Making Science Accessible to All:

Results of a Design Experiment in Inclusive Classrooms

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Abstract

Recent science reform documents call for students to develop robust understandings of scientific concepts and reasoning through inquiry-based instruction. The challenge of this goal is increased in heterogeneous inclusive classroom settings with students identified as having learning disabilities and emotional impairments. This article describes a design experiment conducted over two school years in which we investigated the experiences and outcomes for special needs students in guided inquiry science instruction in upper elementary grade classrooms (n=4). Phase 1 (97-'98) of the design experiment utilized qualitative and quantitative data to construct case studies of individual learners with special needs. Patterns across the cases informed the identification of advanced instructional strategies hypothesized to support special needs children relative to language / cognition, print literacy, attention, and social relations challenges. In Phase 2 (‘98-'99), we studied learning outcomes from instruction including the advanced strategies (same teachers, topics as Phase I). Our findings indicate that in Phase II (with the advanced strategies) all students showed significant learning gains over Phase I and that special needs and low-achieving students in three of four classes showed changes in understanding comparable to those of normally achieving students. We conclude by identifying implications of these findings for the roles of general and special educators.
The Challenge of Inquiry-Based Science Instruction

Recent science reform documents call for students to develop deep understandings of scientific concepts and scientific reasoning through inquiry-based instruction (NRC, 1996). While there are many aspects of inquiry-based instruction that speak to its appeal, it is, in fact, a very complex form of instruction, placing considerable demands on students and teachers alike. Scientific inquiry engages students in designing investigations, and in using the multiple literacies of mathematics, reading, writing, and oracy as they: gather data, determine how these data constitute evidence for the claims they are generating, share and evaluate these evidenced-based claims with others, all along working toward an explanation for the phenomenon they are investigating.

Teachers are challenged in the inquiry context to: determine the kinds of powerful problems that will engage students in productive inquiry, understand the knowledge and reasoning goals (cf. Schwab, 1964) appropriate to the inquiry, mediate children’s thinking and reasoning so that they might attain these goals, and assess their students’ progress toward these goals.

The complexity of this learning and teaching is clearly exacerbated when one places this instruction in the context of an inclusive classroom in which students identified as learning disabled and emotionally impaired increase the heterogeneity that is already characteristic of most classrooms in the upper elementary and middle school years. Furthermore, it is hard to know where educators might turn for guidance regarding supporting the learning of identified students in guided inquiry science teaching due to the paucity of research conducted in this arena.

A recent, extensive review of the literature by Miller (1999) indicated that there have been very few studies of students with special needs in the kinds of guided inquiry classrooms that are called for in the science reform documents. From studies of traditional (i.e., non-inquiry, text-based) science instruction – for example, Carlisle and Chang’s (1996) three-year longitudinal study of students with learning disabilities – we know that special needs students fare poorly and express doubts about their capacity to perform successfully in these classes. One might expect similar if not more extreme results in the face of the complexity and challenge of learning via inquiry; however, early research regarding inquiry-based instruction suggests otherwise. Dalton, Morocco, Tivnan, &
Mead (1997) in a study examining the development of conceptual understanding in an inquiry-based condition compared to an activity-based (essentially unguided) condition found that all students showed greater attainment of conceptual understanding in the inquiry condition. The outcomes for students with learning disabilities in this study were not as great as for their non-identified peers; hence, more research is needed to determine how to sufficiently support students with learning disabilities, but the potential for these students to profit from inquiry-based experiences makes this line of research very promising.

Explanations for the difficulties experienced by students with learning problems in the context of science instruction vary and suggest different forms of intervention. For example, Gersten and Baker (1998) have argued that students with learning disabilities must become "fluent with essential factual and conceptual knowledge" (p.24) before they can profitably engage in inquiry-based instruction. Furthermore, Woodward and Noell (1991) and Mastropieri, Scruggs, and Butcher (1997) submit that students with learning disabilities require significant coaching to engage productively in the kinds of reasoning that are typically associated with inquiry-based approaches to science instruction. However, these claims remain to be tested in science classrooms employing inquiry-based instruction. Toward that end, our research asks the following questions:

1. What are the opportunities and challenges that guided inquiry science instruction presents students with special needs?
2. How do students with special needs respond to these opportunities and challenges?
3. How can teachers mediate students’ participation in guided inquiry science instruction for the purpose of enhancing their engagement and learning?
4. What are the learning outcomes of advanced design and mediation of learning?

Using a Design Experiment to Meet the Challenge of Enacting and Investigating Outcomes from Guided Inquiry Science Instruction

To address these research questions, we have been engaged in programmatic research under the auspices of the Research Institute to Accelerate Content Learning through High Support for Students with Disabilities in Grades 4-8 (REACH). Our multi-phased project is being conducted as a design experiment, which refers in education to the engineering of innovative educational
environments in which one simultaneously conducts experimental studies of teaching and learning over several iterations of the design of the environment (Brown, 1992). In this manuscript, we report on two phases of a design experiment involving the engineering of guided inquiry environments at the upper elementary school level, and the evaluation of learning from that instruction. Phase 1, which took place during the ’97-’98 school year, was designed to answer our first two research questions: investigating the experiences of Grade 4 and Grade 5 students with special needs as they participated in guided inquiry science instruction. Phase 2 of this research, which took place during the ’98-’99 school year, addressed questions (3) and (4) above: investigating the learning outcomes for students with special needs in the condition of guided inquiry instruction with advanced instructional design and mediation of learning, informed by the outcomes of the research in Phase 1.

General Context

The context in which we are conducting this research has its origins in a professional development project initiated in 1996, when 18 Kindergarten through 5th grade teachers with a common interest in enhancing their ability to engage in guided-inquiry teaching of elementary science, committed themselves to joining forces with university-based researchers for the purposes of launching a Community of Practice (Rogoff, 1997; Palincsar, Magnusson, Marano, Ford, & Brown, 1998). The goal of this Community was to determine the range of teaching practices that promote children’s inquiry-based learning of scientific understandings, as well as the means by which the scientific knowledge is produced (i.e., by employing the tools, language, and ways of reasoning characteristic of scientific reasoning) (Driver, et al., 1985; Lemke, 1990; Wells, 1995).

