Montshire-Rivendell-Dartmouth HHMI Science Camp

Year Three Evaluation Report

Based on Interviews with Dartmouth College Science Mentors
and
Rivendell Host Teachers

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Science Camp: A Brief History

Now in its third iteration, the Montshire-Rivendell-Dartmouth Science Camp, supported by a four-year grant from the Howard Hughes Medical Institute, is a smoothly functioning collaboration that achieves far more than the stated goal of bringing excitement, expertise and relevance to elementary school science classes. Drawing on the science education resources of Montshire Museum of Science, and with the support and assistance of teachers in the Rivendell School District, the program trains Dartmouth College students to bring hands-on science to over 150 third through seventh graders in this small, rural school system. In the process, undergraduate and graduate student mentors also improve their science communication skills and Rivendell teachers receive new science materials and ideas. As one mentor remarked, "They get an amazing amount of good out of such a short program."

The high yield Science Camp derives from its modest six-week investment results from conjoining an ingenious idea with thoughtful feedback. The idea—to place talented young scientists in elementary school classrooms to present weekly science lessons designed by experienced science educators—defines the solid core of the program. The personal connection between motivated Dartmouth mentors and receptive youngsters demystifies and personalizes science, transforming it from an arcane topic reserved for older men to an accessible and relevant activity pursued by people with whom Rivendell children can identify. The power of this concept carried Science Camp through its first year, bringing rewards to mentors and children while at the same time revealing ways to improve its implementation.

Each year Montshire and Dartmouth planners have acted on feedback from teachers and mentors, collected in culminating evaluation interviews, to refine and strengthen the program. In Year 1 (2007) mentors and teachers pronounced Science Camp a success, saying that elementary school students learned interesting science and, in the words of one mentor, "that science can be fun and that they can do it too." For their part, mentors uniformly enjoyed the experience and reported that they acquired valuable, transferable pedagogical skills. But both mentors and teachers recommended two major changes that they felt would increase the program's impact on student learning and on mentors' ability to communicate science effectively. First, although the 2007 science lessons were well-designed and carefully vetted, teachers and mentors recommended that lessons should be developed that were keyed to the district's grade curriculum, so that Science Camp activities built upon and reinforced what students were learning in the regular classroom at that time. Second, both mentors and teachers asked for closer communication among all parties, so that they could work together efficiently to make the science lessons smooth, engaging and productive.

Thus in Year 2 (2008) Montshire planners developed new weekly science lessons aligned with the curricular expectations for each grade, an effort that required doubling (from two to four) MMS education staff assigned to the project. This change alleviated faculty concerns about losing instructional time to science topics unrelated to the grade learning goals and about losing the opportunity to reinforce regular science learning. At the same time Montshire planners augmented communication with teachers, initiating a pre-Science Camp introductory meeting among teachers, mentors and science educators where participants reviewed the fundamentals of inquiry science and met together as classroom teams, exchanging information, laying out expectations and establishing rapport. Program syllabi were distributed to teachers and mentors so that everyone understood the trajectory of the experience for the students.

In the 2008 post-interviews teachers and mentors uniformly endorsed these changes. Teachers who had been uncertain about the net value of Science Camp after 2007 were now firmly on board, reporting that the 2008 experience simultaneously made science special and strengthened the regular curriculum. Mentors described a classroom experience that was even more satisfying than the previous year. Teams communicated more frequently and comfortably, facilitating the flow and integration of lessons. To further improve what they now viewed as a very solid program, mentors and teachers who had held voluntary classroom pre-visits suggested those visits be mandatory, so that mentors could meet their students informally and get a sense of classroom dynamic before actually teaching a lesson. Mentors also asked that the Monday night training sessions be more focused, with more substantive instruction in teaching and learning. Teachers and mentors alike suggested evaluating what students actually learned in Science Camp and recommended better publicity for the culminating Family Night at MMS, a free evening event that showcased Science Camp activities and gave students an opportunity to share their excitement about science with parents and siblings (attendance had suffered due to weather-related schedule changes in 2008).

Again, program planners listened carefully and responded resourcefully. They extended the 2009 Science Camp schedule by one week, to include a classroom pre-visit. They revamped the Monday night training session to include more rigorous instruction in teaching and learning. To deepen the connection between Science Camp lessons and grade expectations, MMS educators met with Rivendell third and fourth grade teachers and selected the respected Insights curriculum to guide teachers and mentors through Science Camp units on astronomy and electricity. Teachers made time for students to complete a pre-post exercise about science attitudes and mentors designed constructed response questions to measure content learning about their lessons. The MMS Family Night was publicized through several take-home fliers for children and through the mentors' enthusiastic reminders.

The Year 3 (2009) Science Camp iteration described by this report is thus a program whose core concept of connecting school children with energetic young scientists through the vehicle of professionally designed hands-on science lessons has been refined and enhanced through stronger connection with the school science curriculum, through better preparation of mentors, and through better communication among participants. These changes contribute importantly to the very positive outcomes described in this narrative. This year every mentor said—"absolutely," "definitely," "very much so"—that Science Camp was a worthwhile experience for Rivendell students and for themselves. All mentors said they would volunteer again, or would recommend the program to a friend (indeed, many said they had done so already). Teachers agreed that the experience was worthwhile for their students and gave the program high marks. Asked to grade the program on a scale of A to F, the third and fourth grade teachers all pronounced Science Camp a solid "A." In the fifth and sixth grades the program earned an A, an A-, and two B+'s, with the lower scores reflecting concern about the curricular fit of the material. The following narrative describes the preparation that led to these enthusiastic assessments and the benefits that accrued to participants as a result.

Like previous evaluation reports, this report draws on participant interviews: eight of the nine participating faculty and all 24 Dartmouth mentors met with evaluator Jane Korey for confidential, in-depth interviews in the weeks immediately following Science Camp (March 11 – 31). Korey, who also observed weekly in the training sessions and classrooms, took extensive notes during the interviews. Although not always verbatim, the quotations cited in the report faithfully reflect the interviewees' remarks. To allow for consistency across the years, few changes were made to the interview protocols for each group. The protocols are included as Appendix 1 to this report.

Program Description

The third year of Science Camp began in the Fall term of the 2008-2009 academic year with the recruitment of Dartmouth College students to serve as science mentors. During that same period, Montshire science educators began developing inquiry-based science lessons for each of the participating grades. On January 8, 2009 host teachers and mentors got acquainted with each other and the program in a two-hour orientation meeting at Montshire Museum.

During the week of January 12 mentor teams visited their assigned classes and for the next six weeks (January 21 to March 4, with one vacation week included) mentors met at MMS on Monday nights for weekly trainings and on the following Wednesday traveled to Rivendell schools to present the science lessons to elementary students. Science Camp culminated on March 5 with an open house at Montshire Museum, where all Rivendell students and their families, teachers, mentors and program personnel joined to explore the museum and celebrate the accomplishments of the Science Camp students. This section describes the major components of Science Camp.

Mentor Recruitment and Assignments

<u>Mentor Recruitment</u>. Email announcements were sent to science departments and organizations in October 2008 soliciting applications for the 2009 Science Camp. Twenty-five students completed applications and the recruitment committee selected 24 as mentors for 11 classes. The committee was careful to select enough applicants to ensure a team of mentors for every classroom. In 2008, attrition had left several classrooms with a single mentor, a situation the remaining singletons assured us was not desirable. Although there was no attrition this year, so that two teams ended up with three members, that outcome is preferable to the alternative. One of those solo mentors from 2008 re-applied this year and affirmed that "partners are the way to go. I had someone to back me up and we could play off each other in class. There was somebody in my position to talk to and get feedback from." A teacher who had only one mentor last year concurred: "You really need a team of two. It improves communication in the class."

Contacting science departments and organizations remains an efficient way to reach potential applicants, but increasingly word of mouth has become an effective recruitment tool. Four of the 24 Science Camp mentors had participated last year and many of this year's new applicants heard about the program from someone in their department. When asked whether anything about the program surprised her (Question I), one mentor responded, "No. I knew from friends in the department how it would go; I knew they enjoyed it." While some uncertainty about the outlines of the program remained (one mentor originally thought students would come to MMS for instruction), knowledge about Science Camp seems widespread, especially among graduate students.

While the validation of science departments and the enthusiasm of Science Camp "graduates" has thus far generated an adequate applicant pool, this year it was barely so, with 25 students applying for 24 slots. There are undoubtedly some graduate students who would be interested but are not yet fully informed about this opportunity, but the largest untapped source for mentors is the undergraduate population. More undergraduates have participated in previous years and they seem to contribute and benefit equally with graduate students. It would be worth pursuing that population more purposefully, especially (but not exclusively) in science departments and the education department. One undergraduate, who said she was surprised to find so many graduate students in the program, pointed out that undergraduates had fewer teaching opportunities available to them than do graduate students, who can TA.

Mentor Assignments. Montshire educators assigned mentors to partners and classrooms for the duration of the program, giving each pair the opportunity to develop as a team and to establish rapport with their students and host teacher. Twenty-four mentors were placed in 11 classes, working with nine teachers. As the table below shows, fewer than a third of the mentors were men (29%) and only about 20% were undergraduates. Table 1 below, which organizes the mentors by the grade they taught, shows that planners tried to create teams that were mixed by gender and level of study. This year they also tried to match mentors with a science topic close to their own area of study, a strategy recommended by last year's mentors to better use mentors' knowledge. Although the small number of mentors and the curricular constraints prevent full expression of this principle, it is clear that the physics/astronomy students were assigned the astronomy topic, while the seventh grade biome project includes three earth and life scientists.

Table 1. Mentor Assignments

GRADE	3rd (2 classes)	4th (2 classes)	5th (3 classes)	6th (2 classes)	8th (2 classes)	TOTAL
TOPIC	Electricity	Astronomy	Heat	Electricity	Biomes	
GENDER	2 women 2 men	4 women 1 man	4 women 2 men	4 women 1 man	3 women 1 man	17 women 7 men
LEVEL OF STUDY	1 UG 2 GS 1 post-doc	5 GS	2 UG 2 GS 1 post-doc 1 employee	1 UG 4 GS	1 UG 3 GS	5 UG 16 GS 2 post-docs 1 employee
MAJOR/ FIELD	•chemistry •psych'gy •physiology •molecular biology	•2 physics/ astronomy •2 psych/ cognitive neurosci. •physiology	•biochem-istry •earth sci. •genetics •biology •neurosci	•computer science •biology •pharmaco-logy •2 chemistry	•ecology •chemistry •biology •earth sci.	•4 chemistry •4 biology •4 psych/ cog. neuro. •2 physio-logy •2 earth sci. •2 physics/

						astronomy •ecology •biochem. •genetics •pharma-cology •computer science

Mentor recruitment and assignments: Summary. Solicitations through science departments and word of mouth endorsements yielded a qualified and motivated group of mentors. While the mentors represented a wide range of science fields (good for demonstrating the breadth of science to children), the application pool was barely adequate in number and strongly weighted toward women and graduate students. More aggressive promotion among undergraduates might help to increase the number of applicants, allowing the committee to tap the enthusiasm of the younger students and achieve better gender balance.

