CHAPTER 3: METHODS

Research Context

Participants

The participants of the study were eight 8th grade students who were enrolled in the Constructing Ideas in Physical Science (CIPS) curriculum at a middle school in a semi-rural town just outside a southern California metropolis. These students were organized into two four-person groups. Barring two exceptions (described below), the students stayed in these groups for the entire 5-week length of the study, during which time the groups worked through the last 3 cycles of the CIPS Interactions and Motion Unit. The 3 cycles were Combining Pushes & Pulls, Resistive Interactions, and Non-Contact Interactions -- Gravity. Both groups were taught by the same experienced teacher, although the groups were drawn from two separate classes.

Using the following method, groups were chosen to ensure a heterogeneous mix of students in terms of talkativeness, gender, and prior achievement in the class. As a first step, after having previously observed both classes for 2 weeks, I constructed (on paper) two potential 4-student groups, each with a mix of infrequent, sometime, and frequent small-group talkers (at least one per category), low-, medium-, and high-achieving students (at least one per category), and at least one male and one female per group. I then met with the teacher to discuss whether he thought that the groups would be workable (i.e., would the students get along? was my assessment of the students' prior achievement accurate?). Based on the

teacher's comments, some students were removed from my list of potential candidates for the two groups. They were removed for a number of reasons: because I had misinterpreted a student's prior achievement, because it was known that a student would soon transfer to another class, or because the teacher knew of personal conflicts between the student and other students in the group. The final composition of each group was decided by choosing suitable replacements for the removed students. The teacher and I jointly decided on these replacements.

The groups were formed two days before the start of Cycle 3 so that students could participate in team-building and "doing science" (science methods) activities in their newly formed groups. Group 1 (from class 1) initially consisted of three females and one male: Darla, Grace, Lacey, and Porter. Group 2 (from class 2) initially consisted of two females and two males: Roxanne, Sabrina, Arthur, and Jasper. Porter dropped out of Group 1 during the final week of the study because he left school to be homeschooled. Jasper was transferred out of Group 2 at the end of the second week because he proved to be disruptive and distracting. Neither Porter nor Jasper were replaced once they left their groups.

Overview of the CIPS Curriculum[1]

Hours and duration. Including the team-building and "doing science" activities (neither of which were officially a part of the Interactions and Motion

[1]In this study, the CIPS curriculum was in its first pilot year of testing. A number of the curricular problems that are noted in later chapters of this Dissertation have been corrected in subsequent versions of the curriculum.

unit), the last three cycles of the Interactions and Motion unit were taught from January 3rd - February 8th, 2000. Class periods were 50 minutes long.

Curriculum. The CIPS pedagogy represents a rethinking of the roles of teacher, students, and materials. Students in a CIPS course are largely responsible for the introduction, development, and critical evaluation of ideas, models, and explanations in physical science. They do this by interacting with each other in small groups, participating in whole-class discussions, doing experiments, observing computer simulations, and using idea logs to keep track of the change in their understandings of physical science -- all in a structured setting. This structure is provided both by the teacher (who acts as a guide and mentor, rather than a provider of scientific information) and the curriculum materials.

The CIPS units are divided into cycles, each intended to support students' construction of a relevant model or component of a model. For example, the Interactions and Motion unit is divided into five cycles: Exploring Motion, Pushes and Pulls, Combining Pushes and Pulls, Resistive Interactions, and Non-contact Interactions -- Gravity. Each cycle generally consists of four phases: elicitation (1 activity), development (2-5 activities), consensus (1 activity), and application (1 activity). Activities are typically structured to last for a single class period, although longer activities might take up to two periods to complete.

The Elicitation ("First Contact") activity engages students in an extensive and robust whole-class discussion centered around an interesting phenomenon. Students are asked to make predictions, explain their

predictions based on prior knowledge, observe the outcome of an experiment or demonstration, and then to suggest ways of making sense of the outcome (which is often a surprise to many of the students). At the end of the elicitation activity, students share the ideas that they've used to make sense of the experimental outcomes. First this sharing is done individually (within the group), and then each group shares their ideas with the rest of the class. The purpose of this activity is not to make judgments about which ideas suggested by the students are the most "correct", but instead to open up important issues and ideas that make sense to at least some of the students in the class and can serve as focal points of further inquiry.

During the Development ("What's Up?") phase, which spreads across a number of different activities, students test the elicitation ideas in a wide variety of experimental, hands-on contexts. Development activities are based on research in student understanding for a particular topic, and are designed so that the activities challenge common student ideas and support the development of more powerful ideas. As students go through the development phase, they modify some of their initial ideas, cast some aside as not being useful, and invent new ideas. This evolution of ideas is recorded in the students' idea logs.

In the Consensus ("We Got It!") activity, each group selects a set of ideas that the group believes will account for the phenomena encountered thus far. The instructor then leads a whole-class discussion in which the students consolidate the development ideas and come up with a set of evidence-supported class consensus ideas. These ideas tend to be closely

aligned with target ideas for the cycle, except they are phrased in terms suggested by the class. At this point the instructor may introduce appropriate technical jargon, conventions, and formalism.

The Application ("Power Drive") activity assesses the students' understanding of the cycle's key ideas by allowing students to test those ideas in a novel context. For example, the Lost in Space application (which describes the loss of a space orbiter in Mars' atmosphere) in the Resistive Interactions cycle has the students analyze the motion of the orbiter in terms of systems, pushes and pulls, and energy transfer.

Finally, the CIPS activities and cycles are presented to the students with a justification as to why they might be relevant or interesting. To provide this rationale, the CIPS curriculum is framed by a science fiction storyline in which four alien characters (Kinet, Modulus, Stas, Teract) land on Earth and discuss and investigate various physical phenomena. In particular, each activity is introduced with a brief alien dialogue that sets up the focus question for that activity. In these dialogues, each character possesses unique personality traits and characteristics. Kinet, for instance, is interested in energy and energy transformations. Modulas is concerned with how things work as integrated systems. Teract wants to know how the various components of a system act on and with each other.

Unit, cycle, and activity summary.

This section presents a unit/cycle summary for units 1 and 2 and also presents an activity/idea summary for cycles 3-5 in unit 2 (the cycles directly relevant to this study).

Table 3-1. Unit summary for CIPS units 1 and 2.

Unit	Cycle Summary
Unit 1: Hasty Conclusions	Cycle 1: Characteristics of good and poor scientific arguments Cycle 2: Describing events in terms of systems Cycle 3: Describing events in terms of energy transfers/transformations
Unit 2: Interactions and Motion	Cycle 1: Identifying and representing types of motion Cycle 2: Pushes, pulls, and energy transfers/transformations Cycle 3: Combining pushes and pulls (See Table 3-2, below) Cycle 4: Resistive interactions (See Table 3-3, below) Cycle 5: Non-contact forces -- Gravity (See Table 3-4, below)