental step for the leaders, and it shows them how to handle themselves under pressure. Because the leaders faced their limitations, the leaders' final reflections expressed increased self-confidence.

Leader 5, Final Entry

Leading the sessions made me more confident about speaking in front of others.

Leader 3, Final Entry

I have gained confidence in my teaching and explanation skills. I was originally afraid to make a mistake or lead the students in the wrong direction, but I found that they weren't too concerned if I had to make a correction, or I took a few minutes to gather my thoughts to explain a concept.

Leader 3's comments are particularly insightful in expressing how peer leaders learned to overcome their initial fears of making mistakes in front of the team. They had to admit their limitations to the team but were able to work through these difficulties.

Appreciating intellectual diversity

Leaders observed and collaborated with students from different backgrounds. The leaders encouraged students to think of new ways to explain concepts and to justify and explain their work. Nine leaders reported examples of intellectual diversity in their teams.

Leader 6, Week 8

Surprisingly enough, the student who normally is behind everyone else was the one who knew how to do all of the problems today. I let him answer the questions and sort of take over my job.

Leader 6, Final Entry

I will remember that each student has his/her own strengths. I think that many people are quick to judge, but the [PLTL program] has taught me that everyone has a hidden talent. I have also learned to encourage students to explain their reasoning.

The leaders experienced the intellectual diversity of their students firsthand. Other leaders found that they needed to understand different perspectives on the same topic in order to explain difficult material.

Leader 1, Final Entry

I often had to reevaluate my understanding of material and look for new ways to explain it to students. If they couldn't understand my way of looking at it, I looked at the material again to find a new way of expressing it.

Leader 7, Final Entry

Since students comprehend knowledge in different manners, it was important to think of multiple ways of explaining concepts.

The leaders learned the importance of multiple perspectives in approaching technical topics. They found that diverse ideas occurred naturally in their teams, so the leaders needed to understand different ways to approach a topic.

Reflecting on teaching

Eight leaders wrote explicit reflections on teaching methods in their journals. During the sessions, the leaders commented on their frustration with their methods and the reactions of the students. After a semester of observing students struggle with advanced skills such as engineering design, leaders demonstrated an appreciation for the difficulties inherent in teaching—difficulties that they had not initially anticipated. The leaders realized that learning involves more than finding the correct answer to a given problem. For instance, students should learn more than how to design a specific kind of digital counter; they should learn how to apply their knowledge to design any digital system.

Leader 2, Final Entry

I better understand how much preparation is involved in being a good teacher.

Leader 3, Final Entry

I still hope to learn how to teach and make sure the work gets done while still making the environment entertaining and welcoming to the students rather than stressful, difficult or confusing.

Leader 6, Final Entry

I have definitely realized that teaching is not as easy as it seems.

The leaders tried different methods to encourage student participation and student understanding. Because some students were unprepared and uninterested, the leaders often found their teaching methods less effective than they had hoped. Leader 9 was particularly insightful.

Leader 9, Final Entry

I'm convinced that the more hands off I am, the better it is for the students. The less 'leading' I do, the more they have to learn for themselves . . . That's what I tried, but that may not have been the way things actually worked out. When a student asks for help, I feel compelled to do so. It seems wrong to leave them with meager hints.

The PLTL model emphasizes active learning for the students and little direct involvement from the peer leader. When students struggled, however, it was difficult for this leader to allow them to continue unproductively. These conflicting forces prompted leaders to reflect on their experiences and to change their methods. Leaders needed patience in allowing students to struggle and judgment in deciding when to intervene.

Despite these difficulties and the leaders' growing understanding of the challenges of teaching, eight leaders expressed an increased interest in teaching positions in the future. No leaders expressed decreased interest in teaching. Some of the leaders said that leading PLTL sessions helped prepare them for a teaching position they were already interested in.

Leader 11, Final Entry

I've wanted to improve education methods and materials. This program has given me a lot of ideas as to how to concretely implement them.

Leader 6, Final Entry

I am now definitely ready to take on more leadership positions. I've always had a love for teaching so I think I will be tutoring/helping with teaching for a long time.

