Leadership in Small Online Collaborative Learning Groups: A Distributed Perspective

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Abstract: We examined emergent leadership in small online collaborative learning groups of pre-service math and science teachers. Groups worked online to design interdisciplinary instructional units. We employed a distributed leadership framework (Spillane, 2007) and adapted a coding system previously developed by Li, et al. (2007) to determine that group leadership was highly distributed among participants and to illustrate that leadership emerged through different forms of participation described in this paper. Findings help validate the theoretical concept of distributed small-group cognition and lead to interesting research questions regarding the design and scaffolding of small-group learning online.

Introduction

The nature and quality of leadership in small groups and its effects on group outcomes has been studied for many years by researchers in different disciplines and across many varied contexts and age levels (e.g. Chemers, 2000; Eby 2003; Hare 2000; Kozlowski & Ilgen 2006; Li et. al, 2007; Mumford 2000, Scribner 2007). But the role of leadership within small collaborative learning groups in authentic instructional settings has explicitly been examined very infrequently (Kim et. al, 2007; Hmelo-Silver et al., 2007). That there is little leadership research in small group instruction, despite an enormous literature on peer learning in small groups (O'Donnell, Reeve, & Smith, 2007), is not surprising, because small group instruction is typically scaffolded or scripted (O'Donnell et al., 2007), designed so that students achieve goals without relying on the emergent leadership skills of group members. Yet as emphasis on group cognition increases in the larger world (Stahl, 2006), it becomes increasingly important to understand and develop students' small-group leadership skills as preparation for later life. Moreover, as the need for web-based collaboration accelerates, it becomes increasingly important to understand small group leadership in *online* environments. Accordingly, this study examined the emergence of leadership within five small math-science interdisciplinary teams who collaborated for two months to complete an instructional design assignment made in a learning-science course for advanced pre-service secondary teachers. The teams conducted a large percentage of their work online using a collaborative whiteboard not unlike many commercial whiteboard tools available today. These groups were randomly constituted, received the same general design assignment, used identical technological tools, and were minimally scaffolded as needed by instructors. This setup provided an excellent "natural experiment" enabling us to observe emergence of leadership in small learning groups that experienced varying degrees of success.

Theories of leadership in corporate (Northouse, 2007) and school–administrative contexts (Spillane, 2007) provide useful frameworks for understanding leadership's essential role in small collaborative learning groups. Leadership can be emergent or assigned (Northouse, 2007). It can also be thought of as trait-based (Eby, 2003) or as a set of skills that can be learned (Northouse, 2007). Some perspectives emphasize its situatedness and that some people are more effective leaders in certain contexts (Northouse, 2007). Spillane (2007) proposed a framework of distributed leadership which places leadership, not in discrete actions of and reactions to particular leaders, but in the spread of interactions across group members and tools over time. Adapting Spillane's definition to the small group, we define leadership as distributed activities tied to the core work of groups that are designed by group members to influence the motivation, knowledge, affect, or practice of other members and that are likely understood by group members as intended to influence their motivation, knowledge, affect, or practices. A distributed perspective on leadership links to distributed cognition (Hutchins, 1995; Pea, 1993) and activity theory (Engeström, 1999; Leont'ev, 1981) through an emphasis on interactions among community members and artifacts.

Where leadership has often been conceptualized as residing in one or two people and as being assigned, in this study we hypothesized that leadership would emerge as a distributed and self-organizing entity across group members. We further postulated that patterns in the distribution of leadership behavior would differ for successful versus less successful teams. In addition, based on previous findings from research on collaborative learning that show the influence of status and secondary characteristics such as gender and minority group membership (Chemers, 2000), and roles among participants such as bystanding (Hudson & Bruckman, 2004) or social loafing (e.g., O'Donnell et al., 2007), we speculated that leadership functions would not be distributed equally for all group members, but that different individuals would contribute different amounts and forms of leadership. We also were interested in defining the leadership roles of the instructors: in what ways might they

afford or constrain emergence of student leadership and how did they compensate for leadership weaknesses in groups that struggled?

