MODELING DISCOURSE MANAGEMENT COMPARED TO OTHER CLASSROOM MANAGEMENT STYLES IN UNIVERSITY PHYSICS

by

Dwain Michael Desbien

A Dissertation Presented in Partial Fulfillment
of the Requirements for the Degree
Doctor of Philosophy

ARIZONA STATE UNIVERSITY

August 2002

Introduction to Modeling Discourse Management

Modeling discourse management is the classroom management style I developed and investigated for this dissertation. Modeling discourse management attempts to create classroom discourse that is more student-centered than other PER based management styles. The instructor encourages students to bring new ideas and concepts to the class rather than using lecture or whole class questioning.

Figure 1 compares modeling discourse with Socratic discourse, which is common in PER courses (including previous modeling courses). Socratic discourse in physics education literature is often defined by an instructor questioning small collaborative groups or the whole class (Hake, 1992). The primary discussion occurs between the instructor and the students. Key features of modeling discourse such as seeding,

questioning, and a learning community are demonstrated in **Figure 1**.

Seeding/questioning is a common technique for motivating students to bring their ideas to the classroom community rather than to the instructor. The instructor is outside the community but interacts to provide activities, materials (tools), terminology, and guidance. The instructor extracts information from student discussions for use in formative evaluation of class progress and understanding. Terms used in **Figure 1** such as Learning Community and seeding are based on my own ideas and elaborated in Chapter 4. More details and a narrative example of modeling discourse management can be found in Chapter 4

Modeling discourse management was developed within the framework of the modeling theory of physics (Hestenes, 1992). The modeling theory of physics states that physics is based on a small set of models that represent the structure seen in the world. Modeling discourse management was designed to enhance the curriculum developed for the modeling theory of physics.