The Nature of the Instruction

Important to understanding this context is a specific form of guided inquiry science that students in this design experiment experienced. We refer to our orientation to science instruction as Guided Inquiry supporting Multiple Literacies (GIsML; Magnusson & Palincsar, 1995). This orientation has been shaped from our knowledge of research and practice concerning intentional learning in school settings as well as research examining the norms and ideals of actual scientific
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activity. As such it embodies the principles of teaching for understanding that guides the research and development across the content areas in the REACH institute. In this orientation to science instruction, inquiry is guided by a question that is broad and identifies a general conceptual terrain (e.g., How does light interact with matter? Why do things sink and float?). Inquiry proceeds through cycles of investigation stemming from more specific questions (e.g., How does light interact with mirrors? How can a 100g clay ball be shaped to float and hold the most weight?) or a particular phenomenon (e.g., refraction of light through various liquids, behavior of a diver in a Cartesian Diver System\(^2\)). These activities are authentic to the nature of scientific practice, and provide students with multiple opportunities to engage in higher order thinking toward the development of deep knowledge of major ideas in science.

Integral to this approach, and consistent with our view that learning is socially mediated, is the conception of the classroom as a community of inquiry (cf. The Cognition and Technology Group at Vanderbilt, 1994; Wells, 1995) in which investigations and the documentation of data gathered in the course of an investigation take place in pairs or small groups. A critical feature of GI'sML instruction is a phase during which the investigative teams publicly share their data, reporting to the class about the evidence they have gathered to support or refute extant claims, and to contribute new claims for the class’s consideration. These small and large group conversations to some extent mirror the authentic activity of scientists working within their research group and then reporting to the larger scientific community. Moreover, they are powerful sites for the active construction of knowledge as students share their interpretations of how to investigate, what sense to make of their data, and how to represent their claims to the classroom community. In particular, the conversation in the whole group setting affords students the opportunity to compare and contrast their ideas with others, collectively determining the ideas for which they have consensus and those for which they

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\(^2\) A Cartesian Diver System consists of a small test tube, referred to as the diver, that is partially filled with water and is inverted and floating in a large test tube that is completely filled with water and capped with a piece of rubber sheeting. When the rubber sheeting is pressed, the air in the diver (small tube) compresses, allowing more water in the diver, which changes the density of the diver relative to the total system and causes the diver to sink. When the pressure on the rubber sheeting is removed, the reverse process occurs, and the diver floats back to the surface.
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do not, in a public forum that provides opportunities for the teacher to press for such comparisons and decisions about consensus.

GIsML instruction is recursive to the extent that students repeat cycles of investigation (including reporting) to refine their thinking regarding a particular line of inquiry. For example, having investigated how light interacts with objects, and having developed claims regarding the behavior of light (e.g., light can be reflected, transmitted, or absorbed), the students might advance their inquiry by investigating particular kinds of materials that will enable them to support or refute extant claims about the behavior of light (e.g., that light can be both reflected and absorbed by an object). This recursiveness is critical to advancing meaningful learning; one needs sufficient experiences examining relationships among phenomena before one can meaningfully test explanations for these phenomena.

In the course of GIsML instruction, students and teachers participate in two forms of investigation. Through *first-hand investigations*, children directly experience and study phenomena for the purpose of constructing claims about the nature of the physical world. In the course of *second-hand investigations*, children consult text for the purpose of learning about others’ experiences and interpretations of the physical world and concepts created to describe it. Each of these activities places different cognitive demands upon students. The cognitive strategies that are helpful to meeting these demands are supported in their development and use by being modeled by the teacher and the materials, given explicit attention in public conversations in which the teacher presses for and shapes attention to strategies, and encouraged in their use by the nature of the instruction, which places students in positions where they are asked to reflect and reveal their own use of particular strategies.

Multiple cycles of investigation occur within an inquiry into a specific topic, and each cycle proceeds through several phases of instruction. The phases are: Engage, Investigate, Explain, and Report. A cycle always begins with engagement and ends with reporting (the public sharing of claims and evidence). In-between those phases students are involved in investigating, sometimes
for the purpose of determining relationships about the nature of the physical world, and at other
times also to construct and test explanations for these relationships. The ultimate goal of GIsML
instruction is to support children’s learning of scientific understandings, and to enable students to
experience, understand, and appreciate the ways in which these understandings evolve by using the
tools, language, and ways of reasoning that are characteristic of the scientific community (cf.
Driver, Guesne, & Tiberghien, 1985; Lemke, 1990; White & Frederiksen, 1998). Typically,
teachers conduct a GIsML program of study over several weeks (two to six weeks depending upon
grade level and topic) on a daily basis, for 45 minutes to two hours a day (dictated by scheduling
constraints, instructional requirements, and preferences of the teacher and/or students).

We hypothesized that GIsML instruction provided particular opportunities for students with
special needs because of the following features: (1) the emphasis is on participation in a learning
community in which there are overlapping zones of proximal development (cf. Brown &
Campione, 1994) and students are thought of as having and using distributed expertise, (2) there
are multiple ways in which children can communicate what they know (i.e., thinking is
communicated in the context of orally reporting on one’s investigation, and documenting one’s
learning with the use of writing, drawing, and other graphic representations), (3) there are multiple
cycles of investigation during which children experience coming-to-know as a recursive process in
which one’s knowledge and reasoning are refined over time, and (4) children have the opportunity
to engage in problem solving through activity (e.g., manipulating the phenomena they are
investigating). We also hypothesized that there would be unique and potentially significant
challenges associated with GIsML instruction, posed by the cognitive, linguistic, and social
demands inherent in this type of instruction (cf. Dalton, Morocco, Tivnan, & Mead, 1997). These
hypotheses guided the design of Phase 1 of our research.

Our second-hand investigations feature the use of an innovative genre of text that “lays bare” the thinking of a
scientist; hence, providing a model think-aloud that can guide student thinking.
The Design Experiment: Phase 1

Recall that the overarching purpose of Phase 1 was to investigate the engagement and learning of students identified as learning disabled and/or emotionally impaired, as they participated in GIsML instruction in inclusion classrooms. The vehicle used to conduct this research was the construction of case studies of special needs students in the context of Guided Inquiry science teaching.