Orientation

January Training Day . Science Camp began officially with a January orientation at MMS where Rivendell faculty and Dartmouth mentors got acquainted and learned together about the goals and methods of Science Camp from MMS science educators Greg DeFrancis, Amy VanderKooi, John Woodward and Mike Fenzel. The "Roles and Expectations for Participants" handout for teachers and mentors epitomized the more encompassing vision planners brought to this year's program, making clear that open communication among all participants—listening as well as talking—was critical if Rivendell students were to learn science and Dartmouth students were to have a productive teaching experience.

In the first hour, MMS educators guided groups of teachers and mentors through a hands-on exercise where they planned, carried out, gathered data and reported on a simple experiment. This year, teachers from Rivendell K-2 classrooms participated in the two-hour session along with Science Camp host teachers. Samuel Morey Principal Eloise Ginty cited the school-wide benefit of including K-2 teachers in the professional development opportunity. Teachers of younger children (who will soon progress to Science Camp) were introduced to the principles and strategies of inquiry science, further supporting the use of inquiry techniques in the Science Camp grades. Ginty noted that she had already witnessed one kindergarten teacher using what she had learned at the Science Camp orientation.

This early forum is also intended to jump-start communication among the teams, and in the second hour mentors and their host teachers sat down together to share experiences and establish expectations for Science Camp. Both teachers and mentors felt that this time together was very valuable, allowing them to lay out their respective roles and, for mentors, to learn about the classroom dynamic and "get into the mindset," as several teachers put it, of an elementary school science student. These responses from members of one team are typical:

> • [Teacher] That hour was helpful for mentors and it helped me get more focused. I talked about what it's like to be in n^{th} grade, what I like about this grade, how to deal with n^{th} graders, and what they [the mentors] remember about being in n^{th} grade.
>
> • [Mentor] We talked about how n^{th} graders behave, the class expectations. He had us think back to being in the n^{th} grade, how we looked at things then. It was definitely worthwhile. Getting to know your team and teacher and establishing a relationship ahead of time is very important. Afterwards I had an idea of what to expect.

Several teachers mentioned that they had also hoped to use this opportunity—or the later classroom visit—to do initial planning, what one teacher described as a "scope and sequence" meeting. Those teachers felt that there should be a time before Science Camp began for teacher/mentor teams to sketch a plan for the six weeks, discussing the main points to be covered and figuring out how each will prepare, follow- up on one another's activities, and how they will catch up if necessary. Mentors agreed. A third of them mentioned that the orientation would have been more valuable if they could have begun substantive planning. In their words:

> At the orientation we should have had a handout for each grade showing what concepts will be covered and what activities we will do. That would help us understand the process and would ground the conversation with the teacher.
>
> The teachers thought we knew what we were doing, what we would be teaching, but we were clueless, totally in the dark. The teacher asked us about topics and lesson plans. We felt awkward. There should be a meeting for mentors before we meet the teachers to help us understand what we'll be doing.
>
> Nobody was clear about what we would actually be doing. The teacher thought we knew; we thought the teacher knew. It was confusing.
>
> We knew we would teach about heat but we didn't know exactly what we were doing. We weren't sure what to explore or ask about because the task was so undefined.

Thus while all teachers and mentors found the orientation session worthwhile overall, many also felt that the time would have been more productive if they could have talked specifically about the lessons. It is clear that teachers initiated the conversations about lesson planning; this is the first year they have done so and it is an indication of their investment in the program. With the Science Camp lessons tightly anchored to the curriculum, teachers seem eager to ensure their success.

Classroom Pre-visit. On the recommendation of the 2008 mentors who had visited their classrooms before Science Camp, the 2009 program was extended by one week, with the first week designated for informal (but mandatory) classroom visits. In most cases, the visits began with introductions and, often, a getting-to-know-you game. Mentors talked about their lives in and outside of science and asked Rivendell students to share similar experiences, likes and dislikes. In most cases, introductions were followed by a regular classroom activity, where teachers encouraged the visiting mentors to join in, circulating around the room, assisting students and getting to know them individually. Teachers and mentors uniformly endorsed the visit, which they said allowed mentors to get down to science teaching directly on the first Science Camp day, already confident about classroom routines and familiar with the students. These comments from teachers were typical:

> When the mentors came we were starting a science lesson, so they jumped right in and talked to the kids, helped them. They saw how I handled the lesson. Its much better to participate than observe. The visit made for an easier transition when the mentors came for Science Camp.

> The visit is a good idea. It allows the mentors to size up kids, so they are not strangers to them. It meant they could get right to work on first lesson.

Mentors agreed, pointing out that the visit helps them establish a personal relationship with the students, and "it's the personal connection that important; that's what matters, what makes this memorable." Mentors felt it was more valuable to circulate through the classroom and interact with students than to observe, but all mentors said the visit made them feel better prepared and was integral to the success of the program. As mentors said:

> This was very worthwhile. A "must."

> This was really great, absolutely necessary. We could see which kids were struggling, how they helped each other. It made us more comfortable and it made the kids more comfortable with us.

> It was great. We helped with a science lesson that day and really got to know the kids. I wouldn't do it any other way.

Orientation: Summary. Teachers and mentors emphasized that the January orientation and the class-room pre-visit were very valuable—some said essential—to the program. At the orientation teachers and mentors begin to establish a solid working relationship and mentors learn about the students they will teach. The pre-visit puts real faces on those descriptions and real motion on the class "dynamic." These two meetings help mentors get off to a faster and smoother start in the classroom and as part of a team that includes the classroom teachers. A number of mentors and teachers recommended that mentors receive the lesson plans, or at least an outline of activities and main concepts to be covered, before the orientation meeting, so that mentor-teacher teams can talk substantively about their task. Regarding the classroom visit, mentors who "jumped right in" and helped out during their visit felt their experience was more valuable than those who observed the class in action.

Mentor Training

Hour one: dinner and all-group seminars. As in previous years, mentors participated in a two-hour Monday evening training session before Wednesday's lesson. Again, mentors found the Monday night-Wednesday afternoon schedule convenient. This year, the first hour of training, which had been devoted to a quick dinner and whole-group discussion, was revised to include a more structured teaching and learning seminar, with a progression of topics and associated readings. All but one mentor found the seminars worthwhile overall; those who had participated in previous years judged the new approach an improvement over last year. A student who found the sessions very helpful said, "They were immensely useful, especially the generic talk about teaching strategies. Everything translated directly into our class and improved our performance." Another concurred, "You have to check your assumptions at the door. On Monday nights we would discuss concepts and philosophy, then in class you see it all in action, you would actually experience the philosophy." Discussing the second hour of training, a third mentioned that they often applied things learned in the first-hour seminars to the following grade-specific preparation. Another commented, "They were definitely helpful. The seminars led me to think about science teaching, about asking the right question" The sessions on asking the right question and on science misconceptions were thought-provoking and were the clear favorites among mentors. As one mentor said, "The paper on how to ask questions was very important for me. It changed my idea of how to run a class." As in previous years, mentors appreciated the dinner, the social time and sharing experiences during the first hour. A number called for more opportunities to learn from other mentors' experiences during the all-group session.

But not all mentors found all sessions or all aspects of the lessons helpful, and would probably agree with the mentor who described the seminars as "helpful, but not maximized." Over half the mentors offered suggestions for making the seminars more effective. Five mentors felt the seminars were too long, an assessment that reflected not only how quickly they comprehended the lesson concepts but also the fact that some groups found the following grade-level preparation time inadequate and would have allocated more time to lesson preparation and less to general pedagogical instruction. Several pointed out that discussions would have been more productive if facilitators had followed their own precepts better—waiting longer for responses so that a few voices didn't dominate the discussion, attending to different learning styles, breaking into small groups more often to encourage more complete participation. A number noted that if mentors were to develop their own lessons for the last class day, they needed to be thinking actively about them from the beginning. Although the option to create a lesson is mentioned in the seminar syllabus for Week 5, it is not actively promoted in the previous weeks. Staff need to keep this opportunity before the mentors, so that as they find their footing in the early weeks they can begin to think about a lesson that will fit their class. Because this awareness came late, many students who would like to have created lessons did not do so and the lesson devoted to small group brainstorming about creating lessons from one's own interests was not very effective, since few had ideas ready to talk about.

Despite the reservations of some, it is clear that mentors appreciated and learned from the more focused approach to pedagogy. Several suggested other topics and strategies to help mentors learn to teach better. One wanted to learn more about learning theory, especially what teaching approaches promote retention. Several others asked for opportunities to practice their teaching. One made this suggestion:

> The seminars would be better if they forced us out of our comfort zone more. Perhaps we could meet in small groups with an MMS person who would give us problems to solve. For example, they might set a scenario: How would you ask a question under these circumstances? How would you present this kind of information? Brainstorming about this would help us actually practice our teaching. This is what *we* need to learn, the teaching, not the science.

<u>Hour two: grade-level preparation</u>. In addition to the all-group sessions, grade-level teams spent an hour on Monday nights preparing Wednesday's lesson. Despite the fact that the

grade-level preparation involved four different instructors with distinct teaching styles and 24 mentors with their own learning styles, some generalizations emerge. In general, instructors gave an overview of the lesson, presented the materials for the activities and encouraged mentors to "mess around" with them and think about ways to use them to teach the main concepts of the lesson. Mentors felt the materials were good, as were the ideas for presenting them suggested by MMS staff. Unlike previous years, however, when lesson plans were mostly fixed by the instructors and mentors had only to familiarize themselves with them and perhaps put their own spin on them, mentors this year were encouraged to be more involved in creating the actual lessons, especially in the later weeks.

Mentors were pleased to contribute their energy and insights—all mentors endorsed their level of involvement in lesson planning—and their creativity and flexibility (and enhanced pedagogical training) may have been a factor in the solid student outcomes this year. But leaving much of the lesson to be planned on Monday night left many feeling that this was a "seat-of-the-pants" operation. As another said, "There was too much free-styling by us." A third pointed out that "developing lessons on the fly was less exciting pedagogically, because we had to focus too much on just getting through the hour." About half the mentors said they left the Monday night sessions feeling a car ride away from being ready to teach, but as many did not feel prepared. Sometimes materials to accompany just-developed lessons had to be created between Monday night and Wednesday noon, so that mentors' first look at them came in the classroom. Sometimes it simply meant that the final organization of the lesson came together after the Monday session as mentors worked, alone or in teams, to prepare more detailed lesson plans. This year, for the first time, about half the mentors said the program took more time than they expected. For a few, this was a challenge. While they did not begrudge the time spent at science sites online or perusing textbooks, they did offer suggestions for creating a sturdier structure to support the more inclusive and ad hoc approach to lesson development.

