DOCUMENT RESUME

ED 442 726		SO 031 883
AUTHOR	Johnson, Andy	
TITLE	Sociophysics Norms in an Innovative Physics Learning Environment.	
PUB DATE	2000-04-28	
NOTE	14p.; Paper presented at the Annual Meeting of the American Educational Research Association (New Orleans, LA, April 24-28, 2000).	
PUB TYPE	Reports - Research (143) -- Speeches/Meeting Papers (150)	
EDRS PRICE	MF01/PC01 Plus Postage.	
DESCRIPTORS	*Classroom Communication; Classroom Research; Communication Research; *Concept Formation; Elementary Education; Higher Education; Instructional Innovation; *Interpersonal Relationship; *Physics; Social Studies; Teacher Education	
IDENTIFIERS	Learning Environment	

ABSTRACT

Successful course reforms rely on the development of courses that support productive patterns of classroom interaction. Particularly in the case of inquiry-based classes, the ways that students talk to each other and how they interpret the instructor's actions can make great differences in their learning. This paper describes results of research on patterns of social interactions in a college physics course for prospective elementary teachers. Students in this course developed physics concepts for themselves with support from particular pedagogical structures, collaborative group work, and special computer software. Data consisted of videotapes of class work, interviews, and collections of students' work. The paper extends Yackel and Cobb's "sociomathematical" norms (1996) to the fields of physics, and introduces two "sociophysics norms" that emerged in the course. These were class criteria for accepting evidence and the obligation for each group to have a scientific model of magnetic materials that they could support with acceptable evidence. Implications of this study are that classroom norms seem to be influenced by the instructor, by pedagogical structures, and by students' actions, and that the development of norms seems to be part of the process of developing understanding. (Contains 4 figures and 11 references.) (Author/BT)

Sociophysics Norms in an Innovative Physics Learning Environment.

by

Andy Johnson

Paper presented at the Annual Meeting of the American Educational Research Association (New Orleans, LA, April 24-28, 2000).

Sociophysics Norms
in an Innovative Physics Learning Environment

Andy Johnson
Center for the Advancement of Mathematics and Science Education
Black Hills State University, Spearfish, SD
andyjohnson@bhsu.edu
605-642-6873

Presented to the American Educational Research Association, April 28, 2000, New Orleans, LA

Abstract

Successful course reforms rely on the development of courses that support productive patterns of classroom interaction. Particularly in the case of inquiry based classes, the ways that students talk to each other and how they interpret the instructor's actions can make great differences in their learning. This paper describes results of research on patterns of social interactions in a college physics course for prospective elementary teachers. Students in this course developed physics concepts for themselves with support from particular pedagogical structures, collaborative group work, and special computer software. Data consisted of videotapes of class work, interviews, and collections of students' work. This paper extends Yackel & Cobb's "sociomathematical" norms (1996) to the field of physics, and introduces two "sociophysics norms" that emerged in the course. These were class criteria for accepting evidence and the obligation for each group to have a scientific model of magnetic materials that they could support with acceptable evidence. Implications of this study are that classroom norms seem to be influenced by the instructor, by pedagogical structures and by students' actions, and that the development of norms seems to be part of the process of developing understanding.

Connections between social and psychological processes

Recent thinking on learning looks at social interactions to understand learning processes in classrooms. Taking the perspective that thinking and learning are partially or fundamentally social processes (Vygotsky, 1978; Brown, et al. 1989; Wertsch, 1985), we need to understand the relations between social structures and students' development of knowledge and abilities. Norms are one of the types of social structures that are implicated in learning.

Social norms represent important influences on the "participation structure" and discourse in a classroom (Cobb & Bowers, 1999). They may be seen to support certain actions or discussions, and discourage others. In turn, the kinds of actions and discussions that take place influence students' development of ideas. Norms represent the continually evolving social framework within which classroom activities take place.

Learning to function effectively within a particular culture is an important classroom activity. Learning the culture of scientific inquiry, which is the example of this paper, involves learning how to perform experiments, evaluating their results, judging the viability of an explanation, differentiating between "good" and "bad" models, learning how to make convincing arguments (Latour & Woolgar, 1979; Lemke, 1990), and more. Typically, teachers do not explicitly tell students how to do all these things, but they may (not always consciously) use events in the classroom to shape the patterns of discourse and direct attention to "ways that things are done". An understanding of norms can help one understand the origins and effects of the classroom participation structure, and thus students' learning.