Participants

This research was conducted in the classrooms of all of the fourth and fifth grade teachers in the GIsML Community of Practice (n=5; three 4th and two 5th grade teachers). These teachers represented three districts that are fairly heterogeneous with regard to their student populations. Granite City (two 4th grade and one 5th grade classroom), serves a population in which 51.6% of the students qualify for free, or reduced-cost lunch; and 30.3% of the students are African American. Maple Grove (one 5th grade class) is a low SES, rural community whose population is 91.5% white, while Greenville (one fourth-grade class) is principally a professional, white, community with only 8% of the students qualifying for free, or reduced-cost, lunch. Each school observes an inclusion model, providing full-time education of students with a range of handicapping conditions (n ≈ 3-5) in the general education classroom (n ≈ 25-28). A total of 168 students participated in Phase 1 of the research, 22 of whom had an Individualized Educational Program and were identified as learning disabled and/or emotionally impaired, and one of whom was identified as having a pervasive developmental disorder. Table 1 presents demographic data regarding the students in each of the four classes, for each phase of this design experiment.

Table 1 about here

Procedures

To construct the student cases, we engaged in an array of quantitative and qualitative research methods, including:
Observational Research

The researcher, using a video camera and field notes, followed the teacher during both whole class as well as small group activity. In addition, there was a sound system adequate for capturing students’ participation during these whole-group activities.

During the small group activities, a researcher continued to follow the teacher (who was wired with a remote microphone) while other researchers focused on the activity of the identified students in the class, rotating attention from one child to the next in 15-20 minute intervals. If the researcher found the child to be totally disengaged in the activity of GIsML instruction for a five-minute period, the researcher intervened for the purpose of exploring procedures for re-engaging the student, starting from low-level interventions and proceeding to more supportive interventions, only to the level necessary to re-engage the child. An example of a low-level intervention was asking the student to describe and/or explain what he or she was doing. A more high-level intervention included offering to record the child’s thinking if he or she appeared to have writing difficulties. The nature of the support as well as the student’s response to the intervention was recorded in the researcher’s field notes.

In addition to characterizing the opportunities and challenges associated with GIsML instruction, the research was designed to determine how students with special needs responded to these opportunities. Some of the data useful to answering this query resulted from the observational data described above. However, to understand what individual students acquired in the way of scientific concepts and the ability to engage in scientific reasoning as a function of their GIsML experiences, additional data were needed. These data are described next.

Formal Written Assessments

There were three formal written assessments administered to all student participants in each class: a) a standardized reading assessment – the Gates-MacGinitie – measuring vocabulary knowledge and comprehension, which was administered as a pre-assessment to establish entry-level reading achievement, b) a pre- and post-assessment of the students’ conceptual understandings

\[\text{Districts and participants have been assigned pseudonyms}\]
of the topic of the program of study, and c) a pre- and post-assessment of children’s attitudes
towards and beliefs about the nature of science and scientific reasoning.

Relative to the identified students, these formal measures were used for several purposes. One
purpose was to gather information regarding children’s prior knowledge. These data informed the
teachers’ thinking and decision making as they planned the program of study with the university-
based researchers. A second use was to compare the entering knowledge and beliefs of identified
children with their unidentified peers. A third role was to assess changes in students’ thinking
following the program of study. These formal measures, however, do little to inform the question
of how children have come to these attitudes, beliefs, and understandings. To address that issue,
we collected the following data.

Individual Interviews

Interviews with individual identified children were conducted frequently (each day, or every
other day), following GIsML instruction. They were short in duration (5-10 minutes), and children
were asked the following set of questions; (1) What happened in class today? (2) What did you
do today? (3) What did you learn about [topic under study], (4) Was there anything helpful to your
learning today? (5) Was there anything that was unhelpful to your learning today? (6) What would
have been helpful to your learning today? and (7) Is there anything else you would like to tell us?

Engaging the identified students as informants served the following purposes: a) to ascertain
the child’s perspective on the day’s events, and b) to provide elaboration upon the field notes for the
day. This allowed juxtaposition of the child’s reflections on the day’s events with the other records
of the day’s events.

Student Artifacts

Products generated by all students, which included the notebooks they used during science
instruction and the posters completed by pairs or groups of students to represent their findings to
the class, provide another window on children’s thinking and learning throughout the instruction.
For example, it was not uncommon in small group activity to observe an identified child assent to
the position of the group, only to reveal in her own notebook entry that, in fact, she had a more
accurate or complete conception than did her peers. These artifacts were also invaluable for learning more about the mediational means and semiotics that children drew upon in resourceful ways when traditional writing was ineffectual for them.

**Video Records and Field Notes**

Finally, the (partial) video-record and field notes were integral to “getting another look” when trying to fill in the details regarding the day’s events, or when checking on the relationship between the identified child’s account and the events as they appeared to unfold to an observer.

**Instructional Context**

In two fourth grade classrooms, the teachers implemented a program of study entitled *How Light Interacts with Objects*. In the fifth grade classrooms and the remaining fourth grade classroom, the teachers implemented a program of study entitled *Sinking and Floating*. Each program of study was designed on the basis of a targeted a set of understandings that reflect subject matter knowledge and the nature of scientific reasoning (presented in Table 2).

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Table 2 about here

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**Analyses and Construction of Cases**

The primary outcome from Phase 1 was the development of case studies of identified children. These case studies were primarily designed to address our research questions. A second important purpose, however, was to use these case studies as tools in our conversations with the classroom teachers to provide a means of communicating the experiences of identified students in GI sML instruction and to provide the grist for generating a list of teaching practices that would enhance the engagement and learning of these students. Hence, we focus our discussion of the analysis on the observational, interview, and artifact data.⁵ The construction of the case studies required triangulating the field notes, student artifacts, and teacher and student interview data.

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⁵ For the purpose of efficiency, our analysis of the formal assessments is presented in our discussion of Phase 2 of our research, as our primary interest in these data is to compare the outcomes of instruction in Phases 1 and 2.
Generating Claims from the Cases

We first examined these data sources for the purpose of identifying claims about the opportunities and challenges in GIsML instruction. Each case was examined for confirming and disconfirming evidence regarding the claims that were generated, and the evidence for each claim was noted. For illustrative purposes, Table 3 presents a set of claims that we generated from one classroom of (4th grade) students, and indicates the cases that included evidence for a claim as well as the sources of data that provided the evidence. Students in this class were engaged in the GIsML program of study about sinking and floating. Much of their investigation focused on: (a) constructing and manipulating the Cartesian Diver System (CDS; see footnote p. 5), (b) small groups investigation to construct an explanation for how the diver within the CDS can both float and sink, (c) designing posters to share the group’s explanation with the class, and (d) participating in whole class presentations and discussions regarding explanations for the phenomena in the CDS.