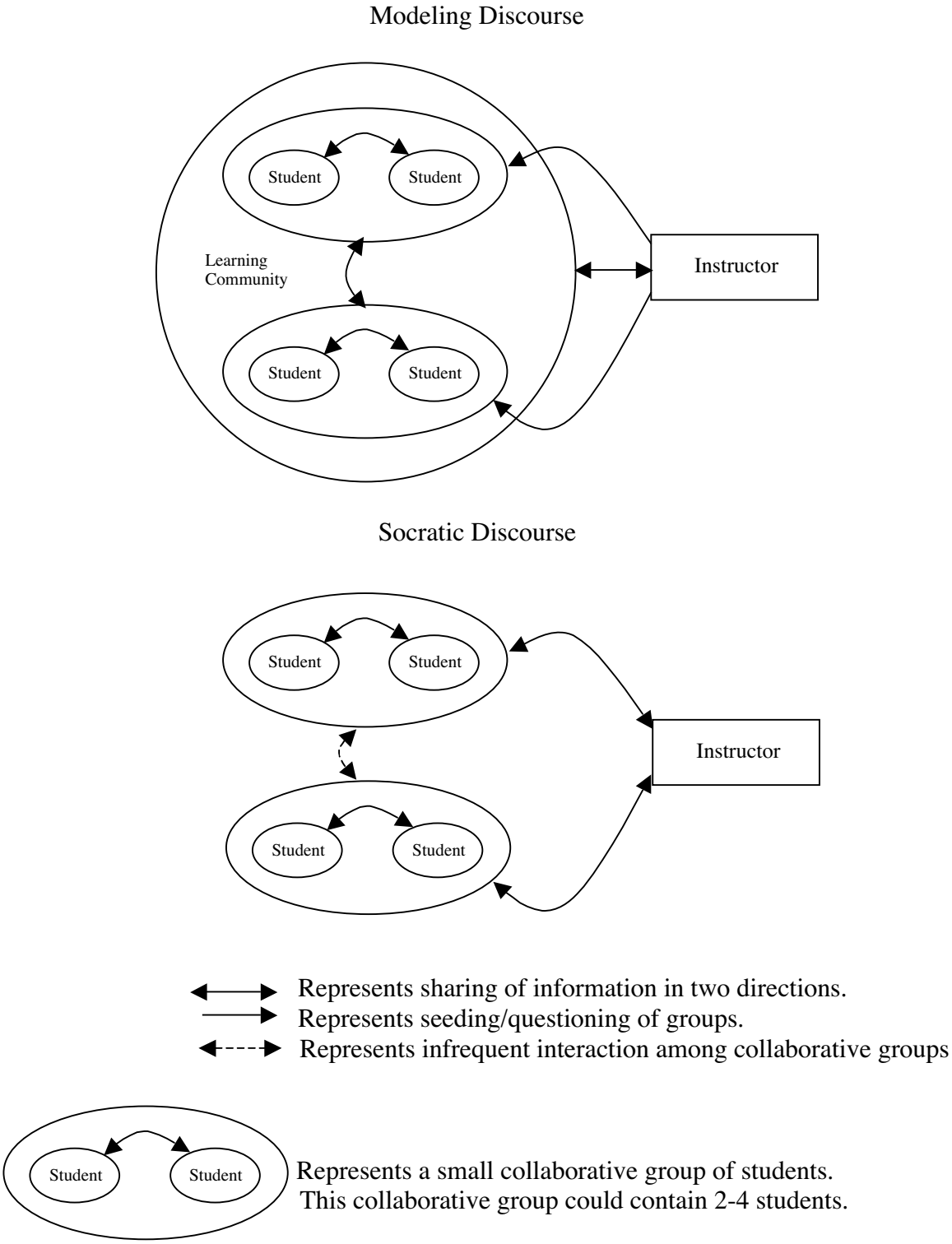

Figure 1. Modeling Discourse vs. Socratic Management Styles.

Chapter 4

Modeling Discourse Management

Introduction

This chapter is broken into two major sections. The first describes the impetus for creating modeling discourse management. The second section is a detailed description of modeling discourse management. Included in the last section is a narrative of a modeling from activity from beginning to end.

Why Was Modeling Discourse Management Developed?

Beginning in the fall of 1995, interviews were conducted with students in an honors university physics course using one version of the modeling method. Three major observations developed from these interviews. First, students felt that the representational tools were a burden, and they only included them on exams and homework if they were specifically asked to. Second, they felt that physics homework and exams should look like those found in a math class. Third, students felt that conceptual questions were unfair and that understanding was shown by the manipulation of equations. Students held onto these beliefs even after being shown holes in their understanding of a physics concept that they had used in a traditional physics problem. Because of the large emphasis placed on representations of structure in the modeling classroom, student resistance to alternative representations was disturbing.

The instructors noted a very interesting point on an exam (Politano, 1998). One question on the exam did not specify what representational tools to be used. However,

the students who used a specific representational tool rather than just equations did significantly better than those students who used only equations. Thus, to improve performance students would need to use alternative representations without instructor prompting. Therefore, a classroom environment needed to be created where students developed or adopted and used the tools.

The second observation from the interviews was that students did not see the usefulness of the models. Students felt like the models were imposed rather than being a natural tool of science. Every student interviewed felt that having to describe what model they were using and why they could use it was a waste of their time. If they got the right answer then that was all that mattered. From the interviews, it became apparent that most students felt that physics was absolute and proven and that Newton's laws were proven facts of the universe that could be applied without discrimination. However, physics does not look upon physical laws in this manner. All physical laws have a limited range of applicability. Thus, for modeling to be successful students would have to see the models themselves as the crucial element of knowledge. No amount of prodding by the instructor would work (that was already being done without success as seen by the interviews).

In order to change the students' views of models and representations of those models, a new classroom management style was needed. The physical models are well defined in the curriculum and physics education researchers have developed many good activities for students to address misconceptions (for example Van Heuvelen, 1991b, Thornton & Sokoloff, 1990, Laws 1991b, Hestenes 1996). Therefore, the problem

solution was not to change the class activities, but rather change how the class was managed. Students needed to develop the models themselves. The epistemology of science needed to be explicit. Use of shared representational tools needed to be developed collaboratively. The class needed to be a community working together like scientists through peer-peer interaction. Modeling discourse management was developed to meet these goals.