Students in the class studied for this paper gradually began to engage in "science processes" at the same time they were developing physics models of ferromagnetic materials. As a result of doing experiments, engaging in classroom discussions, and formulating models, students in the classroom developed expectations for model use and standards for acceptable explanations. They also distinguished between static electric and magnetic phenomena, and formulated models much like the domain model of ferromagnetism. Both accomplishments were done gradually as groups made sense of their experimental results and the teacher's and other students' statements. The models that students developed in the class constituted strong evidence of robust learning of physics. The classroom expectations and de facto standards that emerged along with the models may be called classroom norms.

Social norms in a classroom

When conducting a mathematics teaching experiment in a second grade classroom, Yackel and Cobb (1996; Yackel, Cobb & Wood, 1991) and Bowers, et. al. (1999) investigated social norms that pertained to children's development of mathematical understandings. These authors developed concepts of classroom norms so that they could talk about the networks of obligations and expectations that the teacher and students constructed, negotiated, and continually re negotiated in the classroom. They noticed that some patterns of mathematical behavior came to be steady after a few weeks, and some patterns of mathematical explanations were continually re negotiated.

Social norms are research constructs. They are an observer's interpretations of the patterns of obligation and expectation that play out in classrooms. As such, norms themselves can't be said to play causal roles in classroom interaction. Rather, the important influences are individual students' felt obligations and expectations and their and others' actions. But these specific relationships are often difficult or impossible to characterize in detail because they are many, complex, and frequently idiosyncratic. To gain a general understanding of the classroom participation structure, we distill descriptions of the essential features of obligations and expectations within the class and call them norms.

In the language of Yackel and Cobb, norms are interactively constituted by participants. The phrase "interactively constituted" implies that the teacher and students together continually develop ways of interacting, and much of this process may not be intentional or explicit. Norms are not rules. Although the teacher may declare particular expectations for students' work, different members of the class are likely to interpret these expectations in somewhat different ways, and they respond in individual ways. Students' different actions that are oriented towards' the teacher's expectations constitute simultaneously their sense of obligation and their ways of responding. The teacher responds in turn to students' actions in a cycle of "negotiation" by interactive constitution. Students and teachers only talk explicitly about a few classroom obligations and expectations. Actions constitute the bulk of the normative acts. The researcher who is looking for norms finds not uniformities in behavior but patterns and commonalities that represent each individual's responses to obligations in a social setting.

Sociophysics norms

There are different types of norms. Some patterns of expectation and obligation do not depend on the particular topic of the class, and might be found to be roughly similar in a class on any topic. Other patterns of expectation and obligation pertain directly to the topic of the course, and represent features of the culture of the particular area of study. In this paper, these norms are called "sociophysics norms" after similar terminology from Yackel and Cobb.

Sociophysics norms are those patterns of obligation and expectation that are connected with the particular issues of interest in a physics class. They represent aspects of the culture of physics as it develops in a classroom. These norms might define acceptable ways of describing experimental results, what is a good claim and what is not, or how to justify hypothetical explanations about the physical world. The teacher's goal is to promote sociophysics norms that eventually correspond with certain values within the larger scientific community. By promoting particular sociophysics norms, the teacher and course materials introduce aspects of the culture of science into the classroom.

In the classroom described by Yackel, Cobb, and Bowers, sociomathematical norms provided criteria for deciding what constituted different mathematical solutions, sophisticated mathematical solutions, and acceptable mathematical explanations. As these norms emerged, students in the classroom developed more sophisticated understandings of mathematical reasoning and argumentation.

Interactions in the physics course studied for this paper introduced features of the culture of physics. One important sociophysics norm addressed how students made generalized descriptions of static and magnetic phenomena. Another norm described in this paper prescribed the types of evidence that were acceptable in the classroom. A third norm, also described below, defined the ways that students made explanations or models, and provided impetus for students to change their models of magnetism if they came to be insupportable.

Research on students constructing models of magnetic materials

The students in this study were enrolled in a physical science course for prospective elementary teachers at a large US university. The course used a specially designed pedagogy and classroom materials that were designed to support students' inquiry learning of physics (Goldberg, 1997). The instructor took a "strong" guided inquiry approach by giving the students themselves the responsibility of developing the main ideas of the course. There was no textbook, no lectures, and few or none of the students understood electricity or magnetism before beginning the course. When students asked questions, the instructor only offered guidance about scientific thinking, but did not offer guidance about *what* to think. Only after the class as a whole agreed on a set of "main ideas" did the instructor place his "blessing" on them, as a member of the larger physics community.