Methodology

Data Source

Data analyzed in this study were collected with the STELLAR online course development system (e.g., Derry et al., 2005). We examined five interdisciplinary math and science collaborative groups from a learning-science course taught in Fall of 2004 for pre-service teachers at a large Midwestern university. There were a total of 25 students in the class, 8 males and 17 females. Of the male students 3 were science majors and 5 were math, while 11 of the female students were science majors, 5 were math and one was a math and science major. All groups included both majors and both male and female members. The groups interacted primarily through an asynchronous whiteboard where they collaborated for much of one academic semester to design an instructional unit for a topic and grade level chosen by their group. This whiteboard allowed any member of a group to post a proposal for their project. Only the poster could edit his or her proposal, but all group members could comment and suggest edits and rate all proposals. The groups also met face-to-face several times during the activity, but the whiteboard supported much of their work, which occurred largely online between meetings. The whiteboard posts varied widely in length, but a significant percentage of proposals and comments were lengthy and thoughtful. The online course environment provided deadlines, and the setup of the whiteboard interface reminded students to justify their instructional designs with learning-sciences concepts, the main topics of the course. No other interventions were implemented to scaffold leadership in groups other than the instructors' (primarily one teaching assistant) interacting with groups to guide them as needed. Groups completed a problem-based learning (PBL) activity that comprised three iterations, each lasting 2-3 weeks and focusing on a different step of the backward design approach (Wiggins & McTighe, 2005): 1. define instructional goals; 2. develop assessments; and 3. design instructional activities.

Descriptive Data for Groups

While all groups were successful in meeting the collaborative goals of the PBL activity, some groups demonstrated a higher degree of success than others. In table 1 below we approximately organize groups from high (Group 1) to low (Group 5) based on instructors' nomination, average (across iterations) score given for their instructional design projects (PBL score), and average of the group members' satisfaction with the PBL assignment on a scale of 1 – 5, with a rating of 1 indicating high satisfaction. For informational purposes we also include data on individual achievement in the course, although this particular paper focuses only on the product of group cognition. We also supply the total number of valid posts, including comments and proposals, made within each group. "Valid posts" eliminate entries that were made only as result of a student's repeatedly "saving" work being composed online.

Table 1: Group ranked by grades and satisfaction ratings.

	Group 1	Group 2	Group 3	Group 4	Group 5
Average satisfaction rating	1.4	2.0	1.5	1.8	2.5
Average PBL score	97	97	92	90	88
Average Individual score	93	97	90	95	92
Total number of group whiteboard posts	71	105	65	40	40

Coding

All posts to the whiteboard were coded with a set of leadership moves based on a well-explicated framework developed and vetted by Li, et. al (2007) to study the emergence of leadership in children's face-to-face discussion groups. Building on this framework, we adapted our coding categories to better capture the distinct patterns that emerged in our online data and context. Table 2 describes each code and provides an example of a coded post. Entire posts by individual group members were coded; a single post may receive multiple codes. One successful group and one weaker group were first coded and codes were found to have 94% reliability between coders (the authors). The refined framework was then applied by the first author to all posts for all five groups.

Table 2: Coding framework adapted from Li, et. al (2007)

Code	Description	Example

Acknowledge-ment/Affective (A/A)	Positive: Using language in a way likely to motivate or inspire Negative: Using language in a negative or critical way	*-I liked your expanded explanation - it was considerably clearer than mine! Thanks.* *-That sounds whimpy . . .*
Argument Development (AD)	Soliciting reasons, evidence, and clarification from others; extending others' arguments through elaborating on them or making comments about them. Holding group accountable for justifying their reasons.	*Are these final reports done completely individually? What kind of guidelines will the students be receiving-a list of questions that they will answer in essay form? Or something else? And once again, there needs to be better learning science connections.*
Seeking Input (SI)	Looking for general input from other members of the group; seeking help, advice, ideas on the work	*I've tried to clarify the graphic organizer part. If anyone has any other ideas about how to do it, let me know.*
Knowledge contribution (KC)	Contributing academic knowledge - working toward the academic goal of the project by contributing new ideas and extending meaning (ie., from personal reading or research)	*Graphic organizers are a type of assessment that evoke and require student initiative and explicit reasoning...The graphic organizers are also beneficial in having students demonstrating self-knowledge… Wiggins and McTighe point out that "A student who really understands reveals self-knowledge. . . "*
Organizational Moves (OM)	Planning, organizing, monitoring - both whiteboard space and ideas; statements and other moves that provide structure to the situation	*We also might want to split the goals up...assessment and enduring understanding. So specific and general type of shit.*
Topic Control (TC)	Statements that influence the topic of discussion or direction of the work (looking at another side of an issue, getting back to the original topic, taking up a new topic)	*My only comment is regarding what we have seen in the class of teaching to diverse learners. . . How could we expand the assessment to include a larger diversity of students?*