We then constructed narrative cases of individual students (Merriam, 1998; Polkinghorne, 1997; Stake, 1995) to illustrate the claims embedded in the more complete instructional context (see Palincsar, Collins, Marano, & Magnusson, in press, for a sample case).

Table 3 about here

As the table suggests, different classes of claims arose relative to each child. Some of the claims related to opportunities fostered or denied as a consequence of children gaining entrée to an activity, while other claims speak to the students’ responses to the print literacy demands in GIsML instruction. Data used to support these claims were drawn from a broad range of sources, including observations that were gathered in real time via field notes or constructed later with the use of video records, interviews with the children, and student artifacts.

Uses of the Cases

As we examined the claims that emerged across these classrooms, we sought a useful way to talk with teachers about the profiles of special needs students in GIsML instruction. One pattern that emerged across the claims was that the challenges and opportunities could be represented in four
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areas: language/cognition, print literacy, attention, and social interaction. In addition, it also appeared that it was helpful to conceptualize the patterns of opportunities and challenges in terms of the phases within GIsML instruction (see p. 5). We illustrate the intersection of these two patterns below, in hand with the information presented in Table 4.

As described earlier in this manuscript, GIsML instruction is enacted in an iterative manner: students gather data, begin to identify patterns in these data, and try out their explanations by manipulating the phenomenon, and by comparing and contrasting their ideas with the ideas of others. Having partially addressed the topic of inquiry, they return to the engage phase, perhaps with a refined question or perhaps with new materials, tools, or procedures with which to inquire. The recursive nature of this instruction affords students the opportunity to acquire more experiential knowledge, and to become comfortable with the procedural aspects of the inquiry so that they are freed up to attend to the conceptual issues (Blumenfeld & Meece, 1988). This is a novel experience for most school-age students and places unique demands on their ability to both sustain attention and to refrain from coming to conclusions prematurely. Our observations suggested that some identified students profited from this recursive process; for example, familiarity enabled them to more quickly and fully attend when the class was setting purposes for the next round of the investigation. For some identified children, however, the familiarity led to feelings of ennui. In individual interviews these students complained, "We're doing the same thing we did yesterday… and the day before that!"

During the investigation phase, students typically worked in pairs or very small groups. In this activity there are many jobs to be done; equipment needs to be assembled, observations need to be made and documented, data have to be recorded and then represented in a fashion that will communicate to others in the class. These tasks call on a broad array of abilities, and a number of identified children successfully found themselves well matched with a task (e.g., constructing the Cartesian Divers, or illustrating the context in which the group investigated the behavior of light).
However, there were also students who had such difficulty attaining access to the group work that there was no opportunity for them to demonstrate their particular ability. Video records, some of which were painful to watch, capture group members removing materials from the hands of identified students and precluding their involvement; others show identified students roaming away from their groups, often in search of other identified children, in the apparent hope that they will find a partner with whom to work.

The language and conceptual challenges faced by students with language and learning disabilities have been well documented (Dalton, Morroco, Tivnan, & Mead, 1997; Carlisle & Chang, 1996; Scruggs & Mastropieri, 1994). The relationship between these demands and GIsML instruction is complex. On the one hand, considerable care is paid in this instruction to using language that communicates in precise ways and that engages the students in the norms and conventions of scientific reasoning. In this way, the teacher and class attend very explicitly to some of the very issues that are challenging to identified students. On the other hand, students are typically asked in GIsML instruction to think about complex phenomena in which multiple variables have to be kept in mind. Furthermore, all students are called upon to share their thinking and to learn about one’s peers’ thinking. As one identified youngster explained in his interview, “I am thinking so hard in science that my head hurts. I need to sleep for the rest of the day.”

With regard to the print literacy demands, the fact that multiple kinds of representation of one’s data are valued, reduces some of the print literacy demands; however, it is also the case that students are expected to maintain notebooks in which they record their thinking so that it can be shared with the teacher and with peers. Furthermore, as mentioned earlier, GIsML instruction involves the use of not only first-hand investigations but also second-hand investigations in which the students read and respond to the experiences of others who have investigated the phenomena of interest.

Moving from Claims and Cases to the Intervention and Phase 2 of the Design Experiment

Phase 1 of this design experiment concluded with a series of focus group discussions involving the elementary teachers in whose classes we had collected these data (Cutter, Magnusson,
& Palincsar, work in progress). These focus groups provided important occasions for debriefing with the teachers regarding their experiences with GIsML instruction, with particular attention to students with special needs. As further grist for the focus group conversations, we presented a subset of the cases and also the table of Claims (Table 3). We then began to co-construct, as a group, a list of teaching practices designed to both exploit the opportunities provided in GIsML instruction, as well as to meet its challenges. The purpose of the Phase 2 research was to examine the outcomes of GIsML instruction with the intervention.

The Design Experiment: Phase 2

Participants

The teacher participants in Phase 2 were identical to those in Phase 1, with the exception of the fifth-grade teacher from Granite City, who was unable to participate. The student participants in Phase 2 numbered 111, with 19 of those being identified as students with special needs. The programs of study were identical to those in Phase 1 or our research.

The Intervention

Following the focus group conversations, the university-based members of the research group met with each teacher for separate planning sessions. Teachers were asked in these planning sessions to identify their current thinking regarding the teaching practices that they hypothesized would be effective in addressing the challenges of GIsML instruction given the profiles of their identified students. Although these discussions were with individual teachers, three sets of teaching practices emerged across the four teachers. They can generally be characterized as focusing on: 1) monitoring and facilitating student thinking, 2) supporting print literacy, and 3) improving working in groups. We next identify the specific teaching practices comprising each set.

Regarding monitoring/facilitating student thinking, the teachers were impressed with the findings from the researchers’ interviews of individual identified students, and that played a primary role in shaping their thinking about intervening with individual students. First, they were struck by what the identified students revealed about their thinking and conceptual understanding in these
more private contexts. Second, noting that subsequent to the individual interviews the identified students were more interested in contributing to the whole class discussion, we (researchers and teachers) speculated that there were some respects in which the interview provided an opportunity for the students to "rehearse" or try out their ideas in a safe context before attempting to contribute to constructive conversations with others about what they are learning. As a result, when the identified students were acknowledged for their thinking in the interview context, it served to bolster their confidence to contribute their ideas in the whole class setting. This line of thinking led the teachers to identify a range of ways in which they might simulate the interview with students whose participation they were trying to encourage. Teachers variously described an interest in "rehearsing" with students, or engaging in mini-conferencing with the identified students.⁶

Rehearsing and mini-conferencing served two different purposes: rehearsal provided the opportunity for students to try out the report they would share with their classmates. Some teachers sent children into the hallway alone or with a paraprofessional for this rehearsal. Mini-conferencing, in contrast, was highly mediated by the teacher and it was possible for a rehearsal to become a mini-conference. For example, Ms. Jentzen, in the course of a rehearsal, asked an identified student about his role in reporting to the class; the student responded that he was the one who would ask, "Any questions?" "Hmmm," Ms. Jentzen responded, "and what kinds of questions do you think you should be prepared for." This led to a conversation about what kinds of clarifications fellow students might need, or comments they might make in response to the report.

