

Changing Participation Through Formation of Student Learning Communities

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Abstract. Differences in learning gains between interactive engagement and lecture instructional practices have been well documented and yet the ways in which students participate in each of these learning environments are not clearly established. We use social network analysis as one way to establish differences the participation of students in lecture sections and students in Modeling Instruction, a curriculum that uses interactive engagement. One primary difference in the way students participate in the two instructional practices is that students in Modeling Instruction classes form learning communities and students in lecture classes remain isolated. Students in Modeling Instruction sections report ten times greater numbers of ties between students than those in lecture sections, forming richer and more deeply connected networks. We interpret these differences in terms of a participationist view on learning and as an explanatory mechanism for understanding documented differences in learning gains in the two settings.

Keywords: Learning Community, Network Analysis, Participation, Modeling Instruction

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INTRODUCTION

The statement ‘Interactive engagement leads to higher conceptual understanding gains as compared with lecture,’ [1] is one of the most widely reported results in PER. Unpacking this statement’s implicit meaning, one finds that the instructional practice is the mechanism that causes the differences in conceptual understanding. However, we should strive to understand the underlying mechanisms that lead to positive educational outcomes and the dynamics of the holistic classroom learning environment.

PARTICIPATIONIST FRAMEWORK

Rogoff, Matusov and White [2] eloquently argue that learning happens in all instructional settings, and that what distinguishes lecture practices from interactive engagement practices is in the direction that the participation is transformed. This view, alternately known as ‘learning as transformation of participation’ or ‘participationist’ view on learning, helps to distinguish ways in which the instructional setting transforms how students participate. Students in an

interactive engagement¹ setting are likely to move toward active participation in the construction of their own knowledge base and are likely to see the value in engagement with other members of the learning community. Students in a lecture environment are likely to transform their participation toward passive modes, expecting that knowledge is transferred and the instructor is the primary viable source of knowledge in the classroom. These differences in instructional approach are manifestations of the epistemological foundations of the learning environment and instructor [2].

Taking the participationist view on learning, we propose that investigating the transformation of student participation provides a lens which identifies the epistemological foundations of the instructional practice and, therefore, opportunities to investigate the mechanisms by which educational outcomes, such as improved conceptual understanding, are achieved. By tracking the transformation of participation in a classroom environment we attempt to investigate epistemological shifts students undergo through the course of the instruction. These epistemological shifts

¹ Rogoff, Matusov and White describe two instructional practices, student centered and participationist that would both be described as interactive-engagement.

may be tied to other positive educational outcomes which we have measured previously including positive shifts on CLASS [3], improved conceptual understanding, improved odds of success [4], and positive to zero shifts on the Sources of Self-Efficacy in Science Classes – Physics [5]. The epistemological shifts may also be related to students transferring the classroom modes of participation into informal learning environments.

USING SOCIAL NETWORK ANALYSIS

Social Network Analysis (SNA) allows us to investigate data that are relational in nature. [6] Previously we used SNA to investigate participation in an informal learning environment, a Physics Learning Center at Florida International University. SNA allowed us to investigate how students engage with each other in this informal setting and indicated that participation was equitable, we found no difference in students' centrality (a commonly used measure in SNA to indicate how deeply connected an actor or student is in a network) based on gender or ethnicity [7]. We bridge our experience with investigating the formation of learning communities in an informal setting to the formal setting of the introductory physics classroom.

METHODS

SNA is used to investigate networks of actors and the relations, or ties, among actors. In this case the networks we are investigating are formal learning environments, introductory physics classes, and the actors, i.e. students, in these classes. The methods used in this project are consistent with Wasserman and Faust's [6] descriptions of valid and reliable data collection. For this project we used pencil and paper surveys, administered during the first day of the class and again during the last week of the semester. Students were asked to respond to the question, "Who do you work with to learn physics?" and were given 10 spaces in which to write names. We then used class rosters for each of the two classes to create a matrix of $N \times N$ where N is the number of students in each class. Each written response was then coded, by placing a 1 in the cell when a tie is present. For example, if student G had reported that she worked with students C and L, in row G columns C & L would have a 1, and all other cells have a 0. All student responses were coded in this way and then imported into UCInet 6.0 [8] and a sociogram (network diagram) was plotted for each class both pre instruction and post instruction, using NetDraw [9] using spring-embedded layout.