During much of this class, students worked in small groups at computers. On-screen instructions in page – layout documents directed students to perform experiments alongside the computer and to consider and type or draw responses to particular questions about the current topic. The activities and questions in these documents were carefully planned and sequenced based on published research in student learning of physics and on previous classroom trials.

During this research study, the students were studying static electricity and magnetism, in particular, ferromagnetic materials like iron. The class goal, successfully met at the end of the magnetism segment, was for student groups to construct theoretical models of magnetic materials that could explain a wide variety of experimental results. Student groups magnetized nails and tested for attractions and repulsions in a variety of experiments. For example, one computer document asked groups of students to magnetize a nail and test for effects (attractions or repulsions) at either end of first an unmagnetized nail, and then a second magnetized nail. The groups found that the unmagnetized nail was always attracted to the magnetized nail, but the two magnetized nails attracted or repelled depending on which ends were brought together. Carefully designed questions in this document helped students begin talking about this behavior in terms of the two-endedness of magnetized nails.

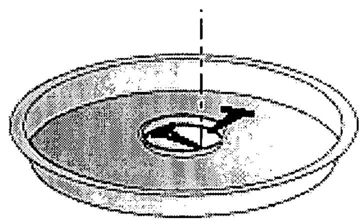

Figure 1: Diagram showing students how to "float" and hold nails for testing

At the end of the segment of magnetism, all of the groups settled on models similar to the accepted "magnetic domains" model of ferromagnets.

Videotapes of the discussions of one group of three students were transcribed and analyzed in detail using methods of qualitative hypothesis testing (LeCompte & Preissle, 1993). The group's working models of magnetic materials and their felt obligations were identified using a variety of triangulated information including video of whole class discussions, one-on-one interviews with students, and photocopies of students' individual journals, homework, and group work.

To identify sociophysics norms, commonalities in students' behavior were identified and explanations were sought for changes in students' ways of talking, how they did experiments, how they presented ideas to the rest of the class, and so on. After a long time of looking at the video data, it became clear that students sometimes changed what they did or said because of obligations or expectations. At the beginning of the unit (also the beginning of the course) most students did not seem to discriminate between what they thought about magnets and what they saw magnets doing. Their explanations and diagrams often combined phenomena with explanations in ways that strongly suggested they didn't understand scientifically accepted relationships between model and evidence. However, as the class went on, the students gradually got better at making models and using experimental evidence to evaluate or support models. Not surprisingly, they also gradually developed more sophisticated models that had more explanatory power. This was the classroom phenomenon that the analysis of classroom norms had to explain.

Observed Sociophysics norms

Two important sociophysics norms are described in this paper. They are connected to each other. The first norm addressed how class members determined the acceptability (or not) of evidence to support their current models, whatever they might have been. The second norm addressed how groups supported their models in public presentations. They were obligated by the teacher, by the course materials, and by their fellow classmates to construct and use models that could be supported by acceptable evidence.

Because norms continually evolve, it may be impossible to pinpoint a time when a norm emerges in a classroom. More likely, a norm emerges gradually and becomes salient when certain obligations change and become increasingly important in people's interactions. This is the case with the two norms described in this paper. The first norm seemed to become important in a whole class discussion after about ten class hours of group experimentation and discussion on both static and magnetic phenomena. There had been some classroom discussion beforehand about models and evidence and their respective roles, but important issues crystallized in a whole class discussion, part of which is transcribed below.

The groups were asked to formulate general descriptions of the similarities and differences between static electricity and magnetic effects. This was not easy for groups to do, because, as mentioned above, many students were only just learning to separate model-like talk and thinking from general descriptions of phenomena.

Evidence: How the whole class determined which evidence to allow

In the whole class discussion, groups noted a number of differences between static electricity and magnetism. Groups listed a number of differences that were not controversial, and were easily accepted as "class main ideas." Then a student named "Joan" claimed there was a difference in longevity between the two effects. She said static electricity wore off quickly but magnetism lasted a very long time because she had seen refrigerator magnets stuck to the fridge for years. Another student ("Diane") disagreed and thought that magnetism also wears off. Diane argued that *since they had not done that experiment in class*, they could not formally declare the permanence of magnetism as a Class Main Idea. The instructor, who had repeatedly asked for evidence in the prior discussion, asked focusing questions and merely reiterated his request that ideas be backed with evidence.