Regarding supporting print literacy, teachers identified a variety of practices that they thought would be helpful. One was to provide a glossary of terms that would be posted in the class and would be a source of environmental print to support students' writing. In addition, generating the glossary with the class members provided an occasion for identifying, with students, terms that would be useful to communicating with precision and parsimony (an important aspect of scientific literacy). While the specific lists were idiosyncratic to each classroom, each of the four teachers maintained a glossary. Sample words appearing on the glossary included: evidence, claim, and

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⁶ The term "rehearsal" was selected because this would provide students the opportunity to share their thinking in
conclusion, and topic specific terms, such as reflect, absorb, and transmit. Second, because a number of students, and most especially a number of the identified students, would conflate descriptions with explanations in their notebook entries, teachers hypothesized that some of these difficulties could be reduced by providing more specific prompts for the lab book entries. For example, when the students were making their entry regarding the behavior of the Cartesian Diver System, they were asked to: (a) describe in words and/or with drawings what they saw when they pressed down on the rubber sheeting that covered their diver, and (b) explain in words and/or with drawings why they thought the diver behaved as it did. Finally, for students with serious writing problems, teachers suggested the involvement of peers or paraprofessionals to transcribe the students' ideas.

The final set of practices was designed to improve the entrée and experiences of students in the small-group contexts. For several teachers, this was conceived primarily as a matter of designing groups in such a fashion that each group had members that were attentive to turn-taking and the distribution of resources. For other teachers, this set included actually monitoring the interactions of small groups and providing feedback regarding their efforts to work together. Both types of practice, of course, are important for maximally supporting students' conceptual development.

In summary, the set of teaching practices identified as interventions were of two types: some were directed at the design or redesign of the learning environment (e.g., manipulating group membership, providing transcription), some were designed to mediate children's thinking and learning (e.g., mini-conferencing), and some were actually a blend of these two (e.g., the redesign of journal prompts intended to support or probe more closely children's thinking).

**Procedures**

**Teacher Journal Entries**

Having identified this set of advanced teaching practices for GIsML instruction, the teachers were asked to maintain a journal identifying the practices in which they actually engaged, as well as advance of the more public presentation of their ideas to the group.
their reflections on the process and outcomes of implementing these practices. In addition, the
teachers were periodically debriefed regarding their teaching experiences.

**Student Assessments**

The same set of formal and informal assessments used in Phase 1 were employed in Phase 2. Before beginning the GIsML instruction, all students were administered the vocabulary and comprehension subtests of the *Gates MacGinitie*. Before and after GIsML instruction, the students completed written measures of conceptual understanding and scientific reasoning. In addition, we continued to collect observational and individual student interview data during Phase 2. In the next section, we report on the outcomes of the formal assessment data, comparing and contrasting the outcomes for Phases 1 and 2.

**Results from Phase 2 of the Design Experiment**

As indicated earlier, for comparison purposes we include in this section the results of the quantitative data from Phase 1 as well as Phase 2. In addition, we present the results with students separated into groups: identified students, low achieving students (low ach Ss; performed at the 40th percentile or below on the *Gates MacGinitie*), and normally achieving students (norm ach Ss; performed above the 40th percentile).

**General Achievement**

We begin with the findings regarding the *Gates MacGinitie*, which we used as an indicator of general achievement. Across Phases 1 and 2, we found that the identified students were among the lowest achieving (performing at the 20th percentile and below) on this measure. Furthermore, non-parametric statistical tests (Mann-Whitney U, two-tailed) indicated that in three of the four classes, there were no statistically significant differences in the *Gates MacGinitie* scores across Phases 1 and 2, and in one class, the scores for Phase 2 were significantly lower than those for Phase 1. Hence, we are comfortable in suggesting that learning differences obtained in Phase 2 are unlikely to be explained by overall achievement differences in the two samples of students. Finally, it is worth

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7 We have not included, in this manuscript, the data from the Grade 5 teacher who participated only in Phase 1.
noting that the means across these four classes were consistently below the 40th percentile; hence, we would suggest that we are working in contexts that are challenged with regard to the achievement profiles of their upper elementary students.

**Conceptual Understanding of Science**

We turn next to the outcomes of the subject matter measures. These measures were designed to assess children's understandings of the concepts that were key to each program of study (identified in Table 2). They included closed items, on which students simply made a choice of response; as well as extended response items in which children were asked to represent their ideas in drawings and/or writing. These items were typically designed to elicit children's descriptions and explanations for phenomenon presented in the item. These assessments were coded and scored, blind with regard to time of administration as well as respondent. In addition, inter-rater reliability of coded items was determined for 25% of the assessments. The inter-rater reliability for the assessments on *Sinking and Floating* was 90%, while the inter-rater reliability for the assessment on *Light Interacting with Objects* was 82%.