Modeling Discourse Management

Creating a classroom setting that meets the goals from the previous section required significant changes from previous modeling classroom management styles. I based on the aforementioned interviews, literature reviews, classroom learning, and personal reflection created modeling discourse management. Modeling discourse management would have to be multi-faceted and address issues from several different perspectives. There are seven major components of modeling discourse management, as seen in **Figure 11**. The names of the components and explanations that follow are my own creations based on consultation with my advisor and others in the PER community. Some of the terms used (such as Learning Community) have been used in education for an extended period of time. However, I am giving my definitions of these terms and acknowledge that others exist. Each of the aspects of modeling discourse management plays an important role in overcoming the short-comings of previous classroom management styles. The reader should note that the similarities between modeling discourse management's components and the section headings in the literature review

under discourse management. The literature cited in those sections was either instrumental in the development of modeling discourse or provided evidence that that aspect would enhance a classroom management style.

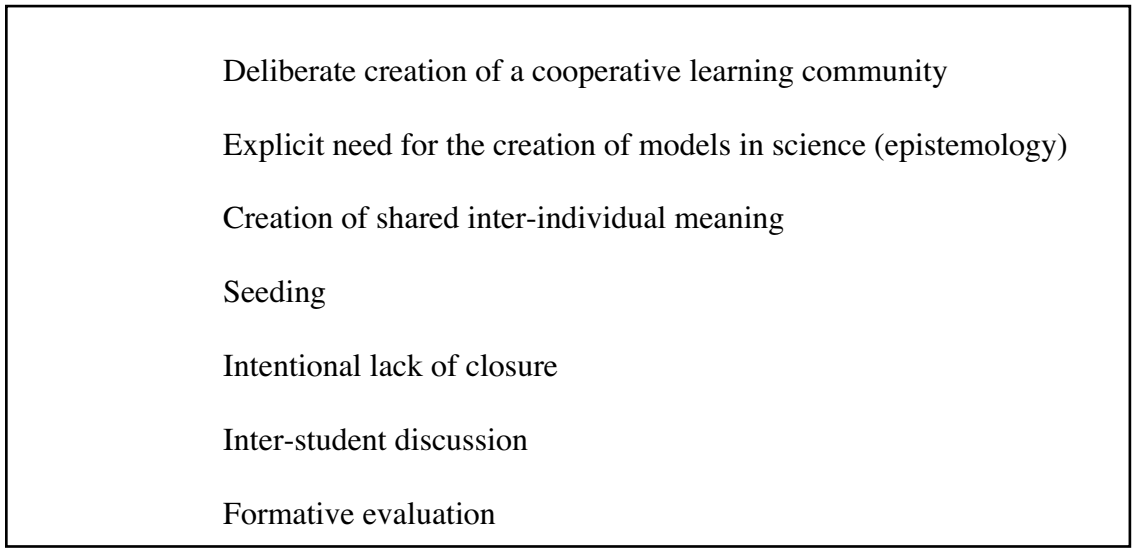

Figure 11. Components of Modeling Discourse Management

Creation of a Learning Community

At the beginning of the semester, the instructor must organize the class into a learning community. Before physics content is addressed, the classroom community must exist to foster student learning. The community is shaped by activities designed to encourage students to interact in a noncompetitive manner. To create this atmosphere without the pressure of "learning physics" at the same time is critical to encouraging the greatest number of students to be both involved in the discourse and prepared to be contributing members of the class (Beane, 1995). Student-student interaction is continually encouraged throughout the semester with an emphasis on cooperation.