For these leaders, the experience strengthened their interest in teaching. Even more striking, though, were leaders who demonstrated an unexpected newfound interest in teaching.

Leader 2, Final Entry

I discovered that I like teaching and explaining concepts. I think that I am more likely to accept a mentoring position/relationship later in my career.

Leader 3, Final Entry

I have begun to think about the possibilities of being a [teaching assistant] in the future when in the past I felt that I would be too shy to fill such a position.

Leader 5, Final Entry

Graduate school is one of the options I'm considering ... Being a [teaching assistant] was one of the things I used to dread about this, but I'm no longer as concerned about this and I think it may even be enjoyable.

By leading learning teams, these leaders discovered that teaching can be an interesting, enjoyable, and worthwhile pursuit. Leading PLTL workshops gave leaders a chance to explore teaching and leadership skills in a small group setting.

Summary of Findings

During the semester, the leaders encountered many challenges and difficulties. A common problem was student attendance: attendance fluctuated, sometimes beyond the control of the peer leader. Student preparation and participation would also vary. Often, the leaders reported that the students were unfamiliar with the week's topic and completely unable to start solving the problems. These difficulties could prevent the team from following the standard PLTL model. Students would be unable to start towards a solution, instead turning to the leader to directly solve the problems. At other times, students would work on problems independently rather than contribute to the team's problem solving efforts. In short, student teams were sometimes unable or unwilling to follow the standard PLTL model.

When faced with these challenges, the leaders tried different actions. For example, many leaders realized that communication was critical to ensuring student attendance. Sending regular communication and reminder e-mails encouraged students to prepare for the PLTL sessions. When teams found themselves unable to follow the standard PLTL model, leaders adapted and responded in different ways. Some questioned the students, guiding them down the correct path by asking carefully chosen questions. Others initially took a more direct approach, showing the students an example of how to solve a problem. Providing this direct guidance then allowed the students to solve further problems following the standard PLTL model.

The leaders' attitudes towards leading learning teams evolved over the course of the semester. The leaders shifted their focus from overcoming personal shortcomings to helping and motivating students. Table 1 summarizes the development of leaders during the semester. At the beginning of the semester, the leaders were apprehensive and confused about how to succeed as a peer leader. The leaders were also concerned with their own inadequacies and mastery of the course content.

	Beginning	Middle	End
Leaders' Attitude	Apprehensive and uncertain	Frustrated and challenged	Reflective and satisfied
Leaders' Focus	Being a content expert. Knowing answers to questions.	Student motivation, interactions between students.	Benefits to students, finding effective teaching techniques.

Table 1. Development of leaders during the semester.

As the semester progressed, the leaders began to understand the role of the peer leader in practice. The leaders began to succeed as facilitators. At the end of the semester, the leaders recognized the difficulty of their role. They focused on benefits to the students and the effectiveness of different teaching techniques.

Guidance for Peer Leaders and Program Organizers

We have also used the lessons learned from the leaders' journals to identify the best practices for future semesters. By applying these lessons, we hope to enable the peer leaders to run more effective PLTL sessions and also to maximize the benefits to the peer leaders. Critically, the support and guidance provided to the leaders should match the experiences of the leaders over the course of the semester. The leaders need help throughout the semester to develop concrete ways to implement the PLTL model and deal with the challenges that arise throughout the semester. Finally, leaders should be encouraged to reflect at the end of the semester and consider how the PLTL experience may shape their future choices.

Our analysis has revealed a distinct development arc throughout the semester, shown in Table 1. Initially, the new peer leaders need support and reassurance. Simply telling the leaders that they do not need to serve as content experts is not enough to reassure them. We have found several concrete ways to support new leaders. First, we pair new leaders with experienced leaders. The experienced leader serves as a mentor. Although the teams work separately, the new leader has a resource in the experienced leader when difficulties arise. Another technique appropriate for engineering courses is to provide the final numerical answers for the PLTL session problems, such as the value of a voltage or current. The team still needs to apply problem-solving techniques to reach the solution, but the numerical answer gives the leaders confidence that the teams' solutions are correct. Also, reviewing the session topics at the enrichment session can refresh the leaders' understanding and help build their confidence. From these findings, we recommend that the course instructors spend time discussing the problems with leaders, to encourage the leaders to focus on facilitating discussion rather than on determining the answers themselves.