Figures 1 through 4 present the outcomes of these subject matter measures. Before discussing these outcomes, we want to acknowledge that the findings about the impact of the intervention are confounded by the fact that the teachers were more experienced with guided inquiry teaching in these topic areas in Phase 2 of the research (at least the second consecutive school year in which each teacher taught the same program of study); consequently we are not able to tease out the effects of the advanced teaching practices alone. Nevertheless, there is a clear pattern in the findings across all the teachers, despite the fact that some were more experienced teaching their program of study than others (two years for teachers conducting the *Sinking and Floating* program of study versus three years for teachers conducting the *Light* program of study). Thus, there is reason to believe that the findings are not simply a function of teachers having more experience teaching the topic of study.
Prior Knowledge

We first speak to the pre-assessment data for each program of study to ascertain what they reveal about the entering conceptual understandings of the identified students when compared with their low-achieving and normally-achieving peers. On the assessment about *sinking and floating*, the non-parametric Kruskal-Wallis test indicated that there were *no* statistically significant differences in pretest scores among the identified, low achieving and normally-achieving students in either Phase 1 (‘97-'98 school year) or Phase 2 (‘98-'99 school year) for either teacher. On the pre-assessment about light, Ms. Lacey's students did not show any statistically significant differences in their pretest scores, but Ms. Dunbar's students did. A Mann-Whitney U (two-tailed) test revealed that the significant differences were between the identified and normally achieving students (Phase 1, p=.0117; Phase 2, p=.0024), as well as between the low-achieving and identified students in Phase 1 (p=.0390). Thus, in three of the 4 cases, neither entering general achievement nor designation as a special education student predicted students' performance on the pre-assessment of subject matter knowledge. These findings are striking because they suggest that identified students were often bringing similar funds of knowledge to the instructional context as their non-identified peers. They also highlight the importance of our learning how to support these students in bringing their prior knowledge to bear in constructing new knowledge in inquiry contexts.

Evidence of New Scientific Understandings

The slopes of the lines in Figures 1-4 provide some indication of the extent to which learning occurred in these programs of study. In that sense, the contrast in data from Phase 1 (‘97-'98 school year) and Phase 2 (‘98-'99 school year) is striking because the increases in Phase 2 among the groups of students are generally quite different for each teacher. While we cannot do full justice to the data that we have gathered in each of these classes, we report the statistical outcomes for the assessment data and then highlight some of the most salient observations regarding each classroom and/or teacher that informs our interpretation of these outcomes. The non-parametric Wilcoxon Matched Pairs Signed-Ranks Test (two-tailed) was used to determine statistical significance of the learning gains achieved by each group of students.
Ms. Jentzen’s class. Figure 1 presents the data for Ms. Jentzen's fourth grade classes. In Phase 1, only the normally-achieving students showed statistically significant learning gains (p=.0129). In Phase 2, identified students and normally achieving students showed statistically significant learning gains, however there were no significant differences between these groups in their learning gains (Mann-Whitney U, two-tailed). Low achieving students did not show gains that were statistically significant.

Ms. Jentzen is a particularly interesting teacher to the extent that, in Phase 1, she indicated that she had little idea of what to do with her identified students in this context as typically these students were not even present for science instruction. She was observed to have very few interactions with her identified students in Phase 1. In Phase 2, there are multiple examples of Ms. Jentzen engaging in the full set of teaching practices described above with the identified students; however, one set of practices was particularly noteworthy. Of the four teachers, Ms. Jentzen was the most enthusiastic when, in the professional development context, we talked about closely monitoring children's thinking, through "conferencing" and providing students rehearsal opportunities. While these were not practices in which she was engaged at the time, they were practices that were consistent with her beliefs about the value of understanding student thinking. In Phase 2, she consistently engaged in these monitoring practices and positively reflected on these practices in her journal, noting, that while they clearly strengthened her teaching, they were also difficult to manage in her class of 27 students.

Ms. Lenowsky’s class. Figure 2 presents the data for Ms. Lenowsky’s fifth grade classes. In Phase 1, only the normally achieving students demonstrated statistically significant learning gains (p=.0045). In Phase 2, only the low and normally achieving students showed statistically significant learning gains. Ms. Lenowsky’s results offers a particularly challenging profile to those of us interested in learning in inclusion settings. Of the four teachers, she appears to have the most well-developed subject matter knowledge and to be confident in this knowledge. However, she has limited expectations of what is possible for some students — her identified students in particular. Confronted with the Phase 1 data, Ms. Lenowsky indicated that there were just certain students
who would not be successful with this curriculum and instruction. Furthermore, in Phase 2, she documented in her journal that she found herself drawn to using the advanced teaching practices (which were designed particularly to enable the identified children) – particularly those related to monitoring children’s thinking – with her "more capable" students. Hence, it was not uncommon for identified children to routinely experience marginalization in her classroom.

**Ms. Lacey’s class.** Figure 3 presents the data for Ms. Lacey's fourth grade classes. In Phase 1, only the normally achieving students showed statistically significant learning gains (p=.0277) whereas in Phase 2, the low and normally achieving students showed significant learning gains, and the gains exhibited by the identified students approached significance (p=.0679). The majority of the four identified students in Ms. Lacey's room during Phase 2 were labeled emotionally impaired and had significant problems of attention. The practice that Ms. Lacey most frequently called upon was the careful monitoring of student thinking. She comments in her journal that although she is a veteran teacher (of 28 years), she had never paid such close attention to "what page" her "difficult" students were on and was fascinated to learn how often they were on a "different page."

**Ms. Dunbar’s class.** Finally, Figure 4 contains the data for Ms. Dunbar's fourth grade students. The outcomes of Phase 1 for this teacher are particularly interesting as only the identified students showed significant learning gains in Phase 1 (p=.0431). The close study of her teaching practices in Phase 1 reveal that Ms. Dunbar (who was a Title 1 teacher before receiving a classroom assignment) was especially attentive to her identified students, often devoting significant amounts of time to guiding these students individually and in small groups. Many of the specific practices that were identified by the group as advanced design and mediation practices were already common practices for Ms. Dunbar. The challenge in Phase 2 was for her to engage in these practices in a way that would not disadvantage the other students in her classroom. The data suggest that Ms. Dunbar was successful in this effort, as she was the only teacher in which there were learning gains for all groups in Phase 2. Moreover, there were no significant differences among the groups in their learning gains (Mann-Whitney U, two-tailed). Indeed, it is the outcomes in Ms. Dunbar's class that
provide the strongest evidence that it is not only the greater experience with the program of study that is leading to the gains that we are seeing in Phase 2, but that the advanced teaching practices are making a unique contribution to these gains, since it was not until Ms. Dunbar implemented these advanced teaching practices that there are gains across all students.

Lessons Emerging From This Design Experiment

In this paper, we have described both the process that we are using to understand the participation and learning of students with special needs in guided inquiry science teaching, as well as the outcomes of engineering particular interventions. Our findings to date point to the importance of understanding the ways in which the teacher mediates student learning, particularly for students identified as having special needs. In this research, we have attempted to understand this dynamic through design experiments that included as a key component, case study research in which we closely document the experiences of identified students, gathering and analyzing data at multiple levels (the student, teacher, and classroom). Claims from these cases played an integral role in informing the identification of instructional strategies which, we argue, provided the necessary advances in instruction to ensure desired participation and learning for identified students.