The course begins with a community building activity. One such activity is to have small groups of students create instructions on how to make a paper airplane. The activity begins with organizing students into groups of three or four. Each group is told to create instructions on how to make a paper airplane on the paper provided. Immediately questions arise, such as:

Can we use pictures?

Does the plane have to fly?

Does create mean write?

All questions are answered the same way, by repeating the charge to create instructions on how to make a paper airplane. Students are also told to decide themselves what that means and act accordingly. After the groups complete the activity, the instructions are collected and redistributed to other groups who are told to use them to construct an airplane. As the papers are being passed out to other groups, the class is told to follow

the instructions exactly. Where the instructions are unclear the group must interpret as best they can. Typically students do not give this last comment much credence. As the groups begin to work the instructor passes among them asking questions. The instructor is looking for certain words or phrases in the instructions. As an example, students will often write "fold the paper lengthwise." The instructor might ask the group following that instruction what edge of the paper is the length and which is the width? Students typically respond that the long side is the length and the narrow the width. The instructor responds, "Why? What if you print on a printer in landscape mode?" The students soon see that every term on the page can be interpreted many ways. Then they gleefully create paper "airplanes" that in no way resemble what was intended by the creator of the instructions. Finally the class is then brought together for a discussion of the activity.

Discussion is best in groups of 20-30 students. If the class is larger than 30, it should be broken into multiple groups. This breakdown was done in the FC courses at ASU. This first discussion establishes a pattern for all future discussions. The students are brought into a circle with nothing inside it. The instructor explains that this will be the standard mode for class discussions. The instructor remains outside the circle during discussion. A typical student circle white board discussion can be seen in **Figure 12**. The instructor occasionally interjects a question but typically remains outside the discussion. To join the discussion the instructor must take a position in the circle. This way the instructor is seen as part of the circle and not the leader of the discussion.

Figure 12. Typical circle white board presentation

For the paper airplane exercise the students are then asked to share the difficulties in making the paper airplanes. What terms were ambiguous? What assumptions did they have to make? This portion of the discussion is typically very short. The instructor then asks the group why they might have been given this activity. What is to be learned? What role does this activity play for the rest of the classroom discussions? The discussion of these questions has been very dynamic and positive. Students quickly comment that terms need to be defined and agreed upon by the class and that pictures are often better than words. The students reach agreement on these questions quickly and without much conflict. When the discussion is winding down the instructor steps in and reviews what

has been agreed upon. The instructor emphasizes the shared definition of terms and the positive tone of the discussion. Homework is given that will allow for then next class to begin with a discussion that does not seem to involve physics. In this way, students practice discussion without the pressure of "learning physics". The homework given will be discussed later in the next section of this chapter.

The entire activity described above is completed on the first day of class to get the learning community started. The reader should note that several other modeling discourse management techniques were introduced, including seeding, creation of shared meaning, and inter-student discussion. A critical component of the modeling discourse management style is to *lay the foundation of a learning community early and continue to build the community throughout the semester*. Students are reminded of basic rules throughout the semester. The most common reminders are that only one person should talk at a time and that evaluation of other student work must be done in a positive manner.

Explicit Need for the Creation of Models in Science

Before beginning physics instruction, the instructor establishes a need for the creation of scientific models. At the end of the first day the students are given the following questions to ponder and answer with their own ideas:

What is reality?

What is science (or physics)?

Is science reality?

The second-class period begins with students working in small collaborative groups to create a white board summarizing their answers to the homework questions. Each student brings different background, experiences, and views of the world to the discussion. While the students work on the white boards the instructor seeds ideas. These ideas include the notion that science is both incomplete and in a constant state of change and evolution. Once the small groups are done, the class comes together for a discussion. As before, the discussion is done in a circle. Students are reminded to hold their white boards so that other groups can see them at all times. **Figure 12** clearly shows students holding white boards in this manner. The instructor emphasizes to the students that a goal of discussion is to reach consensus. One group is asked to present their ideas on the first question and let the discussion flow from that point.