First, many said that mentors need to understand the topics and main learning goals of the six-week session explicitly from the beginning. (Some, you will recall, asked for all the lesson plans at the orientation session, so that they could discuss substantive lesson ideas with the teachers.) In some cases the syllabus was revealed (at least initially) week by week, robbing mentors of the big picture that would have helped them make lessons coherent from week to week and coordinate preparation and follow-up with the classroom teacher. As one said, "They should give us all the lessons for six weeks up front so that we can read ahead, be ready with questions and be thinking of ideas." A mentor on another grade team said, "Most important, we should get the lessons ahead of time so that we can look at it before and spend more class time messing around with the materials." Having a grasp of the material when they arrive for training should help mentors to make better use of the MMS educators' expertise and accomplish more in the planning time.

Second, mentors from every grade level felt that they needed to understand the concepts deeply in order to better create and teach the lessons. As one said, these are "tricky concepts," which although commonplace, can be very hard to explain to youngsters. Some mentors were rusty about the concepts they were teaching and needed to brush up themselves, but they particularly wanted to have good strategies for explaining them to elementary school children. "How," one wondered, "do you explain heat without invoking molecules?" Another remarked, "The book just says 'Discuss repel and attract.' How do you do that with third graders? I did a lot of preparation to understand magnetism and electricity better. It is important to understand deeply, and I didn't get that from the MMS training. Even if you don't need that information directly in the classroom, it helped me feel more confident that I could answer questions." Several pointed out that they were very good at managing experiments; what they needed was help conveying complicated ideas. What knowledge can children of that age draw upon? What kinds of analogies or examples would make sense to them? Addressing misconceptions about science concepts is one of the great challenges of science teaching, as one of the Monday-night pedagogical sessions made clear. Mentors felt that they needed a deep understanding of the concepts in order to figure out how to move students from erroneous preconceptions to accurate—even if simplified—understandings of the phenomena they were studying.

<u>Mentor training: Summary.</u> This year's training program was the most ambitious yet, and mentors found it more useful than in previous years. They endorsed the first-hour seminars that were more focused on teaching and learning, suggesting that there were places where the educators could tighten the focus even more and work harder to involve all participants. Sessions on asking the right question and science misconceptions were particularly valued. Several asked for more emphasis on learning theory and on practice teaching, perhaps involving real-life scenarios. A number pointed out that if mentors were to develop their own lessons for the last day, that opportunity needed to be publicized early and often. Mentors also appreciated their greater involvement in lesson planning for their specific grades, but noted that ad hoc lessons came at a cost. To help mitigate the consequences of last-minute planning, they recommended providing mentors with all six lesson plans at the beginning of the program and focusing more on deep conceptual understanding. Sharing lesson plans would allow mentors to

think about the big picture and thus work more efficiently week to week with MMS staff and their host teachers, while exploring the main concepts of the lessons more deeply would help them locate the common elements through which to connect their understanding of these concepts to the nascent perceptions of elementary school students.

The Classroom Experience

Teachers' Perspective

Integrating lessons into the curriculum. Both directly and indirectly, teachers reiterated the importance of linking Science Camp lessons to their class curriculum. Asked what changes might improve Science Camp, one teacher said, "The big change has already happened—connecting the lessons to the curriculum. This is hugely important." Third and fourth grade teachers praised the Insights curriculum from which both they and mentors worked. Said one, "The most important thing about the lessons was the *perfect* connection to the curriculum." Another remarked, "The lessons this year were more structured and the fit was even better this year because we had the Insights curriculum to work from." One teacher pointed out, however, that magnetism was not covered in the Insights materials, suggesting that MMS offer trainings for teachers to help them present that topic.

The third, fourth and sixth grade teachers felt that the curricular fit was stronger this year than previously.[1] The fifth grade studied heat, which was not part of the regular curriculum (although they do study energy earlier in the year). While teachers felt that the graphing and experimental design aspects of the lessons were strong and reinforced what fifth graders were learning, they felt the topic itself did not engage students. Several mentioned that they didn't think the kids "got it;" one spent an hour after Science Camp helping students "get the meaning of what they had done." Another fifth grade teacher said the program didn't provide the information teachers needed to follow up and support the mentors' presentation. "It was hard for me to add a lot. I'd like to do more than crowd control." All three teachers said MMS staff had not consulted with them about the choice of topic for Science Camp.

This year teachers indicated that it was important to them that their students really understand the Science Camp lessons. With Science Camp lessons integrated into the regular course of studies and linked to the grade-level expectations, teachers have a greater investment in their success. Most teachers mentioned that they had or had wished to follow-up on mentors'

[1] The seventh grade teacher was not interviewed.

presentations to solidify Science Camp lessons. They also said that this year they felt more comfortable going beyond the classroom management role and "jumping in" when they felt a point needed clarification or expansion. As one said, "I helped with time management, class management, and added comments when I thought they were helpful. But they are in charge; it's their show." Teachers did not feel this infringed on mentors' territory, nor did mentors report that teachers were intrusive. If anything, mentors viewed teachers' involvement as instructive illustrations of good pedagogy. Several teachers (and mentors) wanted more opportunities to debrief mentors and talk about teaching practice; a number felt that more time should be devoted to each lesson.

Relationship with mentors. All teachers said they had very comfortable relationships with their teams, attributing that to the orientation meeting and pre-visit where roles and expectations were clarified, to robust communication between teacher and team, and also to the personal characteristics of the mentors. Improving communication among teachers, mentors and MMS has been a continuing goal of the program. This year, all teachers reported that communication with their teams was good and had helped them coordinate their respective efforts. The communication gap identified this year concerned the distribution of lesson materials. As noted earlier, a number of teachers and mentors asked that both the syllabus and lesson plans be made available by the time of the initial meeting so that teacher-mentor teams could use that time to map out the sessions together. Knowing the substance and sequence of lessons in the beginning allows teachers and mentors to coordinate precisely: teachers can develop preparatory and follow-up activities and mentors can begin to think about how to explain the concepts and show their coherence.

Asked to describe mentors' strengths, this year teachers praised not only their science knowledge (which they universally did) but also their teaching skills. One said, "They had good management styles and picked up quickly on class expectations and routines and on my approach. I could tell they had worked on classroom management." Another: "They were good in class, gave positive feedback, had models and gave repeated directions." A third: "They had good communication skills, good class management skills and were interested in their job." A fourth: "They seemed better prepared this year; the MMS training was better." Teachers had pointed out in the past that lack of classroom management skills could render the best-prepared science lesson valueless. This year they felt that mentors' classroom strategies enhanced the lessons, a clear vote in favor of the revamped mentor training.

Teachers did identify a few areas for improvement, most notably in pacing a lesson. Several mentioned that the lessons would have benefited from an introductory overview and a final debriefing. Several others noted the lessons were sometimes rushed, leaving no time for the important "meaning making" at the end. Future lessons should allow time for adequate introduction and summary and future training should teach mentors how to present a compelling and efficient lead-in to a lesson and how to collect the strands of an activity to illuminate meaning at the end.

Value for teachers. Seven of the eight teachers interviewed said Science Camp was a worthwhile experience for them as teachers (one wasn't sure). They enjoyed their interactions with the mentors and they appreciated having science experts—and extra hands—in the class. They were pleased to see their students excited about real science. Five teachers noted that watching others teach their classes gave them a much-appreciated opportunity to reflect on their own practice. Said one, "Watching someone else with my class gave me new ideas and a new appreciation for teaching—it's challenging." Another remarked, "Watching them gives me new ideas about teaching. This is great observation time on many levels." Several others said they learned more about inquiry science and the Science Camp topics; one learned an entire new lesson developed by her mentors, "which I will use in the future." They strongly endorsed the program, assigning an overall grade of A-. All third- and fourth-grade teachers awarded the program an "A;" the two lowest scores (B+) came from fifth-grade teachers. Seven said unequivocally that they would volunteer for the program in its present form. One conditioned support on greater collaboration and consultation between teachers and MMS.

Teachers' Experience: Summary. Teachers reiterated the importance of linking the Science Camp lesson to their class's regular science curriculum. Third and fourth grade teachers whose classes worked from the Insights curriculum were particularly pleased with the curricular fit. With this linkage comes a greater investment in the success of the program, and most teachers appear to have found a comfortable role as part of the Science Camp team, coordinating with mentors and supporting their efforts without diminishing mentors' learning opportunities. Teachers enjoyed their relationship with the mentors and praised both their science knowledge and their teaching skills, which they felt were stronger than in previous years. Their main recommendation for improvement: more emphasis on introducing and summarizing the lesson. They also suggested making teaching materials available at the beginning so that teachers and mentors could plan more effectively. Overall, they judged the program very worthwhile for their students and themselves and awarded Science Camp high marks.

Mentors' Perspective

Lessons. Overall mentors felt the lessons were age-appropriate, well-designed and interesting to students, especially when they were engaged in hands-on activities (five minutes of talking in the third grade, repeated graphing exercises in the seventh grade, and a high planning to execution ratio in the fifth grade all led students to lose focus). Most mentors said the lessons were flexible, so that they could match activities to attention spans and time available. On the other hand, half the mentors recommended that Science Camp be allotted more time each week so that they could do a better, more complete job. (In some cases, scheduling problems at the schools seem to have reduced the appropriated time for Science Camp.) Many said they could be more flexible in responding to classroom immediacies if they had the six weeks' lesson plans, or at least an outline of the main concepts and activities, at the beginning of Science Camp planning. Fourth grade mentors made a special case: many of their activities were weather-dependent and they needed the six-week overview in order to re-sequence their lessons on short notice.

Third and fourth grade mentors were enthusiastic about their curricula. One fourth grade team used the science notebook strategy from the teaching seminar, each week having their students write about their Science Camp activities and answer questions posed by mentors (and later, students). "This was a great idea," leading to livelier discussions and better understanding. Like the teachers, fifth grade mentors found the heat lessons less effective than they would have liked. One said that the lessons "worked, but they could have been more dynamic and exciting. There was a lot of sit and watch and not a lot of "wow" factor." Others pointed out that with an abstract topic like heat, mentors needed to know what knowledge fifth graders brought to the topic in order to couch their explanations in terms that were understandable and relevant to them. One observed that the real goal of the lessons seemed to be science process and suggested that if that were the case, basic chemistry activities might convey that lesson better than experiments about heat. In the sixth grade, several mentors felt that their lessons included too much emphasis on playing with materials and too little on drawing out the main ideas from the activity. One noted that "playing with circuits was too easy. They can handle more complex ideas." They felt the potato battery activity and the switches activity both worked well with sixth graders. All four seventh grade mentors mentioned the overdose of graphing in their lessons and called for more hands-on activities. And while they admired how the Science Camp lessons linked biomes to planetary motion, it was not clear how their lessons connected to what their students were studying in regular science classes.