In this project our aim was to investigate and compare how the learning community develops over the course of instruction in each instructional approach. Because we are interested in characterizing the entire network, which we are taking to represent the learning community, we used the network density as the measure of interest. Density is a measure of the proportion of ties reported as compared with the number of possible ties, see Equation 1. Accordingly class with a density of 1 would have every student responding that they work with every other student in the class to learn physics.

$$d = (\# \text{ ties}) / (N * (N - 1)) \quad (1)$$

For this project we measured the density in two classes, a Modeling Instruction class with 30 students and a lecture class with 80 students. Once we had calculated network density for each class pre and post instruction, we used t-tests to compare within classes and calculated z-scores and p values to compare classes. The t-tests were calculated using UCInet which uses bootstrap methods, as one of the standard assumptions in SNA is that actors are interrelated which violates the standard assumption in parametric statistics. For more comprehensive treatments of calculating t-tests using bootstrap methods, see Snijders & Borgatti [10].

RESULTS

The differences in the formation of student learning communities is evident in the sociograms of the networks from the two classes, see Figures 1a, 1b, 2a, 2b. The sociograms from the Modeling Instruction class indicate that students begin with few connections and over the course of the semester, the number of connections grows and all students become integrated into the network.

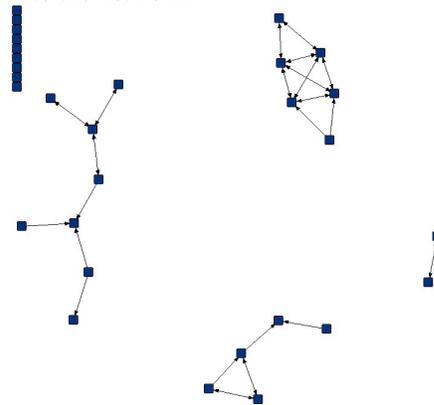


FIGURE 1A. Pre-instruction sociogram of learning community in the Modeling Instruction class. Students are represented by squares and connecting lines represent ties or students who report working together. The squares at the top left are isolates, or students who had no ties to other students.

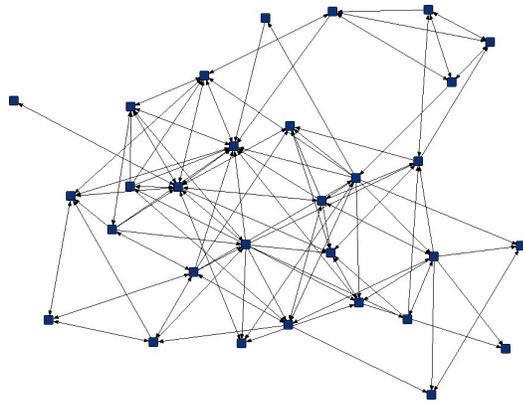


FIGURE 2B. Post-instruction sociogram of learning community in the Modeling Instruction class.

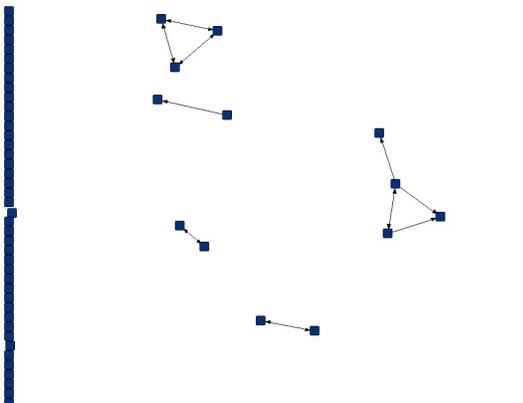


FIGURE 2A. Pre-instruction sociogram of learning community in the lecture class. Line to the left is the isolates, or students who had no ties to any other students.

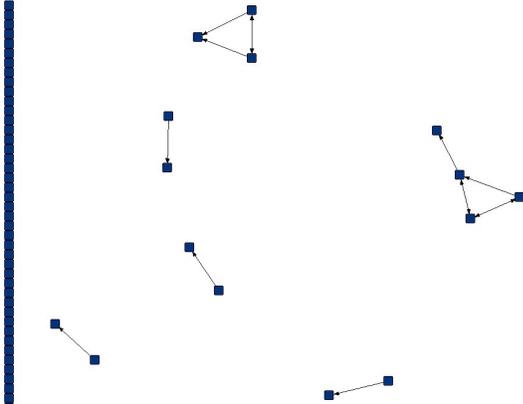


FIGURE 2B. Post-instruction sociogram of learning community in the lecture class. The squares on the left are isolates, or students who had no ties to other students.