During this discussion the instructor will often have to intercede and refocus it. The discussion is often intense and many different points of view are presented. In the end, the instructor's goal for the discussion is to have the students come to the conclusion that no explanation is complete. A secondary goal is to have students realize that how they describe something depends on their own experiences. The description of an event will be dependent on the observer and what aspects the observer focuses on. At the end of the discussion, the instructor summarizes the agreed upon ideas and introduces the idea of a model. The instructor discusses how a model has similarities to the object it represents but certain details are missing. The discussion ends with the idea that science continuously creates models because no one model is ever complete. Scientific models

do not explain reality – they only represent reproducible patterns that anyone can observe.

By the end of the second class the students have began to create a learning community and have developed the idea that science is about creating models, rather than discovering absolutes. Because of their participation in creating it, the students are developing ownership of the idea that scientific models are the basis of science.

Like the paper airplane activity the discussion of the first homework assigned was referred to often in the class. Throughout the semester students are reminded of their agreement that they are creating models and that models have limitations. Students are also reminded that it is important to communicate those limits so that others understand the model was used appropriately. Students are reminded that there is no "right answer", as the answer you develop depends on the model used.

Creation of shared inter-individual meaning

For a discussion to be meaningful the participants must speak the same language. The whole community must agree upon and understand definitions of commonly used terms. Therefore, modeling discourse management aims to have students realize the importance of shared meaning. The paper airplane activity is designed to bring this to their attention in a memorable way.

Besides definitions, students also need to agree on concepts and scientific models. Throughout the semester discussions are focused on building such agreement. The agreed upon terms, concepts, or models can then be used freely in discussions. Terms

that have not been agreed upon cannot be used in the discussions. Guidlines for discussion must also be agreed upon. One such rule is that no term can be used until a definition has been agreed upon.

Another important aspect of shared meaning is to understanding the role of communication tools. The whiteboards used is a physical tool to aid the discussion. Other tools are more essential to physics. One common tool in physics is mathematics. Equations are abstract and often difficult for students to reason with. Modeling theory uses a variety of more intuitive representational tools. Students should discuss the utility and scope of the tools. **Figure 5** shows several such tools, including system schema and force diagrams.

The use of such tools is not unique to modeling instruction. However, modeling discourse management differs from other classroom techniques in involving the students in selecting the tools and assessing their utility. Intentional lack of closure in discourse is often used as an impetus for introducing new tools. The tools are seeded to small collaborative groups that introduce them into class discussion. Since students introduce the tools, their peers are more likely to question and evaluate new tools. Ideas introduced by an authority figure, like an instructor, are often accepted without adequate thought. The shared understanding of the tools is built during whole class discussion. The tools are then available for subsequent class use.

Seeding

Seeding is the primary technique for introducing new ideas into modeling discourse. The instructor seeds a small collaborative group with a question or a hint. This group may be struggling and need some extra help or be further along and need a challenge. The seeding process is illustrated in **Figure 1** in Chapter 1.

By seeding questions, concepts, and ideas the instructor need not introduce an idea to the whole class because the small collaborative group introduces the seeded idea into the class discussion. Seeding is done during small collaborative group time so the group has time to work out details and gain ownership of the seeded idea. Thus, peers, instead of an authority figure, introduce the ideas to the whole class.

What and when to seed are the toughest questions for a modeling discourse instructor. At the start of each activity the instructor should have an agenda and goals for the activity. This much is similar to previous modeling classroom management styles. While the small groups are working the instructor looks and listens for key words or pictures from the small groups. The instructor must then formulate a question or hint. After asking a leading question, the instructor should not necessarily wait for an answer. It is usually better to leave the group to contemplate an answer of its own. A well designed seed should be direct and induce the group to move forward. Seeding should be done early in the small collaborative group work so that the students have time to work out the details of the seeded idea and gain ownership.