Only about a quarter of mentors prepared a last lesson about their own science specialty, but those who did enjoyed bringing their personal experiences to the class. Student results suggest that these presentations had an impact, since students in those classes often mentioned characteristics of their mentors' work in the list of characteristics of a scientist.

Teaching challenges. Mentors said they quickly felt prepared and comfortable in the classroom. As one concluded, "I got better and better. I began to feel like an actor toward the end. I'd come in with lots of energy and enthusiasm—the Greg effect!" Compared to previous years, mentors seemed more confident about their teaching ability. Many mentioned the challenge of teaching a very heterogeneous group, but seem to have found strategies for doing so. The only task that many felt they should have done better was to explain abstract and complicated concepts in simple terms. One mentor captured a common theme, "I wanted to know more about how to present big, deep concepts to kids." As noted above, part of the solution involves understanding the concept deeply oneself, so that so that you command a touch point that connects with many explanations, analogies and examples. Whether MMS staff forward this goal through guided discussion among mentors, suggested readings or some other method, gaining this depth of knowledge should be an integral part of lesson planning.

Another part of the solution involves knowing what science background the audience brings to the problem. One mentor pointed out that "you need to know more than the material. You need to understand how their minds work and be organized in your method and explanation." Another summarized, "I need to understand where n^{th} graders are at." Teachers and mentors already discuss "where n^{th} graders are at" in general terms at the orientation session, but without the lesson plans at hand they cannot talk specifically about what background students have for the concepts they will actually be working with. Supplying the plans at orientation should help teacher-mentor teams determine efficiently what students already believe and where knowledge gaps lie.

Relationship with the host teacher. Mentors confirmed that their relationship with the host teacher was easy and productive, saying that they were supportive without being intrusive. Most communicated frequently by email to coordinate plans. Those who had time to debrief with their teachers appreciated their insights; those who didn't wished they had, like this mentor, who said, "I wanted more concrete feedback, more criticism. I wanted to hear how I did from a real teacher." These representative comments suggest that teachers and mentors have established a mutually satisfying relationship:

> She facilitated, problem-solved, helped and let us go at it. It was great.
>
> Our teacher was fabulous. She followed up on every session, so even if we ran out of time, she completed the lesson. She really wanted the kids to understand. I also learned a lot from watching how she handled the kids and how she found ways to explain tough concepts.
>
> He was great. He was involved, but didn't get in the way. We watched him do a lesson on the first day—very impressive—he could really get kids excited about science.
>
> My classroom teacher was amazing. She did experiments separately with the class, was willing to put class time to Science Camp even after it was over for the kids to finish their graphs and questions, etc. She even kept some of the materials we used to run her own experiments, and she would cut in whenever she wanted to help us explain something more clearly to the class. This was very helpful, because she'd be able to make comparisons and relations to concepts they had already learned in class, or she would just come up with brilliant examples and questions to make sure the class understood what we were trying to teach.
>
> He respected that we were the teachers, but he wasn't detached either. He watched, offered helpful comments, managed the class. He was the ideal participant.

<u>Value to mentors</u>. Mentors uniformly ascribed high value to their experience. It was, as one said, "an extraordinary experience; wholly rewarding." Another noted that it was "very fulfilling on so many dimensions." As they talked about what they gained from Science Camp, two themes appeared at some point in virtually ever interview. First, almost everyone appreciated the opportunity to share their talents and resources (and those of the College) with the community. They were pleased to be able to "give back" by "encouraging enthusiasm for science in the community" and "inspiring young scientists." Second, they all said they had become better teachers, in the largest sense. They learned about inquiry science and the importance of asking the right question. Many acquired a new view of teaching, insisting after Science Camp that lectures did not qualify as "teaching," since they did not directly engage the learner. They also appreciated that presenting a lesson that *does* engage the learner requires a lot of planning and hard work. They learned that people (even themselves) bring different science backgrounds and learning styles to a science presentation, and that any presentation must be tailored to the audience. They learned how to break down concepts so that they made sense to elementary school students—and how to tell when their message was getting across. (And as one teacher remarked, "If you can explain it to a fourth grader, you can explain it to anyone!")

They understood that this process had broad applicability and would serve them whether they were explaining science to kids or to board members. As they stepped back and thought deeply about science concepts and processes, many found their own interest in science reinvigorated. Others found new interest in teaching, like this mentor: " I almost have been inspired to be a teacher. It was amazing to see how you can really make a difference in a child's life." Their own words convey their enthusiasm and excitement about this unique engagement with science and children.

• Real teaching is hard work.

> Teaching is not easy. It takes a lot to put together an effective lesson, to actually address an audience, figure out whether they're getting it or not. It's very different from doing a lecture. It was fun and exciting to figure out how to explain things so that kids would understand them.
>
> Teaching is not the same thing as lecturing. Teaching requires thinking and planning. The huge thing I got out of this is that if you want a listener to understand, you have to plan the lesson instead of just telling them facts.
>
> I learned that there are some very creative ways to teach science that are a hundred times more effective than some of the teaching techniques past science teachers have tried on me. And even though some of these creative techniques require a lot more planning and effort, they are certainly worthwhile and make me want to be a scientist more than straight up lecturing about scientific theories. Being in this program really transformed my image of science education, what it was to me, and what it can be.

• Asking the right question is important.

> I learned how to ask questions. This is phenomenal. Before we read the article for class, I hadn't understood how important the question is. This is really cool. It broadened my horizons. Now I think "I should learn this, " not, "I should know this." Learning does not equal knowing, and learning is not an easy process.
>
> Learning to ask the right question—that's the trickiest skill. I had to think about this all the time. It's easy to slip into "telling" from "leading." The training in "leading" was the most valuable thing for me.

• Teaching has to be tailored to the audience.

> I learned how to craft a message to the audience, the importance of meeting people where they are.
>
> I learned how to refine my communicating science to non-scientists. Not everybody has a science PhD. You have to think about how to explain things,

relate science to things that are relevant to the listener. You have to work with them at their level of understanding.

I learned how to convey difficult concepts to people who have not had as much science education as I have.

I learned how prepared you need to be to teach anyone anything. Concepts must be clear to you and you need different strategies to reach different people.

• Science Camp reinvigorated a love of science.

This influenced my life. As a last year grad student, this was an uplifting experience. I realized that science is not just lab work. I taught this to the kids and to *myself.*

I am a better scientist when I can think about the scientific process in general terms and not just think about the details of my particular work. Science Camp helped me simplify things.

I learned from my students how to engage my mind through inquisitiveness, through play.

This provides inspiration to keep going through grad school. It reminds me of why I like science.

While altruism and learning were dominant themes, part of what makes Science Camp so rewarding for mentors is the fact that it delivers value across the board. Working with children was fun for everyone, and mentors were excited and gratified to "get kids excited about science" and "see kids light up." "My students," one said, "were inspiring." They enjoyed working with the MMS staff, whose skills they admired, and with other students who were committed to science. As one reflected, "It was great to work with others who are passionate about science." Mentors were pleased to be away from campus for an afternoon, using words like "refreshing," "a breath of fresh air," and "a welcome change from graduate student life." They enjoyed the social aspects of the program, the dinners and the paycheck. As one pointed out, it was a very well-structured program.

This made me think about how to run a program like this. This was a well-structured teaching experience--we weren't just thrown in there. We were so well prepared, coached and supported that it was a more thoughtful teaching experience than anything I've ever participated in, so you could learn more from it. We were always thinking about what we were doing.

Apart from suggestions already discussed to improve training, mentors' only recommendations for improvement concerned housekeeping details, particularly informing them about the particulars of the job early on, even before the orientation session, and communicating about day to day matters (especially changes) in a timely way. Several mentioned that supplies for their lessons did not always arrive in time for the start of class.

Mentors' Experience: Summary. Mentors were uniformly and enthusiastically positive about their Science Camp experience. Every one said it was worthwhile and that they would do it again if they could; most had already recommended the program to fellow students. They enjoyed working with the Rivendell students, who both inspired them by their energy and inquisitiveness and exemplified the different backgrounds and abilities people bring to a learning situation. They appreciated the support, the pedagogical model and the colleagueship of their Rivendell teachers, with whom they established a comfortable and productive relationship. They praised the expertise and personable support of the MMS staff. They were pleased to be able to contribute to the community they live in.

Their classroom experiences gave them new insights into teaching, which they say they will use when they themselves communicate science, either as teachers or in other capacities. Specifically, they came to appreciate the inquiry model and the importance of hands-on activities. They learned how to guide learning by asking the right question and how to match their presentation to the audience. As they stepped back to the basics, "thinking down to the most fundamental concept," many also found a frame that gave new life to their own work. The structure and supporting elements of Science Camp enhanced the core learning and teaching activities, adding social opportunities, altruism, new vistas and even tasty meals to the experience. As one mentor summarized, "It was perfect. It was great to be in class, it was great to be away from school, the students were inspiring and MMS was great."

Student Outcomes

The stated goal of Science Camp is (1) to excite students and give them confidence about learning science; (2) to provide students with a sense of contemporary science; and (3) to encourage students to see the relevance of science in their lives. This year, evidence from teachers, mentors and student assessments indicates that those goals for elementary students are being met.

Teachers' perspective

All teachers interviewed said that Science Camp was a worthwhile experience for their students, using words like "absolutely," "definitely" and "great." They cited the hands-on activities, the use of real science data and vocabulary and the emphasis on science process as important value added by Science Camp. They felt that their students understood the concepts they were presented. One summarized, "This year was fantastic, a well-oiled machine. My children really understood the concepts much better than last year. The mentors were great."

Discussing the value added by Science Camp, however, teachers spent more time talking about how mentors introduced their students to the world of science as an enterprise and as a profession than they spent talking about content. Having people from outside the school talk about science in itself made science exciting and important, they said. When these outsiders were approachable young people—the virtual opposite of the stereotypic grizzled old man in a white coat—they changed students' perceptions about who scientists were and what they did. Here are several exemplary remarks from teachers' interviews:

> The mentors made being a scientist seem less abstract. They were young and seemed more "real," so becoming a scientist seemed more attainable. My students hadn't really been exposed to how people become scientists. This really opened their eyes to it, going to college and the whole process. And they learned about the possibilities of science—"Wow, you mean that's science?" They saw that there was so much to it.
>
> My students saw real-life scientists who didn't wear white coats. They saw the connection between subjects: science isn't just "science," it's also math and health and other subjects.
>
> The mentors modeled the world of science. [When they did experiments, they communicated that] we are all scientists!