Results/Discussion

Distribution of Leadership

Leadership was highly distributed, with *all* members of *every* group participating in multiple leadership roles. Even in a group (group 1) where a particular leader (A) was essentially elected and remained in that position throughout, leadership was shared among group members. However, group members participated in leadership in very different ways, with some group members avoiding some roles entirely while embracing others. This pattern is illustrated in tables 3 and 4 below, which show the distribution of leadership among group members, including the instructor, for the highest and lowest performing groups.

Table 3: Distribution of leadership moves in group 1(* indicates a female participant)

	A/A	AD	SI	KC	OM	TC
A*	28%	20%	72%	24%	66%	17%
M	--	27%	--	33%	--	17%
B	39%	--	--	12%	14%	--
S	6%	20%	--	15%	3%	17%
E*	--	--	27%	12%	14%	--
Instr.	28%	33%	--	3%	3%	50%
Total Group Moves	**18**	**15**	**15**	**33**	**29**	**6**

Table 4: Distribution of leadership moves in group 5 (* indicates a female participant)

	A/A	AD	SI	KC	OM	TC
K*	--	6%	--	18%	--	--
A*	--	6%	75%	14%	12%	--
J*	22%	29%	--	23%	35%	11%

AH	11%	6%	--	9%	6%	--
C*	11%	12%	25%	27%	12%	11%
Instr.	56%	41%	--	9%	35%	78%
Total Group Moves	**9**	**17**	**4**	**22**	**17**	**9**

Different aspects of leadership had different characteristic patterns of distribution, with some functions (most notably knowledge contribution) being shared fairly evenly across all group members in all groups, but with other functions (most notably seeking input and topic control, but also argument development and organizational management) being dominated by fewer members. These differences are seen in tables 3 and 4.

As illustrated in tables 3 and 4, the instructor shared in specific leadership roles but avoided others, and participated to different degrees with different groups. In the highest and lowest groups, the instructor was a key contributor to topic control, argument development, and acknowledgement/affective moves. In the weaker group, the instructor also played a primary role in organizational management and was responsible for more than half of the group's acknowledgement/affective moves. These trends were also seen in groups 2, 3 and 4.

When the groups were viewed as the unit of cognition without regard to individuals, the distribution of leadership behaviors represented as a percentage of the total number of posts was not obviously different for successful and versus less successful teams (see figure 1). There was a tendency for all teams to devote relatively less time to seeking input from others and to topic control and relatively more time to providing affective statements, contributing knowledge, developing arguments, and organizational management. We did not find evidence that differences in distributional leadership patterns were associated with differences in quality of group product. However, we noted that the gender distribution of participants was highly imbalanced only in the lowest performing group. Higher performing groups demonstrated a higher overall use of the whiteboard.