Joan	Static electricity is short lived, magnetism is not.
Instructor	What do you think of that?
Diane	No, magnetism wears off. I just said "both will eventually lose their
Megan	Magnetism doesn't wear off, does it?
Diane	Yeah it does. When we rubbed our -
Megan	Well, but not the magnet, the magnet never lost its magnetism.
Joe	Maybe not as far as we can see now but it may not be permanent forever.
Debbie	I think you have to put it under two different categories, the ones that are magnetic objects and magnets.
Instructor	Is there a difference in terms of short-lived or long lived? Do magnetic objects seem to be as short lived as electric objects based on our experiments?
Diane	Well, we didn't watch static electricity to see how long it would last.
Instructor	Okay so the question is do we have enough evidence to make a statement at all here.
Diane	No
Unknown Student	No, we didn't note the duration, we just wanted to see if there was an effect.
Diane	We just moved on to the next one. We didn't care how long it lasts.

Instructor Okay, class, because some people didn't put a statement down here – Only if we feel comfortable should we have it as a main idea. If we can't we can put it aside as a possibility but not as a main idea.

Eventually, after longer discussion, the instructor wrote down the longevity idea as a possibility only, rather than as a formally accepted main idea. Some students in the class were not happy with this demotion of an idea that, to them, was obviously true.

It may have been that Diane was using the idea of "not having done the experiment" as an argumentation tool to advance her position that magnetism wears off. Regardless of her purpose, other students agreed with her on this point. As a result of this and other discussions, the following norm emerged in the classroom:

Evidence: Students in the class were obligated only to admit evidence that was obtained from experiments deliberately conducted in the class.

The normative way to support claims in whole class discussions was to refer to relevant experimental results that had been done in the class. When students or groups supported claims using experiences from outside the classroom, these were challenged by other students or by the instructor, and claims based only on experience outside the classroom were not accepted.

This obligation to refer only to experiments done in class continued to be negotiated and constituted. Later on in the same discussion, Susan proposed another idea for the whole class to consider as a consensus statement. She wanted to have something written about how floating magnetized nails oriented North and South. The way she justified this idea indicates she was aware of the issue of having had evidence in the classroom experiments:

Susan Can we say something about magnetism has something to do with direction - it had a directional pull? Cause that's totally different, we haven't put it up there, and it's significant. I think, because, you never saw anything like that in the static electricity. But then we did the whole experiment on the magnet and which way it would float when you put it in the water. And obviously there was a certain natural direction that it tended to.

When making her statement, Susan emphasized three things. She said that her directional pull idea was different from the other ideas so far accepted by the class, that the phenomenon was significant, and that the class had done a whole experiment on how nails would point certain ways. Thus, her statement constituted the emerging evidence norm, that is, it was a significant statement that was consistent with the norm. Susan's proposal was accepted by the class and by the instructor, and was made into a main idea.

Two days later the class had another discussion in which each group described their current model for magnetic materials. Each group had to describe two things: their model of a nail, and their reasons why they had that model. In supporting their models, all of the groups referred to experiments done in class, and none said anything about observations of magnets made outside of class or about experiments that hadn't been suggested by the course materials. All of the groups' supporting statements were consistent with the evidence norm.

Although the group statements all constituted the evidence norm, individual students were still working out ways to talk about ideas and how to support them. In one group, a student seemed to have a different idea from others of how to support ideas. She seemed to want to base her model claims on authoritative statements that had been accepted in class rather than basing model claims on results of experiments. Her negotiations with fellow group members and the instructor led both to changes in how she supported models herself, and in how the group as a whole related model and evidence. This example is shown in the next section.

Models: How students justified or changed their models

A new cycle of the course began one day after the above discussions when the instructor asked groups to begin formulating models of magnetic materials. The initial task for groups was to formulate magnetism models based on their current thinking, and to present their model diagrams to the rest of the class. The instructor asked all the groups to justify their models of magnetized and unmagnetized nails by referring to the evidence they had collected thus far.