Mentors' perspective

Like teachers, mentors felt that Science Camp was "definitely," "absolutely," "100%" a worthwhile experience for Rivendell students. Mentors in all grades felt that most of their students understood the main concepts they presented. This marks something of a change from previous years, when mentors were sometimes uncertain that they had conveyed concepts effectively. While a number said they had to spend extra time acquiring the depth of knowledge they needed to explain electricity or heat, for example, they felt that their students "really got the concepts," including, in the fifth grade, experimental design (as well as heat). As one mentor exclaimed, "Our class was so diverse academically, but in the end, they all got it. It was an amazing feeling—they really got it!" These content gains are testimony to the combined efficacy of well-designed lessons, tight curricular linkage (and support from teachers), extensive pedagogical training and hard and creative work by mentors.

Content gains do not appear to have been won at the cost of other desirable outcomes. Discussing what students learned, mentors said that students improved problem-solving skills, learned to persevere, learned that mistakes are part of doing science—and had fun. Most important, almost every mentor mentioned that the experience changed students' ideas about what science is and who scientists are. The quotes below are typical:

> I believe that their concept of what science is, of what it means to explore the physical world, has changed. Third graders are very inquisitive and I think that some look at the world differently now. I also think that their conception of scientists has changed, and that's cool. It's good to have diverse pairs of mentors.
>
> They thought that science was boring and that scientists were old men. They saw that science is fun and exciting and so varied—you can do so many different things.
>
> Many kids don't get to see actual scientists. Here they see that they are all different kinds of people and do all different kinds of things.
>
> I think they understood better what a scientist can look like and the variety of science, that everybody can do science.
>
> The big lesson: it extended their idea about what science is. My partner showed that code making and breaking is science. That was really cool. Science is cool and fun!

Several mentors, however, mentioned that they were presented to their classes not as scientists but as Dartmouth students, an identification which they feared prevented students from fully appreciating their role as representatives of the field. Introducing mentors as scientists is an easy way to be sure that students make that connection.

Student assessments

Responding to the recommendation of teachers and mentors, this year a brief assessment of student learning and attitudes was conducted. To assess student learning, mentors created a short constructed response question for their students to complete on the last Science Camp day (or immediately thereafter). In addition to providing measurable data on student learning, creating the assessment tool gave mentors another valuable teaching experience.

The questions asked students to use concepts they had learned to solve novel problems. Although apparently simple, some of the questions about heat, energy, and solar motion address challenging concepts that puzzle many adults. The questions are included as Appendix 2 to this report. Seven classrooms turned in completed constructed response exercises.[2] The results, summarized in Table 2 below, concur with the evaluation of teachers and mentors that most students mastered the material they worked with.

Table 2. Results of final constructed response questions

GRADE	TOPIC	QUESTION SUMMARY	% PROFICIENT	% PARTIALLY PROFICIENT	% NOT PROFICIENT
3 Kendall (N = 25)	Electricity	Draw and explain a circuit that uses a switch	60%	32%	8%
4 Crimmin (N = 8)	Astronomy	From diagram, identify and explain seasons on Earth and on planet without tilted axis.	63%	37%	0%
4 Derosier (N = 13)	Astronomy	Draw morning, noon and afternoon shadows, explain why sun appears to move across the sky.	54%	46%	0%
5 Belknap (N = 13)	Heat	Explain energy changes in preparation and drinking a mug of hot chocolate.	23%	46%	31%
5 Noseworthy N = 13	Heat	Identify testable question, variables, results and conclusions for an experiment you conducted.	31%	54%	13%
6 Gaine (2 classes) (N = 24)	Electricity	Connect elements of a circuit so that one bulb is brighter than others; identify characteristics of the circuit.	42%	33%	25%

To evaluate the program's success in changing students' perceptions about scientists, teachers asked their students to write down five things that describe a scientist before the first Science Camp lesson and again after the final session. Students' perceptions of scientists influence their attitude toward science itself (Finson 2003, Jane et all 2007). Students who enjoy science may choose not to pursue the field because they believe that scientists have unpleasant personal characteristics or undesirable lifestyles or because they feel that science simply isn't

[2] Responses from several classes were, regrettably, lost in the end-of-program shuffle.

open to people like them. One goal of Science Camp is to give science a friendly face, showing through interactions with personable young scientists that scientists enjoy their work and have well-rounded and satisfying lives. By sharing their personal stories, mentors illuminate the science career pathway and show that anyone can be a scientist.

Matched pre-post characteristics lists were collected for 75 students in the 3rd through 6th grades. Students' pre- and post-descriptions were scored according to the rubric in Table 3 and a pre-post difference score was computed for each student. The scoring is, of course, arbitrary and represents an ordinal (rather than cardinal) organization of the descriptors. Note that the scoring neither credits nor penalizes students for including characteristics of the omnipresent "mad scientist," a stereotype which, like all stereotypes, is partly true but which indicates lack of awareness of science beyond the stereotype.

Table 3. Scoring rubric for the "Five things I think about scientists" exercise

Score	Type of Comment	Description	Examples
-1	Negative	Unflattering characterization	Weird, evil, not affectionate, no romance, know-it-alls, geeky
,	Mad Scientist	Includes characteristics of stereotypic "mad scientist"	White lab coat, crazy/white hair, aging, goggles/glasses, potions, beakers/flasks/test tubes
1	Neutral	Accurate, no emotional valence	Do experiments/research/tests/analysis, work in labs/outdoors, study bugs/diseases/rocks, etc.
2	Positive	Positive emotional valence	Are nice, try to help people, try to make the world better, cure diseases, are smart*
3	Personal	Refers to students' own experience (including their experience with mentors)	Can be anyone of any age/wear anything/work anywhere/study multitude of things, studies what my mentors study or what I studied in Science Camp, teaches, reads, thinks, follows special procedures described by mentors, e.g., "take accurate information," "are careful about what they do when they do experiments," "explain their work," "use cool tools," "love to learn," "make mistakes," "graph," "talk to their lab partners".

"Smart" was coded as positive, although some students may have ambivalent feelings about that descriptor.

The results of the "5 things" exercise confirms teachers' and mentors' perceptions that Science Camp changed students' ideas about who scientists are. While an ordinal difference scores can provide only a rough estimate of student change, they do indicate overall gains and important trends among the grades. (Graphs included as Appendix 3 display the pre-post change in each type of descriptor by grade.) Table 4 below summarizes the scoring, showing that younger students started out with more positive views of science than older children (mostly due to fewer negative and "mad scientist" qualities in the younger children's characterizations) and made greater gains during Science Camp, due primarily to an increase in characterizations that referenced a personal connection.

Table 4. Means "5 Things I think About a Scientist" score

GRADE	NUMBER OF STUDENTS	MEAN PRE-SCORE	MEAN POST-SCORE	MEAN DIFFERENCE
3	21	3.9	9.7	5.8
4	19	3.2	7.9	4.7
5	11	2.8	4.9	1.7
6	24	2.0	1.6	-.5
ALL	75	3.0	6.0	3.0

The graphs in Appendix 3 also show that younger students' view of science shifted strongly toward a more personal conception. As an example of this change, one third grader wrote on the pre-test that scientists "study plants, they try to time travel, they look at tiny things, they look at dinosor bones, they write notes on things," a neutral portrait that seems to reflect both school learning and media exposure. On the post-test, the student wrote that scientists "study magnettism and circits, experiment with magnets, ask questions to people, use bar grafs, take notes," all directly referencing his experience in Science Camp and suggesting that his view of science is now connected to that hands-on experience with exemplary role models. By contrast, sixth graders sometimes seemed almost perverse in their desire to appear untouched by the Science Camp experience. One dramatic example was this sixth grader, who in his pre-test wrote that scientists are "smart, different (in a good way), glasses, nice, planet savers," but in the post-test said scientists were "nerdy, smart, weird, no romance, not attractive at all." While this sixth grader's attitudes may not have changed as much as he would like us to believe (sixth graders are just learning to game the system), it still seems fair to conclude that younger students are more open to the Science Camp experience and benefit more from it.

<u>Student outcomes: Summary</u>. Student pre-post attitude measures and their responses to constructed response questions about their Science Camp topic are consistent with the assessment of teachers and mentors: most Rivendell students understood most of the science they encountered in Science Camp. The content measures , developed by mentors, were open-ended and required students to organize what they had learned and apply it to a novel situation. As a whole, students also appear to have modified their attitudes about science as a profession. Using their pre-post characterizations of scientists as an index, they see science in both a more positive

and a more personal light. Younger students, who are less influenced by unflattering stereotypes of scientists, were more likely than older ones to characterize scientists in terms of their own personal experience, as being like themselves or someone they actually knew.

Conclusions and Recommendations

In this third iteration Science Camp appears to have matched its ingenious idea with solid implementation. Evaluation results indicate that more rigorous and creative mentor training paid off in greater learning and more effective classroom practice for mentors. Tying Science Camp lessons even more closely to each grade's curriculum increased teacher satisfaction and involvement; in the one instance where the connection was not close, teachers and mentors both judged their experiences to fall short of expectations. The orientation session and mandatory classroom pre-visits helped teacher-mentor teams communicate productively and work together effectively. Anecdotal evidence from teachers and mentors and written work by students all suggest that Rivendell students made conceptual and attitudinal gains.

As Science Camp has fleshed out its core idea over the past three years—filling in communication gaps, improving mentor preparation, tightening curricular connections—participant commitment and expectations have also risen. Increasing realization of the concept appears to reveal ever more possibilities for refinement and reward. In response to participant feedback, each year MMS educators have invested more effort in developing mentor training and purpose-built student lessons. With better training and better lessons, each year mentors contributed more to lesson design, worked harder to meet that responsibility and asked MMS educators to give them tools to do the job even better. And as mentors improve their classroom performance and lessons support the curriculum more, teachers have become more involved with program as a whole and have asked for more information and organizational transparency to help them support the program better. Thoughtful feedback from teachers and mentors and equally thoughtful responses by Dartmouth and MMS educators have fueled a cycle of improvement that if not yet "perfect" (in the words of one participant) is surely "extraordinary" (in the words of another).

Most of the recommendations of this report can thus be glossed by "keep doing what you are doing." Close integration of Science Camp with the curriculum improves student learning, close communication among Science Camp participants makes their efforts more effective and efficient, and more structured mentor training gives them more strategies for success. Suggestions for change mostly involve refining major modifications already in place.

To support science learning, continue to:

- Integrate Science Camp lessons with the regular science curriculum for the classroom.
  Consult with all teachers annually to make sure you are on track. As one teacher noted, "We need to keep looking at the curriculum. Is it the way we want it?"

- Create lessons that involve hands-on activities with relevance to students.
  Lessons that are too easy, repetitive or involve a great deal of seat work tend to reduce student interest and make the mentors' job harder.