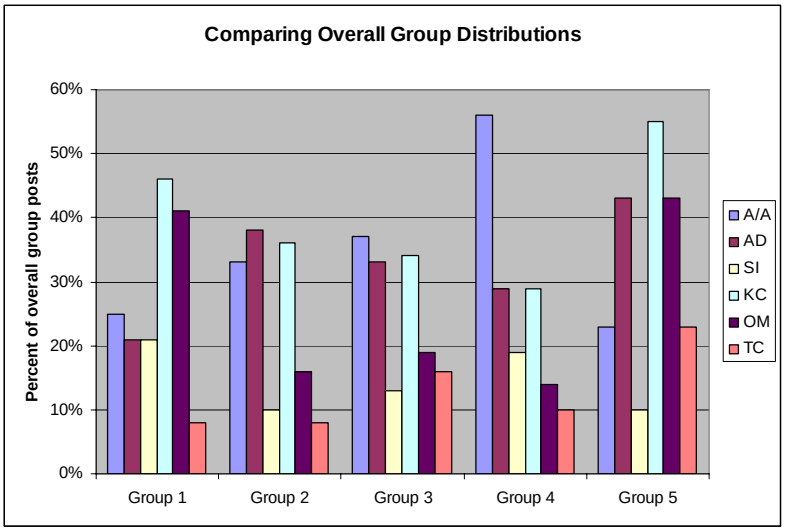

Figure 1. Comparing Within-group Distributions of Forms of Leadership

Different Forms of Leadership are Differently Distributed

Under the distributed definition of leadership we have adopted, the concept of leadership is illustrated by the overall distribution of leadership moves within groups. While we will discuss moves individually, it is important to note that our conception of "leadership" is not characterized in any one move but is distributed among moves between group members. Had we adopted a different definition of leadership, our study may have had a different conclusion about the leadership model we observed.

Acknowledgement/Affective

Acknowledgement and affective forms of leadership were fairly evenly distributed among group members in all groups, with the instructor playing a part in each group. Figure 2 shows a typical within-group distribution for acknowledgement/affective moves that was very characteristic of the middle three groups. All but four students in the class (in groups 1 and 5) assumed this leadership role at some point in their group. With the exception of Group 5 (lowest performing), all of the affective moves by individuals were positive and encouraging. In Group 5, where there were statements of a negative nature, there was a stronger instructor presence in this area, indicating a possible effort to compensate for the students' negative affect.

Seeking Input

"Seeking input" was the least prominent form of leadership. The role of seeking input was primarily assumed by two or sometimes three members of a group. Figure 3 illustrates a typical distribution. While there is some overlap between "seeking input" and "argument development," seeking help from other group members was a student move that the instructor did not make. Females more actively sought input than males; this was the only obvious gender difference and was statistically significant (Mann-Whitney U = 98.5, $p<0.05$).

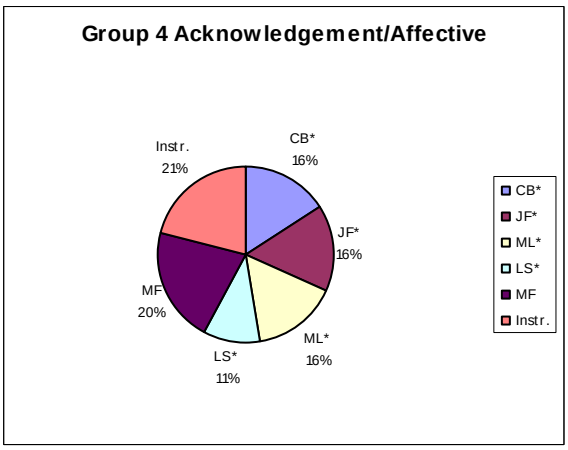

Figure 2. Typical distribution of Acknowledgement/Affective moves

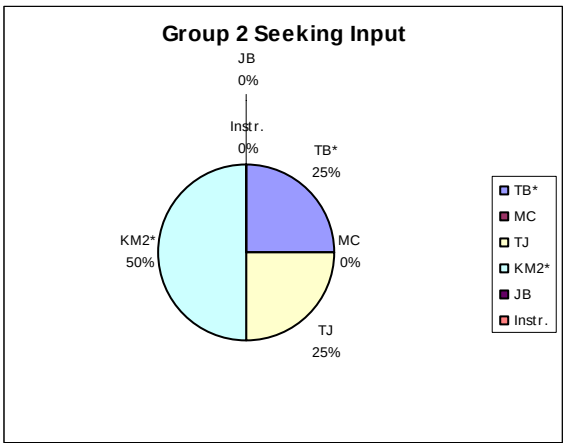

Figure 3. Typical distribution of Seeking Input moves

Argument Development

Argument development was typically demonstrated by the instructor and a few (1-3) members of each team, so not all students actively participated in argument development. The instructor's role ranged from 11 – 50% of a group's overall moves, with fewer moves being made in more successful groups. Examples of how argument development was distributed among group members are illustrated in characteristic distributions shown in tables 3 and 4.

Knowledge Contribution

As group members worked toward their goal, knowledge contribution was an essential component of whiteboard activity in all groups with all members making some contributions (tables 3 & 4 are characteristic distributions). There was one exception in Group 4. In this group, one female member, JF, made no contributions of knowledge despite making other contributions to her group's project. This case is discussed in more detail below.