Instructor	Also, what evidence do you have that would support the model? In other words, did you make it up out of the clear blue sky? Or did you invent it based on some observations you did in Cycle 1, and your model seems to go with those observations? That's the kind of evidence we'd like to bring to bear and come up with a model.

This and other statements made by the teacher, along with requests in the written course materials, led to a norm about supporting models with evidence:

Models: Students and groups were obligated to have models that they could support with specific evidence that was acceptable to the class. In this class, supporting a model required referring to experimental results or to previously accepted ideas.

The class's obligation to support models with evidence led students to modify their group models when they encountered experimental results or recalled experiences that their model could not account for. Groups were expected to have models they could publicly support. This effect will be discussed below.

In one of the small groups, the instructor's statement shown above seemed to have an influence on the group's discussion. They were asked to draw their current best model and present evidence to support it. For this group, what they would draw was not at issue. They all agreed on a model that made sense to them at the time (see figure 2 below). Their discussion focused instead on how they would support their model. (italics added for emphasis)

Donna	So, um, This is "what do you think?" Therefore can we sort of create this model of what's happening?
Marge	This is model creation time..
Donna	Cool.
Marge	[laughs!]
Donna	So we can use our hard evidence, observation, meaning the facts that magnetism has a directional pull, you know, *these things that we as a class have agreed with.*
Marge	We can do that and we can also describe our *observations*
Donna	And it was confirmed by our instructor that two sides of a magnetic object hav- behave differently. We know that by observation, positive- you know, attracting and repulsion, right?
Marge	Mhmm

Donna	So based on those things we've observed we therefore make the model at the ends you know, we're thinking that opposites, do the pulling, you know.
Donna	If you put it - the north, north end down it's going to drag those south, whatever they are,
Marge	Mhmm

Notice that Donna appeared to be concerned about the kind of evidence that would be acceptable - she used the terms "hard evidence, observation" and referred to "these things that we as a class have agreed with" and a statement that was "confirmed by the instructor." Donna appeared to be responding to a sense of obligation to use appropriate evidence–this was how Donna constituted the evidence norm at that time. Donna may have used the word "observation" to mean "things we know that have been accepted." Marge, however, had a different idea of observations as "things we saw happening when we did experiments." This discussion was an example of how the evidence norm was negotiated by two students in one group. It also illustrates the development of obligations related to the models norm. The group's obligation to have a model they could support with experimental evidence was apparent in Donna's statement "So based on those things we've observed we therefore make the model."

A few minutes later, Marge stopped the circulating instructor to clarify her group's task. Their instructions were to draw a model diagram on a whiteboard, and to summarize their supporting evidence below the diagram. The following interchange seems to be an example of direct negotiation between instructor and students of expectations and obligations in presenting and supporting a model:

Marge	Um - Dr. ....? We have our picture. Now down here on explanation do you want us to write why we decided that this is what we think is happening inside the nail? Like we observed -
Instructor	Yes. So you have to have some kind of evidence from the first cycle that you have gone on to lead you to make this type of a drawing
Donna	Oh oh oh oh
Instructor	So you just kind of summarize in a few statements here. You don't have to write in long sentences, but just summarize the main reasons or the evidence that you are drawing on.
Marge	So we talk about our experiments and what we saw?
Instructor	you could-
Donna	We can't think of a mo-, we can't say a model, though right, but say we just, decide on evidence we have come up with as class consensus
Instructor	Okay
Donna	For example magnetism has a directional pull.
Instructor	okay
Donna	We can use that hard, well, sort of fact, I don't know if I would say fact
Instructor	okay
Donna	To help us think why it's -- is that fair?
Instructor	Right. This is kind of an invisible model of what you think is going on inside the nail. You don't actually see these things happening, you only see the solid nail. So what you're doing is, you know how it behaves, and you're using that behavior that you discovered in class to come up with a possible model that would give that result that you saw, which is what you're representing here.
Donna	Okay

Instructor	And these pictures in a sense comprise your model. And down here just a few statements about the evidence or the reasons why you think this is a particularly good model.
Donna	Okay
Instructor	That's what we're asking each of the groups to do, and it'll be interesting to see the various ways, the various models that groups come up with at this point. Okay?
Donna	Okay

This discussion was about both the evidence norm and the model norm. When Marge first flagged the instructor, she suggested that the group could write "why we decided that this is what is happening" The instructor responded with "Yes, you have to have some kind of evidence." Marge seemed to already be thinking about something like experimental evidence as the appropriate thing to use to support her group's model diagram. On the other hand, Donna did not seem to be thinking that way in either of the discussions shown above. Either she was trying to clarify what constituted valid evidence or she was trying to see whether her scheme of using earlier ideas would be acceptable. Marge used the words "observed", "experiments" and "what we saw". Donna again used the phrases "class consensus" and "hard facts" both of which refer to a set of idea statements agreed on by the class at an earlier time. Their discussion shown above was a negotiation of the kinds of obligations they would fulfill.