Throughout the semester, leaders face many different challenges. From the journals, we have found that communication is key. It is important to remind the leaders to communicate regularly with their teams via e-mail, to encourage students to prepare. Regular communication also helps build team cohesion. During the PLTL sessions, the leaders also struggled with how to best help stalled teams. According to the journals, the most successful leaders balanced directly helping the students and allowing the students to solve problems on their own. We have found the idea of cognitive apprenticeship (Collins, Brown, & Newman 1989) as an informative way to approach helping struggling students. Following the principles of cognitive apprenticeship, leaders can initially

show the unprepared students how to solve the first problem. The leaders can also explain the key concepts that they apply to solving the problems. After one or two example solutions, the team can then approach the problems with minimal guidance from the leader. From these findings, we believe that instructors should recognize that leaders often have difficulties with students who struggle to follow the PLTL model. Instructors should provide methods for leaders to help guide their students to an effective PLTL model.

At the end of the semester, instructors should encourage leaders to reflect on their experiences. The leaders' journals have revealed that they learned several lessons about teaching and leadership throughout the semester. Encouraging reflection helps the leaders to process and interpret their experiences. For new leaders, peer-led team learning is the leaders' first experience in a teaching role. The journals suggest that this experience has a positive influence on many of the undergraduates, encouraging them to consider further teaching opportunities Instructors should also provide opportunities for leaders to continue their development by allowing them to return as peer leaders or identifying further teaching and leadership opportunities for them. Providing these students with further information on graduate school and teaching careers will also enhance their long-term development.

DISCUSSION

To understand how the peer leaders were changed by the experience of leading PLTL sessions, we can interpret our findings in the context of Chickering's Theory of Identity Development (Chickering & Reisser 1993). This theory proposes seven vectors of development of individual identity for university students. The first two vectors of Chickering's theory are Developing Competence and Managing Emotions. Progress along these two vectors occurred when the leaders reported facing and overcoming challenges while leading the sessions. At the later stages of identity development, leaders progressed along different vectors, including Developing Mature Interpersonal Relationships. Progress along this vector can occur when leaders learn to understand and acknowledge others' viewpoints. We found that leaders learned to appreciate intellectual diversity from leading their teams. Finally, the leaders expressed and increased interest in teaching and graduate school. The PLTL experience of the leaders helped them explore teaching, finding a new interest and purpose in teaching. We believe this interest can be interpreted as development along the vectors of Establishing Identity and Developing Purpose, because the PLTL experience allowed the leaders to explore teaching and to take a leadership role in the process of education. Since we do not have multiple journals across multiple semesters, we cannot track the long-term progression of leaders along these vectors. However, it seems that many of these experiences helped different leaders progress along different vectors of Chickering's theory,

helping them form their sense of identity. Chickering's theory helps us understand the formative role of leading PLTL sessions and the changes that the leaders' experience.

Prior work on understanding the experiences of PLTL leaders by Micari, Strietwieser and Light (2006) found the leaders perceived an improvement in their conceptual knowledge (cognitive growth), an improvement in their ability to engage with students (personal growth), and professional growth (instrumental change). The results of our examination of the leaders' journals complement their findings. Using a different source of data and a different student population, we found similar benefits to the peer leaders. Moreover, the weekly journal entries enabled us to understand how leaders' experiences and perceptions changed over the semester.

Streitwieser and Light (2010) focused on how the leaders' teaching styles changed and evolved. They found peer leaders were broadly divided into teacher-centered and learner-centered teaching frameworks. The peer leaders in their study reported difficulty balancing deep discussions of conceptual topics and basic review of problems. Participating students could not or would not participate in conceptual discussions, focusing instead on solving specific, exam-like problems. The leaders in our study reported similar difficulties in balancing the needs and desires of students. Streitwieser and Light suggested that this lack of student participation raises fundamental questions in managing a PLTL program: How should leaders deal with students who are unwilling or unable to engage in deep conceptual conversations on the course topics? How should PLTL program organizers prepare peer leaders to respond to student resistance? We have found the cognitive apprenticeship model (Collins, Brown, & Newman 1989) to be a useful framework for peer leaders to help students in these situations. Further work will be needed to address this fundamental question of how PLTL leaders can best help students move towards conceptual understanding and help them appreciate why conceptual understanding of course material is beneficial.