Organizational Moves

In each team one primary organizational manager emerged. A typical distribution was shown in table 3. This manager organized both the physical whiteboard space and the intellectual ideas of the team. The role of primary organizational manager is assumed by a student in all groups but Group 5, the weakest group, where the instructor took over as the main organizer.

Topic Control

Topic control was primarily exhibited by the instructor (see tables 3 and 4); however, there were two special cases, M in Group 1 and JB in Group 2, where an individual male student assumes this role in conjunction with argument development as a means to influence the direction of the group's final product. In M's case this was to ensure that his content area (mathematics) was adequately represented in the group product, and in JB's case this was to ensure that other group members were making pedagogical choices that were strongly rooted in the learning sciences theory that was the main course topic, and were being sensitive to student diversity. These cases will be discussed in more detail next.

Illustrative Cases

Individuals exhibited different leadership styles, which will be illustrated by two pairs of contrasting cases. The first two are male students, M and JB. Their stories relate to how each similarly used topic control and argument development to influence their group's product. The second set of cases are A and JF, two female students who demonstrate strongly contrasting roles within their groups; A is a strong contributor in all

categories of leadership while JF exhibits some leadership behaviors without actually contributing any knowledge to her group's final product.

Using Topic Control and Argument Development to "Advocate"

In the two groups that we characterized as more successful, a similar pattern of leadership behavior was noticed in one member of each group. In Group 1, M uses argument development and topic control to guide the assignment in the direction of his area of expertise, math. Through making 26% of the group's argument development moves and 30% of their topic control moves, M extended the group's initial proposal and contributed new topics to the group's plan that integrated more mathematical content. The initial project proposed by the group, to develop a middle-school unit to teach understanding the seasons, included primarily learning goals related to science. By using topic control and argument development to advocate for his discipline, M insured that a math-rich lesson evolved. Relevant examples of M's discourse are in table 5 below:

Table 5: Examples of M's use of argument development

I also think that we should teach topics like orbit and other properties of the earth and sun to help the students better understand. We can then combine some more math activities in. Here is a standard that might help…
I do agree with B-- that we may have too many goals for enduring understanding for only a two week lesson. But I feel the math goals are very important and should be included in enduring understanding not just assessment. Especially number 9 and 10!!!

Similarly, JB extensively used topic control in Group 2 to influence the direction of the group's final product. Taking on 40% of the topic control (shared with the instructor), JB repeatedly pushed the group to draw links between the design of the project and the concepts being taught in the course (such as cognitive apprenticeship, scaffolding, transfer), while also advocating for equity issues that the group members had taken up in another course on inclusive schooling. Table 6 provides examples of topic control as employed by JB. In the first example, JB influences the direction of the group's project by questioning whether it is instruction that is appropriate to all learners since the group is considering an assignment and assessment which assumes that all students take vacations over spring break. JB is a minority student, so this is an interesting contribution and the group does reframe their problem based on his leadership. Both examples are typical of JB's constant re-directing of the group's thinking toward the learning-science ideas.

Table 6: Examples of JB's use of topic control

My only comment is regarding what we have seen in the class of teaching to diverse learners. We want to tap on students' prior knowledge and connect the assignment with their life, is it good to assume all of our students take spring-break vacations? How could we expand the assessment to include a larger diversity of students? *I do not think this assessment falls under [the topic of] cognitive apprenticeship.*
For all of us, this activity is meant to provide support to students (scaffold) for their final assessment, but I believe they should be less similar. I think of the final assessment as a problem solving activity in which students need to transfer what they have learned. I would like the activity to be something new, not just an assessment in which students repeat a previously seen activity. Am I missing something here?

Social Loafing or Legitimate Peripheral Participation?

In contrasting the leadership of A in Group 1 with JF in Group 4, we illustrate the nature of strong leadership in a distributed environment (illustrated by A), while observing that even a social loafer can make leadership contribution (JF). A is a strong, active leader who structures the whiteboard space to establish individual accountability for contributions. In addition to organizing information (66% of total group moves), A plays an active role in seeking input (73%), acknowledgement and affective moves (28%), knowledge contribution (24%), and topic control (17%). Examples of A's communication are in Table 7. The first example demonstrates how A, a science major, takes up an idea from another group member, expands on it, linking it to other facets of the project, and directs it back to the group. In the second example A communicates with group members initial ideas about assessment and involves them in improving the ideas. A's moves demonstrate her horizontal role in her group's leadership as she worked to guide the group toward their goal without overpowering other members of her group.