The model norm was important in this discussion because part of Donna's difficulties seemed to involve making a clear distinction between writing a model description and supporting it with evidence. This would explain why she said "we can't say a model, though, right?" She appeared to be trying to understand what her group was supposed to write in the space below their diagram of the nail. By negotiating with her group and the instructor about that task, Donna had the opportunity to learn something about the differences between models and evidence.

This event illustrates the inextricable connectedness of social and psychological processes. Marge and Donna seemed to be concerned with understanding their obligation to make an appropriate presentation to the class and the instructor. They wanted to know what was the "right" thing to do. At the same time, Donna and Marge were each developing ways of thinking and talking about evidence and models, which represents individual learning of important course content.

In later group work and discussions, groups were repeatedly asked to record their magnetism models and support them with evidence. Magnetism models, ideas, and explanations became the currency of exchange in this classroom. The models were central to the groups' activities, so how the groups understood scientific models was important to the unfolding of the science content of the course.

Connections with model development

The obligation of groups to use models and support them with experimental evidence supported the course goal of students understanding fundamental ideas about magnetism. The development of scientific models was not straightforward for students. Around the time of the discussions transcribed above, most of the students thought that unmagnetized nails contained a mixture of positive and negative charges. They explained their tentative ideas that rubbing the nail with a magnet moved the positive charges to one end and the negative charges to the other end. This was consistent with their observations of bringing a magnetized nail near either an unmagnetized or a magnetized nail.

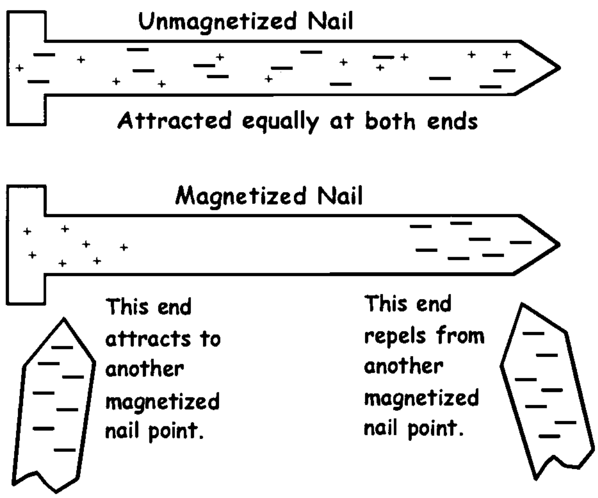

Figure 2: Common student model of nails *before* cutting a nail.

This type of model, while it explains a great deal of magnetic phenomena, is not consistent with the current textbook model of ferromagnetic materials. Had the class not changed to a model that was consistent with the accepted "magnetic domains model", the instruction would have been considered a failure. However, the groups did change their models. In later activities (after the discussions transcribed above) groups did the experiment of magnetizing and cutting a nail, and observing its magnetic behavior. This crucial result challenged the groups' models because each cut piece behaved like a complete magnet itself.

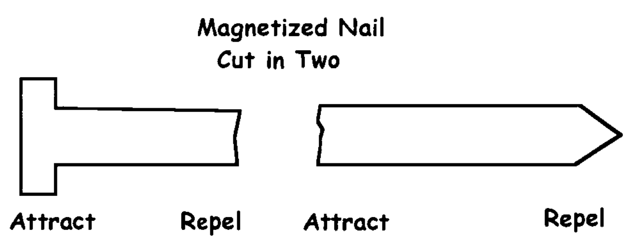

Figure 3: Cut nail challenges the "separation of charges" model.

When groups observed this behavior, they recognized it as important evidence that related to their models. This was essential to the success of the course materials. It was also important that groups were obligated to reconcile their models with the evidence they observed. This obligation was one of the causes of many small group attempts to modify or change their magnetism models based the cut nail evidence.