- Share information widely among participants.
  Ensure that all parties—MMS, teachers, and mentors—are in the communication loop and that responsibilities about communication clear: Who should contact teachers about the weekly lesson plans? When should that happen? Individual teacher-mentor teams will undoubtedly work out their individual communication patterns, but everyone should be able to count on a general protocol for disseminating program information.

- Improve the January orientation session with mentors and teachers.
  Have lesson plans in the hands of mentors and teachers by the orientation session. This will allow them to develop a plan for activities and responsibilities for the entire six-weeks' session. If everyone has the big picture in the beginning, it is easier to make adjustments later on. It will also allow teachers to share with mentors knowledge their students bring to the specific lesson concepts so that mentors can develop appropriate strategies to address them.

- Devote the first Monday night hour to structured learning about teaching.
  Consider shortening the time allotted and tightening the presentation.

- Involve mentors in the creation of lesson plans and give them tools to deal with more open-ended activities.
  Spend time in the training sessions discussing the concepts at a fundamental level and helping mentors devise ways to explain them to students. Ensure that each lesson includes an introduction and a summary, and allots time for them. Providing an overview of the activity in the beginning and discussing it at the end help students make meaning of the experience.

To improve student attitudes about science, continue to:

- Extend Science Camp by one week to allow for mandatory classroom pre-visits by mentors.
  These visits not only jump-start team-building, they also facilitate the personal interaction between mentors and students that is critical in changing student perceptions.

- Use all opportunities to present mentors as real scientists.

  Refer to mentors as scientists, so that students are clear that they represent the profession.
  Encourage mentors to share personal science experiences where appropriate.
  Support mentors in creating a final presentation that showcases their own work.

• Hold a culminating MMS Open House and advertise it widely.

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Appendix 1

Mentor Interview Protocol
Dartmouth-Montshire Science Camp at Rivendell
Winter 2009

Introduction. Thanks. Confidential/anonymous.

I. Did this program surprise you in any way? Please expand.

II. For the next part of the interview I'd like to talk about the science lessons themselves.

1. First, please comment on the lessons themselves. Were they interesting? Age-appropriate? Logistically smooth?

3. What do you think the Rivendell students learned from Science Camp? (Feel free to think specifically and globally.)

5. Do you think this was a worthwhile experience for the <u>Rivendell students</u>? Why or why not?

III. Now I'd like to talk about your role in the program.

1. [PRE-CAMP ACTIVITIES] There were two activities that took place before Science Camp began.
   • First was the January 8 orientation session at MMS. Please describe briefly what your team (mentors and teacher) talked about. Did that meeting help you do your Science Camp job better? If so, why?
   • Second was the meeting with your class the week before Science Camp actually began. Same question: Please describe briefly what your team did during that hour. Did that meeting help you do your Science Camp job better? If so, why?

2. [TRAINING SESSIONS] Overall, what is your assessment of the training sessions?

   • Were Greg's pedagogical sessions in the first hour helpful? Why or why not?
   • Did the grade-level training sessions prepare you adequately for the classroom?
   • How did you feel about your degree of involvement in developing lessons for your grade?
   • Is there anything that could have been done differently to make the trainings more effective? Or more interesting? Or more worthwhile to you in the longer term?

3. [CLASSROOM EXPERIENCE] How comfortable did you feel when you were actually with the class in the classroom?
   • Did that change over the course of the program? How? Why?

4. Please describe your relationship with the classroom teacher.

5. Please tell me something you learned from this experience.
   (Why did you pick that to tell me?)

• Can you tell me something you learned from this experience that you believe will be useful after you graduate?

6. Now I'd like to ask you the same thing I asked about the Rivendell students: taking into account the time and effort involved, was this a worthwhile experience for <u>you</u>?
   • Unpacking the cost-benefit analysis, what were the costs and what were the benefits for you as a science mentor?
   • Please complete the following sentence: "The Dartmouth-Montshire-Rivendell Science Mentor program is a great way to________________________."
   • Knowing what you know now, would you do this again? Or, put another way, would advise another student to do this? Why or why not?

7. Would you like to comment on the organization of the program–scheduling, food, travel, arrangements with school, use of time, etc?

IV. This is a four-year program, so now I'd like to ask you to think about the program as a whole and suggest any changes that would make this program more effective in future years. We've covered some of these areas already, but I want to give a chance to offer any other thoughts you may have about:

- increasing value to the Rivendell students
- increasing value to the Dartmouth mentors
- increasing value to the Rivendell teachers

VI. Is there anything else you'd like to add about the Science Mentor program that we haven't talked about already?

Thanks so much for your time.

Teacher Interview Protocol
Dartmouth-Montshire Science Camp at Rivendell
Winter 2008

Introduction. Thanks. Confidential/anonymous.

I. This is your second/third year to host Science Camp in your classroom. What are the major differences you see between this year's program and previous year's?

- Next—and we'll unpack your answer to this over the rest of the interview— would you say that this year's program worked better, worse or about the same as previous years'?

II. For the next part of the interview I'd like to talk about the science lessons themselves.

1. First, please comment on the lessons themselves. Were they interesting? Age-appropriate? Logistically smooth?

3. This year the Science Camp activities were tied to your classroom curriculum. How well did the activities mesh with the curriculum?

4. What did your students learn from Science Camp that they would *not* have learned from their regular science curriculum and activities? In other words, what is the value-added of Science Camp?

5. Do you think this was a worthwhile experience for your students? Why or why not?

6. What could we change about the program to make it a more worthwhile for your students?

III. Now I'd like to talk about *your* experience in the Science Camp classroom.

1. Because of your previous experiences, did you approach this year's Science Camp differently, either in the way you prepared yourself or your students, or in the way you conducted yourself in the classroom?

2. Next I'd like to talk about your relationship with the Dartmouth mentors.

- This year there were two events that preceded actual Science Camp. The first was the January 8 meeting at MMS. Please describe briefly what your team (mentors and teacher) talked about. Was that meeting worth the time invested, in terms of the ultimate success of Science Camp?

- The second was the mentor's pre-camp visit to your class. Please describe briefly what went on at that visit. Same question: Was that visit worthwhile, in terms of its contribution to the ultimate success of Science Camp?

- Next, please describe your relationship to the mentors in the classroom. Was that relationship comfortable? Did you feel it was productive—i.e., did it work for them, for you, for students?

3. What were the mentors strengths as science teachers? Were there aspects of their teaching that could (or should) have been better?
   • Are there skills and understandings they could realistically acquire—in their training or in some other way—that would make them more effective science communicators in the classroom?

   • What do you think the Dartmouth mentors got out of the experience in your classroom?

4. Please tell me something you took away from this experience.
   • Why did you pick that to tell me?

5. Now I'd like to ask you the same thing I asked about your students: taking into account the time and effort involved, was this a worthwhile experience for <u>you</u>? Why or why not?
   • If this were a volunteer activity next year, would you do this again? Why or why not?

7. What could we change about the program to make it more worthwhile for you?

8. Would you like to comment on the organization of the program–scheduling, materials, information sharing, organization of personnel, etc.

IV. Finally, thinking about Science Camp overall, how would you grade it on an A to F scale?

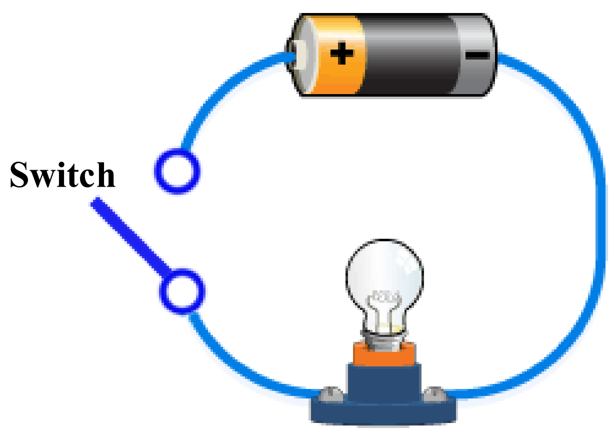
Is there anything else you'd like to add about the Science Mentor program that we haven't talked about already?

Thanks so much for your time.

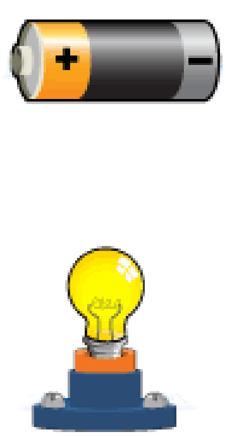
Electricity and Circuits

Name:______________________ **Date:**________

Opening the simple circuit: Switches are used to control the components in circuits. In the space provided to the right of the circuit below, explain why the light bulb goes out when you open the switch.



Closing the simple circuit: Using the switch symbol pictured in the circuit above, draw a complete circuit that lights the bulb. Label the parts of your circuit and add notes that describe why the bulb lights.



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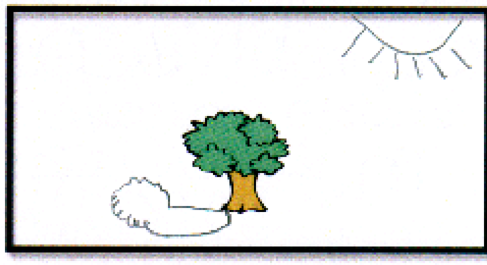
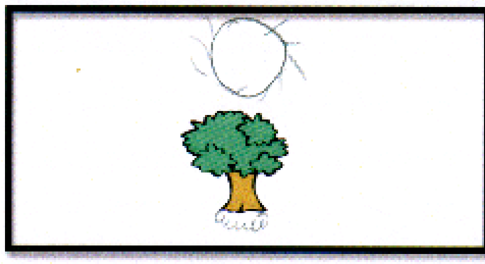
Name: Jessica 3-6-09

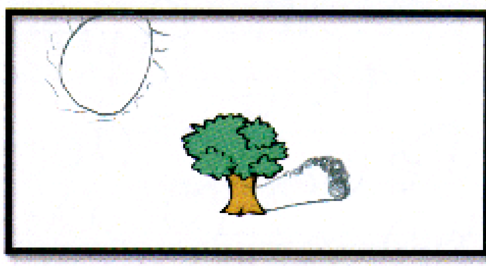
For each picture below, draw the **Sun** and the **shadow of the tree** at three different times during the day.

20/20

9:00 am West  East

10

Noon West  East

3:00 pm West  East

On the back of this page, describe how the Sun moves across the sky during the day. (You may want to draw a picture.) Why does the Sun appear to move across the sky?