A striking contrast to A's style is is JF's role in Group 4. JF makes a total of four posts out of her group's 40 total posts (see table 8). Within her limited contributions, however, JF plays some role in the group's leadership, taking up acknowledgment and affective behavior (17% of her group's moves), argument development (17%) and seeking input (13%). In contrast to the contributions made by A in group 1, JF's contributions reference surface features of posts previously made by group members. While A both takes up and seeks input on her contributions, JF offers suggestions on others' work. While we have found that certain members in each group have distinct styles of leadership, specializing in certain moves, what makes JF's case interesting is that she makes no knowledge contributions toward her group's final product. Contributing knowledge is a move that all other members of the class and the instructor make. A similar pattern of behavior was found in a male participant, B, in Group 1. Are these students legitimate peripheral participators (Lave, 1991) or social loafers (O'Donnell et al., 2007)? However they are viewed, they contribute to group leadership in some ways. What legitimate individual learning might be accomplished by such participants is an interesting question.

Table 7: Examples of A's communicative contributions.

B has a good suggestion regarding splitting the goals into more manageable groups…This makes me wonder if we're being too specific in our enduring understanding? Or, in other words, are we going into another section of the PBL? I don't know. What do you guys think?"
** Ok - Please let me know how you guys would like to modify these assessments. I've tried to explain the activity and how it's done. I may have delved into the justifications or been insufficient in describing them so let me know what you think can be done to improve them. [lists names with specific assignments on whiteboard]*

Table 8: Summary of JF's Whiteboard contributions.

I think this looks great. I am not sure we had to include much in that box???
Looks great guys!
Facet 2 - Instead of saying there is no one way... perhaps say the students are free to present their genetic knowledge in any approved way they choose? Otherwise this looks great. *Formative assessment - I like C's idea about the questions at the end of class. This is a great way to track the students' progress as well as use formative assessment…* *Great job so far though!!!*

Conclusion

In five online groups, a distributed model was confirmed, with members of every group participating significantly in multiple leadership roles. Even in a group where a particular leader was "elected" and remained throughout, leadership was intricately shared. However, group members participated in leadership in different ways, with some members avoiding certain roles entirely while embracing others. These differences may exhibit gender-related patterns, although this must be further investigated. Different aspects of leadership had different patterns of distribution, with some functions being shared more evenly across group members (e.g., knowledge contribution), but other functions (e.g., seeking input) being dominated by fewer members. Moreover, different specific functions were more or less prominent as emergent aspects of leadership. The instructor shared in specific leadership roles (e.g., topic control) but avoided others (e.g., seeking input), and participated to different degrees with different groups, focusing primarily on the strongest and the weakest groups. Yet when groups were viewed as the unit of cognition without regard to individuals, the distributions of leadership behaviors represented as a percentage of total posts did not obviously differ for more versus less successful teams. While there are limitations to the model we've adopted in this study, it has provided a baseline understanding of how leadership can be characterized as distributed in interdisciplinary online learning groups. Future research design will take into account Social Networking Theory (Scott, 2000) in an effort to develop a more robust understanding of group interactions and leadership functions in small virtual groups.

These findings support aspects of Stahl's (2006) theory of group cognition in which he argues for more analytical and instructional approaches that treat the small group as a cognitive unit. Leadership, like problem solving in Stahl's online virtual math teams, was an emergent and distributed phenomenon in our groups. It would be impossible to develop a theory of leadership by looking at individuals separately. These findings suggest the importance of investigating models of small group collaborative learning based on emergent, distributed leadership, and of exploring peripheral participation in such leadership as it relates to individual learning and group cognition. They also raise a number of research questions: What are the potential learning

benefits to students of encouraging emergent distributed leadership in collaborative learning groups? How can such models of leadership be scaffolded? Can manipulating the components and patterns of distributed leadership affect individual learning and quality of group outcomes? What are the benefits of emergent leadership models compared to typical scripted models in which leadership roles are assigned and rotated?

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