As a result of these struggles with models, and further experimentation and discussions, the class did eventually propose a "magnetic domains" model. One group's drawing is shown here. The diamond shaped pieces represent compass needles, which the group members felt were also magnetized. The unmagnetized nail has its compass needles (or "magnetic domains") aligned randomly, which causes no net magnetic effect outside of the nail. The "Rubbed" nail (meaning it was rubbed with a magnet) has all of its compass needles pointing in the same direction, so that one end of the nail is a magnetic north pole and the other end is a magnetic south pole.

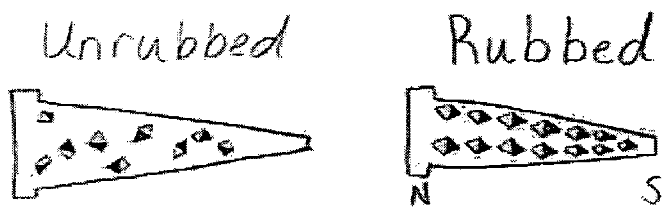

Figure 4: Magnetism model drawn by one group

Implications

Two sociophysics norms have been discussed in this paper. The first, that "students in the class were obligated only to admit evidence that was obtained from experiments conducted in the class" described the social constraints on groups' use of evidence, and was a part of the development of understandings of the relation between models and evidence. This norm emerged when students were trying to sort out different ways of supporting claims about what might be going on with magnetic nails. The students had many different types of "reasonings" at their disposal, including such things as life experiences with refrigerator magnets, remembered interpretations of things they had heard about magnets, sanctioned ideas from earlier discussions in the class, results from experiments, and logical connections between explanations and observed nail behaviors. The students had to develop, under the guidance of the instructor, the course materials, and peers, ways to make claims and support them. The evidence norm restricted the choices available to groups when making claims in the class, and more importantly it removed alternative types of "warrants," or ways of supporting claims, from discussions. This had the effect of making discussions more like accepted patterns of discourse in science.

The second norm, that "groups were obligated to have models that they could support with specific evidence that was acceptable to the class" led groups to reformulate or modify models to fit with their growing bank of experimental evidence. It seems likely that this norm was an important part of the class development of a "magnetic domains model" of ferromagnetism because when groups found evidence that clearly contradicted their current magnet models, they did not simply brush it under the rug. Instead, they actively sought ways to reconcile models and evidence, by questioning the experimental results or by questioning their models. When the ten groups cut the magnetized nails (described above), six groups changed their models, two groups had models similar to figure 4 already and did not change their models, and only two groups kept their separation models (in figure 2). What is most important is that all or nearly all the groups recognized the significance of the broken nail experiment and felt obligated to do something about it.

These two examples of norms show how the obligations associated with emerging sociophysics norms can be important influences on discourse patterns and thus the learning in a physics classroom. They also hint at the degree of negotiation and discussion that is sometimes necessary for students to understand the relations between models and evidence in ways similar to what the instructor intends. In the class studied, the students did this primarily because of the expectation that they use evidence appropriately for that setting, rather than because of any overt assignment to "learn how to use evidence." Development of these understandings was clearly a social process, and was closely connected to the development of norms for model use in the classroom.

The observed modeling trajectories and hypothesized sociophysics norms are consistent with the claim that in a classroom, the pedagogical methods and curricular materials strongly affect the participation structure of a course. The evolution and constitution of norms takes place in a setting constrained by the structure of the course materials, and within a framework established by the pedagogical structure. If our goal is for students to understand important aspects of the culture of science, then we probably want to provide structures that promote norms that are characteristic of the culture of science.

References

Brown, J. S., Collins, A., & Duguid, P. (1989). Situated Cognition and the Nature of Learning. *Educational Researcher*, **18**(1), 32-42

Cobb, P. (1996). Accounting for Mathematical Learning in the Social Context of the Classroom. *L'Educazione Mathematica*, **5**, 65-81 (Part 1) 123-142 (Part 2).

Cobb, P., & Bowers, J. (1999). Cognitive and situated learning perspectives in theory and practice. *Educational Researcher*, **28**(2), 4-15

Goldberg, F. (1997,) *Constructing Physics Understanding in a Computer-Supported Learning Environment* Paper presented at The Changing Role of Physics Departments in Modern Universities: Proceedings of ICUPE, College Park, Maryland.
(For further information on the CPU pedagogy and materials, visit the CPU web site at http://cpuproject.sdsu.edu.)