As hypothesized, there were, in fact, unique opportunities for students with special needs in the ambitious instructional context represented by guided inquiry science teaching. University and school based members in this research effort were impressed with the participation and contributions of identified students, despite their significant language and print literacy challenges. For example, in these classrooms, we observed identified students: pressing the thinking of their peers (cf. Collins, 1999 for details), quickly and successfully manipulating the materials in their investigations, and taking great care to document and share their findings with others. However, these students' conceptual understanding, as assessed by our pre- and post- measures, was not increased in significant ways until the teachers engaged in advanced teaching practices. If there were a thread characterizing these practices, it would be the extent to which they address access; not only the identified child's access to the instructional context (i.e., by attending to issues of environmental
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print, and interactions in small groups) but also the teacher's and peers' access to the identified child's thinking and reasoning (i.e., through conferencing with the child, or providing transcription). Perhaps the most pleasing finding, to date, from this study is the fact that these advanced teaching practices enhanced the learning of low-achieving and normally achieving students, as well as identified students.

We conclude by identifying the challenges that we have become aware of in the conduct of this research, and then consider some of the emergent implications of this research for the inclusion movement. Virtually every aspect of the work reported above has posed unique challenges. Given the complexity of inquiry teaching, the preparation of the teachers to engage in GIsML instruction is an enduring challenge. The call from the Department of Education to study special needs students’ access to rigorous curricula was based on the assumption that this type of curriculum and pedagogy was in place. Our experience, particularly in the study of children in grades four and five, suggest that a necessary first step toward such a program of research in many classrooms may be to support teachers in the planning and enactment of such ambitious curriculum and instruction. However, we are not simply interested in ensuring that special education students have access to more rigorous curriculum and instruction. The goal of the REACH institute is to determine how special education students can attain the higher standards represented in the rigorous curriculum.

The preponderance of research conducted to date in inclusion settings indicates that general educators are not accustomed nor prepared to plan and enact instruction in a fashion that reflects the unique needs of special education students while enabling these students to achieve high standards (Englert, Tarrant, & Rozendal, 1993; Schumm et al., 1995). The response on the part of the special education research community typically has been to identify generic teaching practices to employ with these students – practices that do not reflect the unique demands of learning specific subject matter and are not generally recognized as advancing the learning of all students. We hypothesize that these disparities may help us to understand why findings from the general strategy instruction research have had relatively little influence on the practices of general educators (Baker & Zigmond, 1995). A different response would be to identify interventions that have integrity with regard to the
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curriculum and pedagogy reflected in contemporary *subject-specific* standards movements and that will serve to advance the learning of all students – an approach embraced by the researchers of the REACH Institute.

Our decision to use design experiments was shaped by the daunting nature of the challenges described above. In a design experiment, one works from where the teachers are and shapes the next steps, guided in each iteration by one’s progress toward the desired outcomes. Ultimately this research strategy expands and deepens our knowledge of instructional practice and provides invaluable information about how practice can be changed to reach the targeted outcomes. Thus, a design experiment provides two dimensions of information, the outcomes of new instructional practice and what is required to engage in that practice. Knowledge along both of these dimensions is necessary if we are to realize, for all students, the vision suggested by the standards.

What are some of the emerging educational implications of our research? First, the lenses that the teachers in this research needed to bring to their instruction included having a deep knowledge of subject matter and the ways of thinking and reasoning within that subject matter. Elementary teachers and educational specialists do not have this tradition of thinking about teaching, learning, or intervention in discipline-specific ways. For general educators and specialists to productively collaborate in inclusion settings, especially settings in which reform efforts are underway, it is necessary for them to jointly consider the subject-specific nature of the instruction in order to inform the design of appropriate ways of supporting the learning of identified children, as well as to identify the learning goals and indicators of success within that instruction.

Second, the interventions that are identified in this research as advanced teaching practices are, in many respects, simply part of exemplary teaching. Nevertheless, they place significant demands upon classroom teachers in terms of time, energy, and cognitive space. Furthermore, while each of our four teachers were experienced educators (ranging from 8 to 28 years of experience), the advanced teaching practices were typically novel practices for these teachers. Conversations with these teachers suggest that they were unaccustomed to thinking about their students in terms of *individual* learning profiles and that, while these practices were challenging, given the numerous
demands on them, they empowered the teachers. In fact, several of these teachers, following their experiences with Phase 2 of this research, reported taking a more active stance relative to their identified students (e.g., advocating on their behalf and demanding particular assessments and forms of support for these students).

A third implication addresses the nature of the social support that educators must be prepared to provide students with special needs. In inclusion settings, classroom teachers have the additional responsibility of ensuring that all students have access to the curriculum and instruction. While the majority of identified students had success gaining entrée to the large-group instructional context, they were more challenged in the context of the small-group activity, where their contributions were ignored or rebuffed. In the complexity of a classroom environment, it is easy for the teacher to be oblivious to this phenomenon and ignorant of the events that might eventuate in "acting out" on the part of identified students. This finding suggests a valuable role that specialists could play in their collaboration with general educators. Specialists, through close observation, can note these often invisible aspects of classroom life. Furthermore, they can assist identified students to develop strategies for effectively gaining entrée to the group activity. Finally, specialists, together with the classroom teacher, can model for a class and individual students, effective ways of engaging in small group interaction (e.g., sharing turn-taking, use of the materials, and finding a good match between the skills of the participants and the tasks to be done).

In closing, an important implication is that specialists consider the ways in which their interventions can be tailored to enhance the capacities of children to become more active participants in specific instructional contexts. Special educators typically have a deeper awareness and understanding of the individual learning profiles of students; hence, they are particularly advantaged in assisting identified students to use multiple ways of representing their thinking. For example, specialists can coach identified students during instruction when small groups are preparing to report, helping them think about the ideas they seek to share with their small group or rehearse how they will share their thinking with the whole class. In addition, specialists in this context can reinforce the language and concepts that are central to the study of specific topics. In order for this
activity to be effective, however, there must be a shared understanding – on the part of the general and special educators – of the purposes of the instruction, the targeted subject-matter understandings, and the ways to advance children's learning within the specific instructional context. These expectations are not common to the preparation of special educators; thus, our findings speak to the need for special educators to reconsider the knowledge they need in order to effectively support the learning of identified students in these contemporary inclusion settings with increased subject matter learning expectations for all students.
References


Cutter, J., Magnusson, S. J., & Palincsar, A. S. (work in progress). Reconstructing group work as an intervention to support the learning of identified students in challenging science instruction.