Seeding also stimulates broader participation in class discussion. If a group is reticent, the instructor might seed that group with a simple idea that is important but easy

to introduce, or with a question that the group can ask of the whole class. If one group tends to dominate discussions the instructor should suggest to that group individually that they let other groups explain the results. The instructor can also ask certain groups to present their white boards first and ensure the most vocal groups do not start out the discussion.

Students often come up with a technique or idea that the instructor had not thought of. Therefore the instructor must be flexible and prepared to develop ideas for seeding in real time. Occasionally a seeded idea will lead to a discussion tangent to the planned activity or discussion. As long as the result is desirable, the tangent should be explored. Thus, instructor flexibility is required.

Intentional lack of closure

Previous sections stated that at the end of the whole class discussion the instructor reminds the class of what had been agreed upon and unresolved observations or problems. The instructor does not resolve the issues but merely keeps them alive. Without closure, students continue to wrestle with the issues outside class and return with new ideas to share. Thus, lack of closure can foster student thinking about the class activity between classes and keep the discussion lively. An unexpected benefit of not resolving issues before the end of class is an increase in office hour attendance.

Adequate follow-up is essential to reap benefits from lack of closure. Lack of closure is of three common kinds. First, at the end of a class the class may not have agreed upon some issues or definitions. The next activity or assignment should then be

designed to help students resolve the remaining issues. The students are then given the opportunity to discuss the results with the whole class. The second kind of lack of closure comes from an incomplete class activity. For example, students working in small groups may be asked to think of at least five questions that their group has not resolved. The students then white board their questions for whole class discussion. At the end of the discussion a master list of unresolved questions from the various groups are developed. The instructor gives no closure at this time other than stating that these questions need to be answered. By the next the instructor has developed activities or homework that help students address those questions. However, by that time the students may have arrived at answers themselves.

The third kind of intentional lack of closure is more radical. Students are occasionally given a homework problem that they do not have the tools or knowledge to complete. This kind of problem should be given early in the semester. Students are typically not pleased they cannot solve the problem. Most are worried that since they did not finish the problem, their grade will suffer. However, the instructor should explain that this problem will only be graded on effort and that the class will discuss the solution. The problem should also require application of the next topic that the class is scheduled to cover. The students are prepared for a new idea because of their inability to solve the problem. While small collaborative groups are working on the problem the instructor seeds the new idea to a few groups. Follow-up activities or homework that use the new idea are given.

This last technique is ineffective unless a working learning community has been developed. A level of trust among the students and instructor must exist. Otherwise students worry more about their grade than the problem at hand. Also, the students need to see the class as built on cooperation and not competition. Otherwise, students will not share seeded ideas.

There is a one possible negative to this lack of closure. Some students use this kind of problem as an excuse for not putting sufficient effort into homework. Some students assume that any problem that requires extra effort will be discussed in class. Therefore it is important that the follow up problems to an impossible problem require thought and work. The follow up problems cannot be simple problems.

Inter-student discussion

All aspects of modeling discourse management aim to foster student-student dialogue. Inter-student discussions allow for the free flow of ideas. Real discussions and real cognitive dissonance occur more frequently when students do not feel the pressure of an authority figure questioning their ideas. A fundamental goal of modeling discourse management is for inter-student discussion to be the dominant mode of discussion. The components of modeling discourse management previously discussed contain techniques and methods to help foster inter-student interactions. However, these techniques alone are not sufficient to foster quality student-student interactions.

Two more critical issues need to be addressed: the physical layout of the classroom and the role of the instructor during the class discussion? These two issues are discussed below.

To facilitate modeling discourse a classroom should have two major components. First, it should have tables on which students can perform experiments, have small group discussions and create white boards. **Figure 13** shows what this portion of the room might look like. Second, the room should have an area for whole class discussions that is free from obstructions. When in the circle for whole class discussion there should be no tables or chairs between the students. This can clearly be seen in **Figure 12**. Having the students in this arrangement allows for students to see all white boards at the same time. Then, similar items on the white boards are quickly noted and attention can turn to differences. Since common items are not repeated, the discussion moves more quickly and deeper issues can be addressed. Also, the avoidance of unnecessary repetition keeps the students from becoming bored and allows for more questions to be addressed. Note that this overall approach is a large departure from traditional modeling white boarding.