Latour, B., & Woolgar, S. (1979). *Laboratory life - the social construction of scientific facts*. Beverly Hills: Sage Publications

LeCompte, M. D., & Preissle, J. (1993). *Ethnography and Qualitative Design in Educational Research*. (Second ed.). San Diego, CA: Academic Press, Inc.

Lemke, J. L. (1990). *Talking Science: Language, Learning, and Values*. Norwood NJ: Ablex Publishing Corp.

Wertsch, J. V. (1985). *Vygotsky and the social formation of mind*. Cambridge, Mass.: Harvard University Press

Vygotsky, L. S. (Ed.). (1978). *Mind In Society - The development of higher psychological processes*. Cambridge, Mass: Harvard University Press

Yackel, E., & Cobb, P. (1996). Sociomathematical Norms, Argumentation, and Autonomy in Mathematics. *Journal for Research in Mathematics Education*, **27**(4), 458-477

Yackel, E., Cobb, P., & Wood, T. (1991). Small-Group Interactions as a Source of Learning Opportunities in Second-Grade Mathematics. *Journal for Research in Mathematics Education*, **22**(5), 390-408

U.S. Department of Education
Office of Educational Research and Improvement (OERI)
National Library of Education (NLE)
Educational Resources Information Center (ERIC)

ERIC®

REPRODUCTION RELEASE

(Specific Document)

I. DOCUMENT IDENTIFICATION:

Title: Sociophysics Norms in an Innovative Physics Learning Environment

Author(s): Andy Johnson

Corporate Source:

Publication Date: April 28, 2000

II. REPRODUCTION RELEASE:

In order to disseminate as widely as possible timely and significant materials of interest to the educational community, documents announced in the monthly abstract journal of the ERIC system, *Resources in Education* (RIE), are usually made available to users in microfiche, reproduced paper copy, and electronic media, and sold through the ERIC Document Reproduction Service (EDRS). Credit is given to the source of each document, and, if reproduction release is granted, one of the following notices is affixed to the document.

If permission is granted to reproduce and disseminate the identified document, please CHECK ONE of the following three options and sign at the bottom of the page.

The sample sticker shown below will be affixed to all Level 1 documents	The sample sticker shown below will be affixed to all Level 2A documents	The sample sticker shown below will be affixed to all Level 2B documents
PERMISSION TO REPRODUCE AND DISSEMINATE THIS MATERIAL HAS BEEN GRANTED BY ____ Sample ____ TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC) 1	PERMISSION TO REPRODUCE AND DISSEMINATE THIS MATERIAL IN MICROFICHE, AND IN ELECTRONIC MEDIA FOR ERIC COLLECTION SUBSCRIBERS ONLY, HAS BEEN GRANTED BY ____ Sample ____ TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC) 2A	PERMISSION TO REPRODUCE AND DISSEMINATE THIS MATERIAL IN MICROFICHE ONLY HAS BEEN GRANTED BY ____ Sample ____ TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC) 2B
Level 1	Level 2A	Level 2B
[X]	[ ]	[ ]
Check here for Level 1 release, permitting reproduction and dissemination in microfiche or other ERIC archival media (e.g., electronic) *and* paper copy.	Check here for Level 2A release, permitting reproduction and dissemination in microfiche and in electronic media for ERIC archival collection subscribers only	Check here for Level 2B release, permitting reproduction and dissemination in microfiche only

Documents will be processed as indicated provided reproduction quality permits.
If permission to reproduce is granted, but no box is checked, documents will be processed at Level 1.

I hereby grant to the Educational Resources Information Center (ERIC) nonexclusive permission to reproduce and disseminate this document as indicated above. Reproduction from the ERIC microfiche or electronic media by persons other than ERIC employees and its system contractors requires permission from the copyright holder. Exception is made for non-profit reproduction by libraries and other service agencies to satisfy information needs of educators in response to discrete inquiries.

Sign here, → please

Signature: Andy Johnson

Printed Name/Position/Title: Dr. Andy Johnson

Organization/Address: CAMSE, Black Hills State University
Spearfish SD 57799-9005

Telephone: 605-642-6893

FAX: 605-642-6871

E-Mail Address: andyjohnson@bhsu.edu

Date: 5/26/00

(over)