The reflective nature of journal writing may have played a positive role in enhancing the experience of leading PLTL sessions for the peer leaders. By reflecting on their actions and journaling, the leaders may have learned from their experiences in leading PLTL sessions. In one-on-one peer tutoring, the benefits of tutoring for the tutor (the tutor learning effect) are often underwhelming (Roscoe & Chi 2007). Roscoe and Chi (2007) found that peer tutors have a distinct knowledge-telling bias, focusing on delivering knowledge rather than building it. In our PLTL implementation, by contrast, reflective journal writing may encourage leaders to think critically about their own actions and the process of learning.

Since the prompts for both the weekly and the final journal entries did not imply specific expected benefits, the leaders were not predisposed to report particular events and experiences. Instead, the leaders identified and reported their own ideas about the key experiences. The leaders tended to focus on their own difficulties and their personal responses. Few leaders mentioned personal

fulfillment from helping others, and no leader expressed a feeling of obligation to help others. Leaders may have been too focused on the mechanics of individual team meetings to recognize the broader implications of their actions.

In both the spring and the fall of 2008, the leaders were provided with various supplemental materials on models of student intellectual development, gender and racial issues in the classroom, and group dynamics. No leaders explicitly connected their experiences with these supplemental materials, but their observations do implicitly connect to these materials. For example, leaders were given an introduction to student development using Perry's model (Perry 1999). The leaders observed that students often focused on finding the "right" answer rather than on explaining their reasoning, but the leaders did not explicitly relate students' behaviors to Perry's model of intellectual development. It is unclear from the journals whether the leaders effectively applied the training materials to the workshop sessions.

Limitations

The anonymity of the electronic journals limited us in several ways. We were unable to distinguish reliably between experienced and new leaders. From comments in the journals that refer to previous experiences as a PLTL participant or leader, we believe there is a difference between these two groups but were unable to explore this difference in greater depth. However, since this is a mixed population of PLTL leaders, these results are still interesting and go beyond studies of graduate teaching assistants.

We also cannot assume that our results will apply to any group of leaders or any PLTL implementation. Our peer leaders were mostly unpaid volunteers rather than paid employees. The implementation of PLTL in our course used optional PLTL sessions, so the occasional low student attendance, low student preparation, and problems with student interaction may be unique to this implementation. Since the difficulties and benefits might differ for a different implementation of PLTL, we caution against over-generalization of these results.

CONCLUSIONS

In an introductory course in electrical and computer engineering, we implemented optional PLTL sessions led primarily by undergraduate volunteers. Leaders wrote weekly entries about their experiences in electronic journals. A basic qualitative analysis of these journals yielded a rich description of what the peer leaders experienced and how their experiences changed throughout the semester. Initially, the leaders were apprehensive and worried about their own limitations. Throughout the semester, the leaders faced many challenges and took actions to improve cooperation within

their teams. These leaders reflected on their teaching methods, recognized their own limitations, and began to appreciate intellectual diversity. By the end of the semester, they expressed increased self-confidence and interest in teaching or mentoring in the future.

For courses implementing sessions led by peer leaders, this analysis gives guidance for leader training and support. Initially, the leaders should be supported and reassured. As the semester progresses, the leaders need advice on how to deal with the challenges that arise. At the end of the semester, the leaders should be encouraged to be reflective and think about the lessons they have learned from the experience.

Using Chickering's Theory of Identity Development, we interpreted the PLTL leaders' experiences as progress along the different vectors of identity development. Understanding this process is critical to understanding the benefits of leading PLTL sessions. Leading a PLTL workshop is a formative experience for peer leaders and contributes to their development as individuals.

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ADVANCES IN ENGINEERING EDUCATION

What Do Students Experience as Peer Leaders of Learning Teams?

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