Figure 13. Workspace for small groups in a modeling classroom

Some of the modeling discourse classrooms used in this research had less than optimal designs. However, the classrooms were physically arranged to be as close to optimal as possible. The CGCC classrooms were very well designed for modeling discourse management. A diagram of the CGCC classroom can be seen in **Appendix D**.

During the all class discussions, the instructor's actions are critical. First, the instructor should not be central to the discussion if involved at all. If the instructor is the focus, student-student interactions are unlikely to occur. Therefore, the instructor should observe discussions from an unobtrusive position. The instructor should be able to easily hear the discussion, but in a location that is difficult for students to see. The instructor should typically only intervene to enforce the agreed upon rules of discussion, refocus the discussion with a question or comment, or summarize the agreed upon ideas at the end of

the discussion. Major ideas that the instructor wants addressed in discussion should be seeded during the small group work. A modeling instructor should expect silent time during the discussion and should not talk during the dead time. The instructor must resist the urge to "explain the idea" that is not being understood. This seemingly passive role is difficult for many instructors. However, the next section of this chapter discusses how the instructor is not passive.

Formative Evaluation

The whole class discussion is a critical time for a modeling discourse instructor. Though the instructor should appear passive to the students, the instructor is actively evaluating the student discussion for understanding, misconceptions, and conceptual holes. The instructor should pay careful attention and take copious notes on the discussion. However, the students should not be aware of the amount of notes the instructor is writing. The notes serve two purposes. First the notes serve as a reminder of agreed upon concepts or ideas and of questions to ask the class at the end of the discussion. Second the notes serve as information for the instructor to use in post-class reflection. Critical reflection by the instructor is essential for the success of a modeling discourse class.

After each class the instructor must evaluate the days classroom activities. The instructor must decide if the goals were met, if progress was made, if misconceptions surfaced and if correct unplanned ideas were discussed. Without adequate notes this reflection is very difficult. During reflection the instructor develops future activities that address the shortcomings of student understanding. The instructor can also modify the

pace of the class to meet the students' level of understanding or change the order of activities to better suit student needs. Reflection on the notes after each class can be time consuming. After each class the instructors using modeling discourse management spent 1-2 hours on reflection. Some of this time was in self-reflection. Self-reflection would include personal evaluation on what the instructor seeded and how well it worked. It would also include reflection on the management of the classroom discussion. Common questions reflected upon include the following:

Did I intervene too much during discussion?

Did I let the discussion progress too far/not far enough?

Was more time needed for the activity?

What ideas surfaced that I was not prepared for?

Not only is instructor reflection important, but so is student reflection. The students should be given activities and homework that requires them to evaluate their own understanding and the classes' understanding. The instructor's job of evaluating class progress is simplified when students reflect on their own understanding and bring their unresolved questions to the class for discussion. The instructor designs activities that address the questions students have identified.

In addition to instructor and student reflection there is another critical element to formative evaluation in modeling discourse management. The instructor should keep a journal for each class taught using modeling discourse. This journal is based on the classroom notes and the reflection upon those notes. The journal allows for both reflection on the whole semester and tracking of student and instructor progress. The

instructor can perform self-evaluations of discourse management. The instructor also tracks what activities have an impact on students for a specific course. Students from different courses overcome misconceptions at different rates and through different activities. The journal helps the instructor recall the types of activities or homework that has been the most effective for a particular course.

The journal also serves as a starting point for future courses. Future courses are built using activities and homework that were effective; and less effective activities are replaced with new ones. The journal helps the instructor pace the future course. The journal provides reference for future semesters on difficulties and common places misconceptions arise. Previous semester's journals are a valuable tool for formative evaluation of current classes.