Figure 1. Ms. Jentzen, fourth graders' subject matter knowledge of sinking and floating.

Figure 2. Ms. Lenowsky's fifth graders' subject matter knowledge of sinking and floating.
**Figure 3.** Ms. Lacey's 4th graders' subject matter knowledge about light.

**Figure 4.** Ms. Dunbar's 4th graders' subject matter knowledge about light.
Table 1

Demographics for four classroom in Phases 1 and 2

<table>
<thead>
<tr>
<th>TEACHER</th>
<th>School Yr.</th>
<th>Normally Achieving Students</th>
<th>Low Achieving Students</th>
<th>Identified Students</th>
<th>Disability</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>LD  D E I P D D</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dunbar</td>
<td>97-'98</td>
<td>7   11 6</td>
<td>6</td>
<td>4 2</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>98-'99</td>
<td>15  9 5</td>
<td>5</td>
<td>4 1</td>
<td>-</td>
</tr>
<tr>
<td>Jentzen</td>
<td>97-'98</td>
<td>17  4 3</td>
<td>3</td>
<td>3 -</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>98-'99</td>
<td>16  5 5</td>
<td>5</td>
<td>4 1</td>
<td>-</td>
</tr>
<tr>
<td>Lacey</td>
<td>97-'98</td>
<td>7   15 5</td>
<td>5</td>
<td>3 1 1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>98-'99</td>
<td>14  8 4</td>
<td>4</td>
<td>2 2</td>
<td>-</td>
</tr>
<tr>
<td>Lenowsky</td>
<td>97-'98</td>
<td>15  7 3</td>
<td>3</td>
<td>3 -</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>98-'99</td>
<td>15  9 5</td>
<td>5</td>
<td>4 1</td>
<td>-</td>
</tr>
</tbody>
</table>

Table 4

Challenges and Opportunities in GIsML instruction by Phase of Instruction

<table>
<thead>
<tr>
<th>GIsML Phase</th>
<th>Opportunity</th>
<th>Challenge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engage</td>
<td>Multiple visits to the same conceptual terrain, providing iterative experiences that promote depth of understanding.</td>
<td>Sustaining attention in the face of familiarity.</td>
</tr>
<tr>
<td>Investigate</td>
<td>There are multiple roles due to the multiple tasks to be accomplished in an investigation.</td>
<td>Social relational problems may preclude entrée to the activity and taking on any role.</td>
</tr>
<tr>
<td>Explain</td>
<td>An array of ideas are typically entertained during this phase; the classroom climate is one of acceptance of diverse ways of thinking and reasoning.</td>
<td>Defending one's ideas is both cognitively and linguistically demanding.</td>
</tr>
<tr>
<td>Report</td>
<td>Students are encouraged to use a broad range of ways of representing their thinking, including: drawings, demonstration, print, oral description.</td>
<td>Constructing alternative representations is cognitively demanding and presenting one's thinking publicly is linguistically and socially challenging.</td>
</tr>
<tr>
<td>Conceptual Goals for the Programs of Study</td>
<td>1. Scientists seek to understand why the world works in particular ways.</td>
<td>2. Scientists observe specific aspects of the world in order to determine how it works.</td>
</tr>
<tr>
<td>------------------------------------------</td>
<td>-------------------------------------------------</td>
<td>-------------------------------------------------</td>
</tr>
<tr>
<td>LIGHT INTERACTING WITH OBJECTS</td>
<td>1. Light can be reflected, absorbed, or transmitted by objects.</td>
<td>2. There is an inverse relationship between light reflected from and absorbed by an object: if more is reflected, less is absorbed.</td>
</tr>
<tr>
<td>SINKING AND FLOATING</td>
<td>1. Weight alone does not determine whether something sinks or floats; weight and volume influence sinking and floating.</td>
<td>2. The weight of an object in a particular amount of space (volume) determines whether it sinks or floats.</td>
</tr>
</tbody>
</table>
## Table 3

### Claims Emerging From Observational Research

<table>
<thead>
<tr>
<th>Claim</th>
<th>Relevant Cases</th>
<th>Sources of Data</th>
</tr>
</thead>
</table>
| The participation of the identified students was influenced by the nature and amount of appropriate assistance or intervention received. | Positive evidence: Gail, Don, Buddy  
Negative evidence: Abe and Ardis | Close observation / field notes  
Video tapes  
Some trial intervention w/Ardis |
| Students who struggled with writing were supported in participating fully when assisted with the documentation of their thoughts. | Buddy’s and Don’s initial notebook attempts and their subsequent responses | Video tapes  
Journals  
Close observation / field notes |
| Students who struggled with writing were supported in participating fully when given the opportunity to document graphically. | Don’s journal -- graphics of diver show evolution of his argument | Journal  
Close observation / field notes |
| Environmental print and graphic documentation served to support students who initiated using it; this could be developed and its use made explicit for other students as well. | Buddy’s test strategy  
Don’s journals -- both graphic and written | Close observation / field notes |
| Participating -- gaining access “to the floor,” to the investigation materials, or to the approval and support of peers was difficult for these students in both small and large group contexts. | All of the identified students except Greta (who is not actually identified). | Close observation / field notes  
Video tapes  
Student interviews (Don and Buddy) |
| The ability to learn from large group discussions was difficult for these students unless they were provided concrete support (e.g., a discussion guide, notes on board/overhead projector). | Don and Buddy’s self-report of this; lack of engagement of the others (especially Abe). | Video tapes  
Interviews (Don and Buddy) |
| The opportunity to engage in one-on-one discussion, particularly with the teacher, seemed important for these students for engagement, development of thought, and as a rehearsal for sharing with others -- peer discussion did not work as well. | Abe (did not ever truly engage) is an extreme example of what happens without this type of support.  
Don and Buddy exemplify how these opportunities (when they are recognized by the teacher) can support students in entering large and small group discussion. | Close observation / field notes  
Video tapes  
Interviews (Don and Buddy) |
| Given appropriate social and cognitive supports (which do not appear untenable in a classroom setting) these students were able to participate and express understanding of floating and sinking during the activity. | Buddy  
Don  
Ardis  
Greta (seemed to support self with journal) | Video tapes  
Close observation / field notes  
Interviews |