Several features are represented on the sociograms. First, the Modeling Instruction class starts with considerably higher density. Several explanations are plausible to understand this difference, first is the physical layout of the classroom may have cued students to expect interactions. In the Modeling Instruction classroom students sit around tables where

it is evident that interaction is to be expected. The evidence that supports this conjecture is that three of the five clusters in Figure 1a are groups of students all sitting at the same table. A second interpretation is that students enter Modeling Instruction with an understanding that the course will be different from traditional physics instruction. A second feature of the Modeling Instruction network is that in the post-instruction network no student is isolated, each student has at least one tie to other students in the class. One interpretation of this result is that because the network is more tightly established there is a greater potential for flow of information and influence. From the lecture class, the striking feature is that the clusters that exist in the post-instruction measurement are nearly identical to the pre-instruction measurement. This indicates that students who have entered with a collaborator tend to continue to work with the same collaborator.

TABLE 1. Network densities and t-test results. All t-tests use bootstrap methods, with 5000 samples.

	Pre instruction density (standard error)	Post instruction density (standard error)	t-test for pre-post differences within instruction
Modeling Instruction (N = 30)	d = .0425 (.0120)	d = .1529 (.0223)	t = 4.603, p=.0002
Lecture (N = 80)	d = .0022 (.0011)	d = .0025 (.0010)	t = .3466, p=.697
z-score for differences across instruction	z = 25.12, p<.0001	z = 78.67, p<.0001	

The differences between the two instructional approaches clearly shown in the sociograms are further evidenced by the t-tests and z-scores on the network densities, see Table 1. First, the lecture class showed few interactions at the beginning of the semester and only one new tie develops over the course of the instruction. The densities of the lecture class pre instruction and post are not statistically different. The Modeling Instruction class begins with a statistically higher density than the lecture class but after instruction the Modeling Instruction class density has increased, and the increase is statistically significant. This increase is important, even if it is unsurprising, because it indicates that students became more connected to each other over the course of the semester.

DISCUSSION

In social network analysis, a tie between two actors is seen as an opportunity for influence. In this paper we have used the methods of SNA to consider how the instructional approach shapes students' approach to learning.

Participation vs. Isolation

Our SNA analysis indicates that lecture instruction does not foster students participating with other students, the majority of students in the network are isolates, students who are not involved in any ties with other students. Conversely, the students in the Modeling Instruction class move from an initial state with several clusters of students and many isolated students to a network where all students were involved in at least one tie. These differences are striking, indicating that lecture does not promote a sense of community whereas Modeling Instruction does. Developing this sense of community has been linked to the retention of students [11-13]. Further, we have previously measured differences in retention between Modeling Instruction and lecture, so the differences in participation provide one explanation for the differences in retention.

Using participation to infer epistemology

The differences we measured between the two instructional practices are primarily in how students participate in the learning of physics. We contend that students evolve the ways they participate in a learning community (or do not) as the result of the underlying epistemology of the instructional practice, this is the basic nature of the hidden curriculum. Modeling Instruction is an instructional practice founded on the epistemological premise that physics is inherently an iterative modeling process. With this premise, students should be engaged in ways that mimic practicing physicists, building an explicit Nature of Science theme into the instructional practice. Engaging students as scientists requires involving them in the scientific community rather than isolating them. Practicing scientists collaborate and engage with the broader scientific community. Instructional practices which engage students in interactions with other students provide students with opportunities to learn to negotiate meaning, to learn the norms and practices of the discipline and to become members of a learning community.

Using Social Network Analysis to understand interactive engagement

We have utilized the methods of SNA to attempt to identify lasting patterns of interaction in data that is inherently relational. Building on this project and previous work we see several opportunities afforded by SNA. First is that we have looked at the formal learning environment and focused on differences between entire networks, by focusing on actors within the network we believe further understanding of the transformation of participation is possible. Second, if the patterns of interaction are lasting, this provides mechanism for studying transfer of learning from the physics class to other classes or to learning in informal or semi-formal environments.

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