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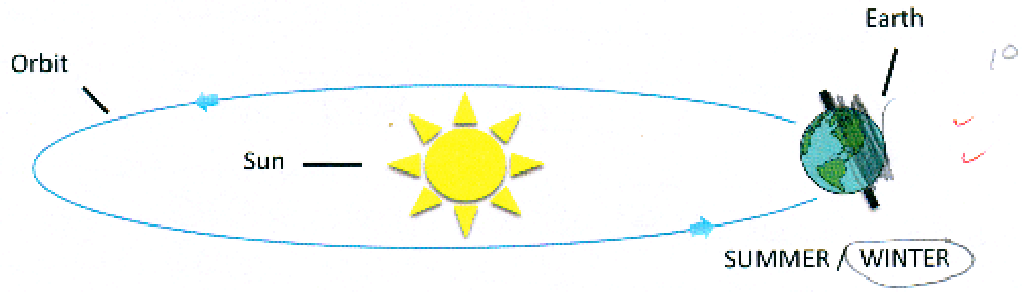
17/20

Name: Amanda

Below is a representation of the Earth in orbit around the Sun. The line through the Earth represents the approximate 23.5 degree tilt of its axis with respect to its orbit.

1. CIRCLE whether WINTER or SUMMER best describes the season people in Vermont would be experiencing.
2. SHADE in the portion of the Earth experiencing night.



Now it's time to use your imagination. Pretend a planet called Planet B orbits around the Sun the same way as the Earth except that it has no tilt in its axis. What would be different between the Earth and Planet B? Would the seasons be the same? Why or why not?

The difference would be that the Earth has a tilt and planet B has none. Also the seasons would be different because, Planet B has no tilt and the tilt has things to do with the season's. 7

Constructed Response Question Grade 5 (Student work not available)

On a warm and sunny day (the outside air temperature is 75^{o}F), you take three beakers of water with equal volumes and place them at three different locations outside. You put one beaker on the pavement, one beaker on the grass, and one beaker on sand. In each beaker you put a thermometer to measure the water temperature.

Which beaker of water do you think will heat up the fastest? Why?

Which beaker of water do you think will heat up the slowest? Why?

What is the variable in this experiment?

If it were a cloudy day but still 75^{o}F, would the results have been different? Which beaker of water would heat up the fastest? Why?

Constructed Response Question Grade 5

Hot Chocolate in a mug with marshmallows is a perfect drink on a cold winter day. Answer the following questions about the heat energy involved in the making and drinking of hot chocolate (or tea, or coffee...). Please give **brief** answers to the following:

1. When the water is boiled for hot chocolate, is the energy of the water increasing or decreasing? Is this an increase or decrease in temperature?

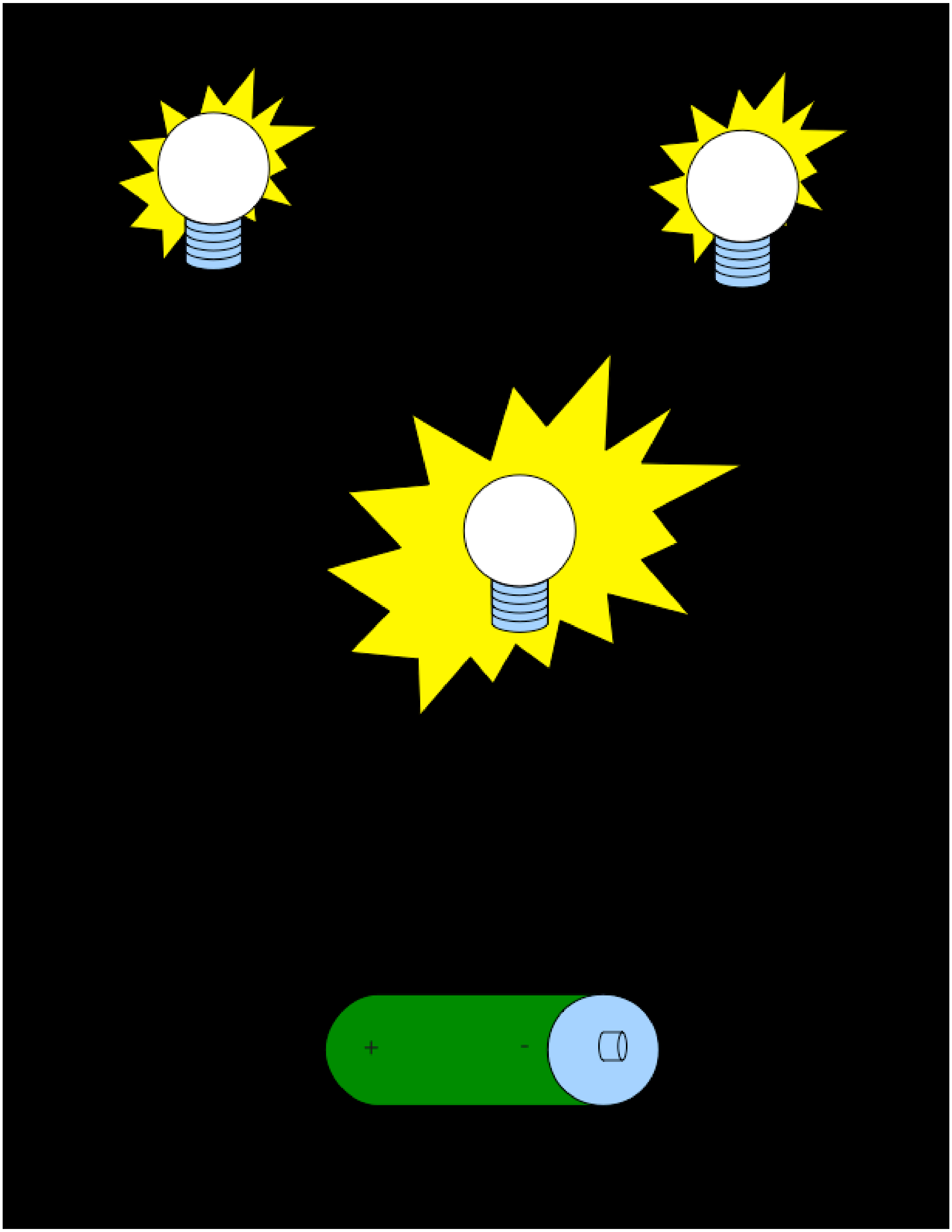
2. Once the water boils, steam arises from the bubbling surface of the water. Describe this phase change and answer which phase has more energy (water or steam).

3. Your hot chocolate mug is twice as big as your friend's. If you both fill your mugs completely to the top, which mug has more heat energy? Why? Which mug will cool down faster and where does the heat energy go?

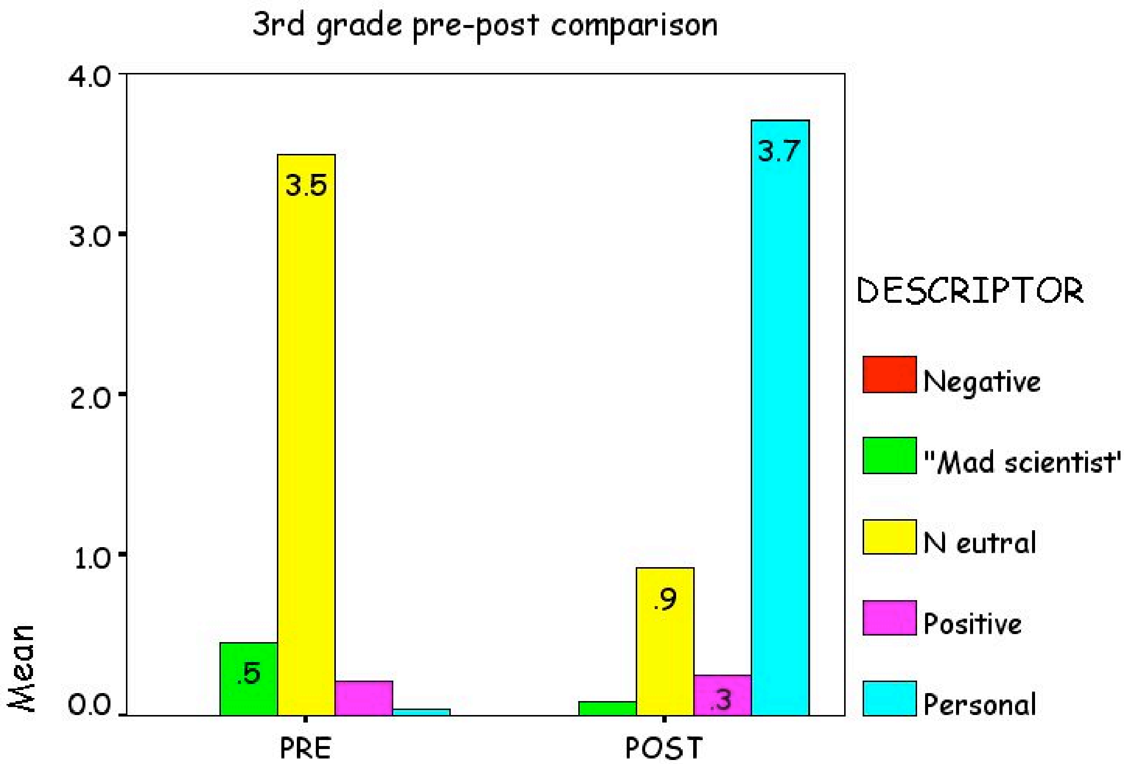
4. Hot chocolate mugs are usually ceramic. Paper cups can also be used. Which cup (ceramic or paper) do you think transfers heat better (hint: why do people often use 2 paper cups or a cardboard sleeve for their hot chocolate/coffee?). Which cup will keep your hot chocolate at a higher temperature for a longer time? Explain why you picked the cup you did.

Bonus: Is heat energy always moving between objects, even if they're at the same temperature? Briefly explain. (No obligation to answer this question! It's a bonus).

Constructed response question Grade 6: Connect the lights bulbs to the battery so that one light bulb is brighter than the others. Tell what type of circuit you have drawn (parallel or series) and whether resistance and current increase or decrease.

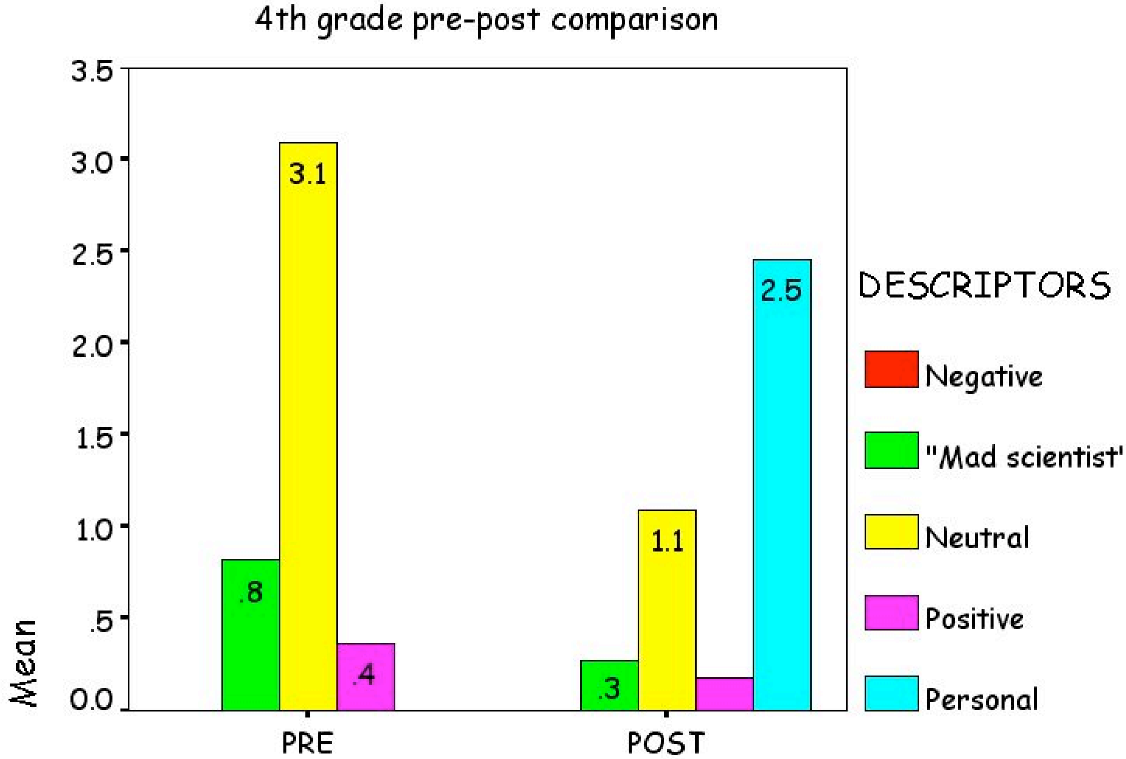


FIVE THINGS I THINK ABOUT A SCIENTIST



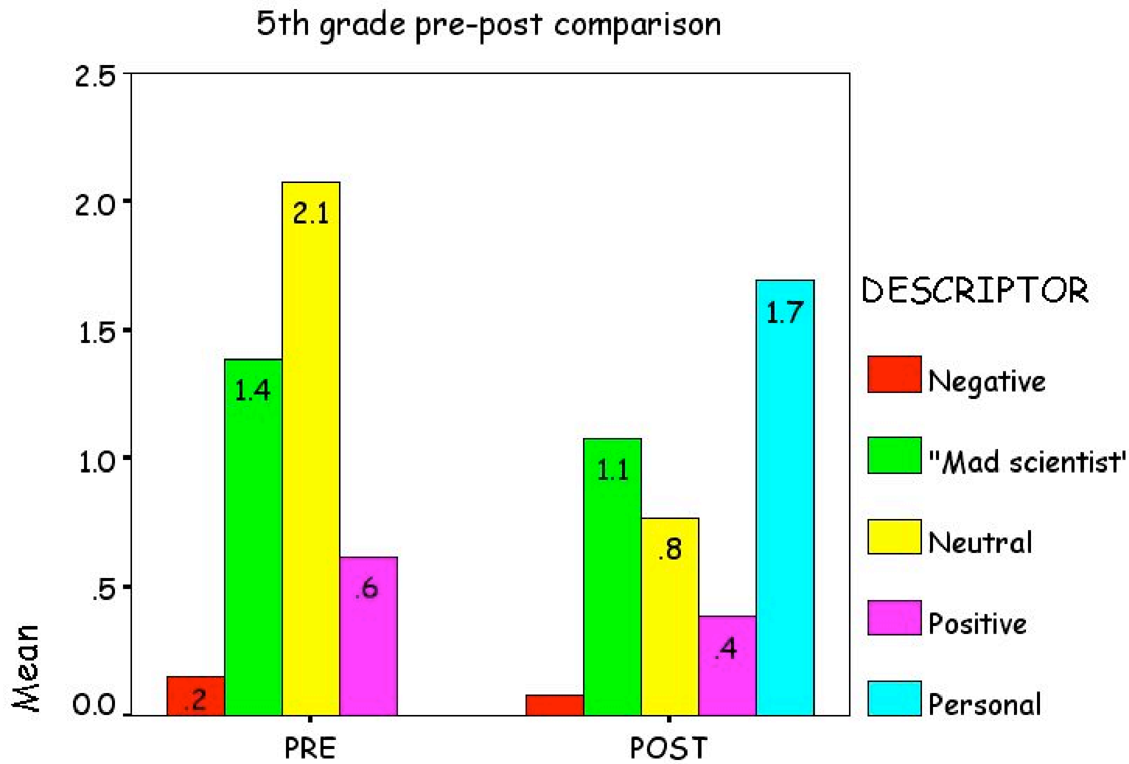
Results from 21 students in one 3rd grade class.

FIVE THINGS I THINK ABOUT A SCIENTIST



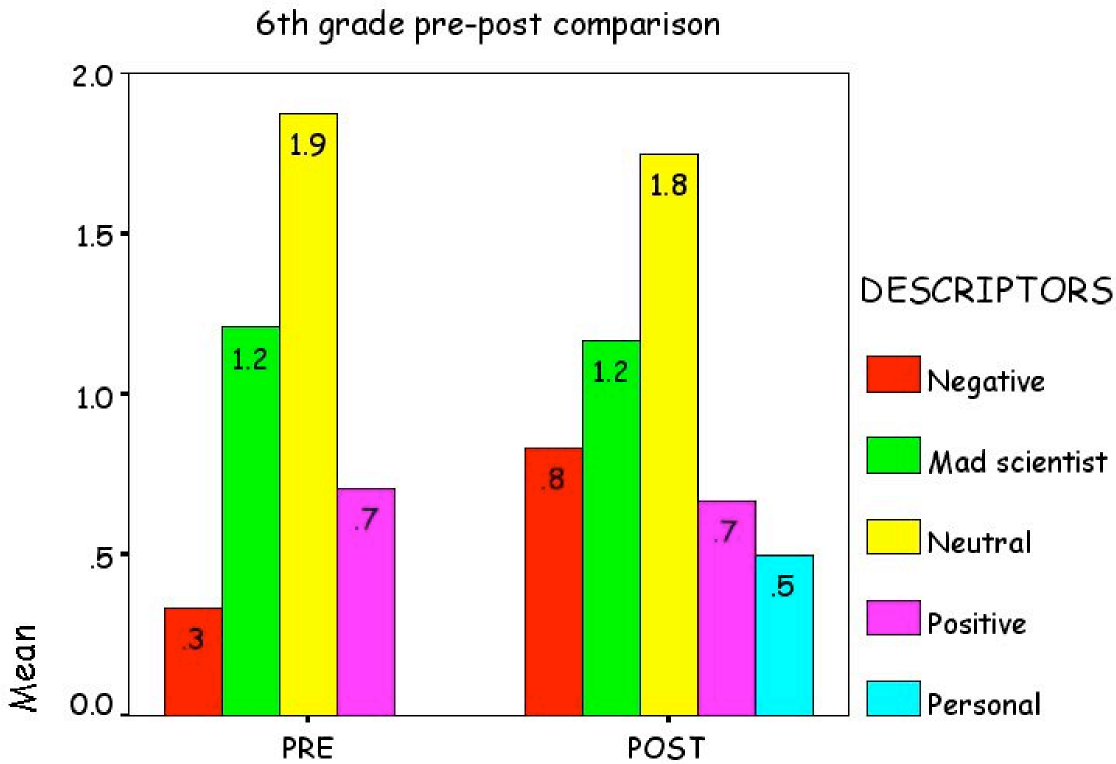
Results from 19 students in two 4th grade classes.

FIVE THINGS I THINK ABOUT A SCIENTIST



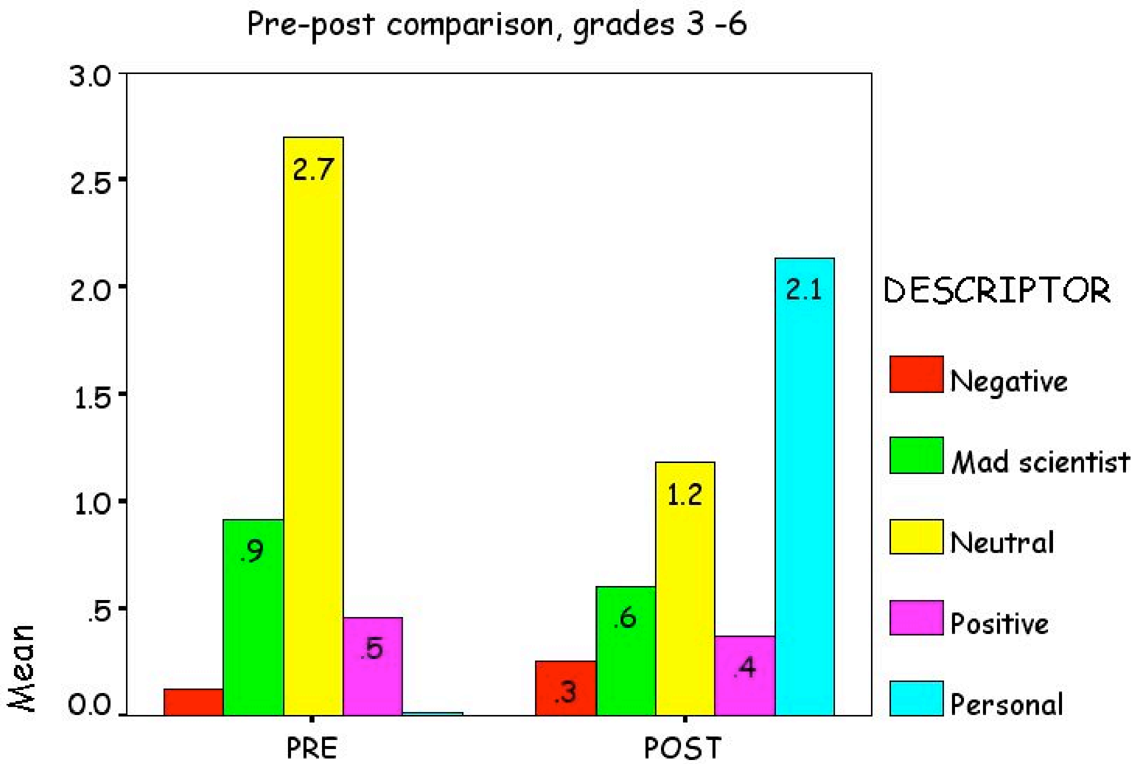
Results from 11 students in one 5th grade class.

FIVE THINGS I THINK ABOUT A SCIENTIST



Results from 24 students in two 6th grade classes.

FIVE THINGS I THINK ABOUT A SCIENTIST



Results from 75 students in grades three through six.