Talk Science Annual NSF Report 2014

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Accomplishments

*** What are the major goals of the project?**

Talk Science is a research and development project to enhance and study elementary science teachers' facilitation of academically productive science talk in the classroom. The project aligns professional learning with a conceptually-driven curriculum (The *Inquiry Project* curriculum) and provides a collection of tools to help teachers orchestrate productive science discussions and deepen their understanding of core disciplinary ideas in science.

We collaborated with schools, scientists, and linguists to develop, pilot-test, and refine *Talk Science,* a professional development program for 4th and 5th grade teachers focused on promoting productive, teacher-guided science discussions. The PD program includes web-based independent study, trying new learning in the classroom, and face-to-face grade-level study group meetings. The PD resources are deployed side-by-side with the *Inquiry Project* curriculum on the *Inquiry Project* web site and are also embedded within the curriculum (inquiryproject.terc.edu). The program provides a model of video-rich professional learning that is high quality, scalable, sustained, accessible anywhere anytime, and that can be used flexibly to meet the needs of teachers and schools.

The research studied the development of teachers' skills in facilitating productive science discussions. Our underlying theory of change was that as teachers implement strategies to support productive talk, the nature of talk shifts from teacher initiation/student response/teacher evaluation (often referred to as "recitation" or the I-R-E pattern) to evidence-based reasoning discussions, in which students explain and justify claims with evidence, and build on and critique the thinking of their peers.

The project's research findings reveal the potential effect of productive science talk on student learning and insight into how teachers move from unconscious and spontaneous talk to strategic and purposeful classroom talk with the support of professional development. The work documents the effectiveness of a model of professional development designed to 1) deepen teachers' content knowledge, understanding of discourse practices, and transfer of new learning into practice; 2) align professional learning with curriculum by using advances in web-based technology; 3) use video cases and emerging media resources to contextualize teachers' learning in and from practice and to reveal the nature of science talk.

The *Talk Science* PD promotes effective science teaching and learning, and the research results enhance the field's understanding of the role and importance of classrooms discourse as well as our understanding of how teachers develop skills for facilitating effective classroom discussion.

By encouraging and coaching teachers to focus on equitable classroom discussions in which every child participates in scientific meaning-making, the project advances the goals of rigorous science learning for all students. Through partnerships with three universities, two urban schools, a suburban school district, and a rural school district, the project enhances the infrastructure for educational research and development. The teacher professional development program is disseminated openly on the web and results of the work and research are disseminated through conference presentations, scholarly publications and the project's web site. Conversation with state and district leaders continues, and a publishing agreement is underway.

Goals, Outcomes, and Indicators

The aim of *Talk Science* is to support deeper science learning through effective science discussions as part of students' science investigations. To meet this aim, our goals are to:

1. develop, pilot-test, and revise *Talk Science*, a web-enabled professional learning program for 4th and 5th grade teachers to support the NSF-funded *Inquiry Project* curriculum and that is focused on promoting scientific discourse in the classroom. We hypothesized that the program would result in a model of web-enabled professional learning that is scalable, accessible, and of consistent quality and that can be used flexibly to meet the needs of teachers and schools.
2. investigate the development of teachers' skills at facilitating productive discourse in science classrooms. We hypothesized that aligning professional learning with conceptually-driven curriculum and emphasizing development of scientific discourse would promote changes in classroom culture and increase student learning. We further hypothesized that as teachers implement strategies for scientific discourse, the nature of talk in classrooms and classroom culture would shift toward shared scientific meaning-making.

Three specific objectives were identified to support teacher learning:

1. Deepen teachers understanding of science as a knowledge-generating enterprise and develop the skills needed to support discipline-specific discussions grounded in the practices of science
2. Develop the understanding and skills needed to support productive science talk in the classroom
3. Incorporate productive science talk into classroom practice

These objectives address principles of productive talk that teachers manage and maximize in the classroom.

- Intelligibility: Everyone participating in the discussion must be able to hear and understand the contributions of others if all are to benefit from being a part of the conversation.
- Conceptual coherence and rigor: While talk is improvisational, it has to lead to

conceptual understanding. Productive talk goes beyond expressing different opinions to attending to and building on others' ideas and provide evidence for positions.

- Motivation to participate: Students need to be invested in the conversation and want to go public with their ideas. They need to have a stake in the outcome of the discussion.
- Equitable participation: This kind of talk is for everyone. All have an obligation to participate.

In addition, we identify four necessary and foundational goals that underpin productive science discussions. We use these four goals in our discourse coding tools and in our PD and reflection tools for teachers.

1. Help *Individual* Students Share, Expand, and Clarify Their Own Thoughts

If a student is going to participate in the discussion, he or she has to share thoughts and responses out loud in a way that is under-standable to others. If only one or two students can do this, it is not a discussion––it is a monologue or, at best, a dialogue between the teacher and a student.

2. Help Students Listen Carefully to One Another

Students need to listen to others and try to *understand each other* in order to contribute to the discussion. The ultimate goal involves helping students to share ideas and reasoning. It is not enough to hear a series of students giving their own unconnected thoughts one by one. Students need to hear and understand the ideas of others.

3. Help Students Deepen Their Reasoning

Even if students express their thoughts and listen to others' ideas, the discussion can fail to be academically productive if it lacks solid and sustained scientific reasoning. Most students are not skilled at pushing to understand and deepen their own reasoning. Therefore, a key role of the teacher is to continuously and skillfully press the students for reasoning and evidence.

4. Help Students Engage with Others' Reasoning

This final goal involves students in actually taking up the ideas and reasoning of other students and responding to them. Students become critical of their own and other's ideas, asking: "Does this idea (mine or someone else's) make sense based on experience and evidence. Is there enough evidence to support the idea? What questions will others have about my idea?" The point of engaging with others' reasoning is to build on it, critique it, and improve the thinking of the group (that is, build toward consensus). In doing this, they deploy an approach to knowledge building that is used and valued by the scientific community.

*** What was accomplished under these goals (you must provide information for at least one of the 4 categories below)?**

Major Activities:

A. Research Activities

The research activities in Year 4 concentrated on developing and refining coding schemes to analyze the data from Year 3 from Grades 4 and 5; on detailed data analysis and interpretation of research findings; and on preparing and presenting research reports for the *Talk Science* web site and at conferences. The data that were analyzed in Year 4 were: (i) interviews with Grade 5 teachers regarding their understandings of the core science ideas in the *Inquiry Project* curriculum; (ii) interviews with teachers in Grades 4 and 5 regarding their perspectives on the nature and importance of classroom science discourse for students' learning; (iii) Grades 4 and 5 pre- and post-concept cartoon discussions from the curriculum, and Grade 5 make-meaning discussions from the curriculum. The data gathered on teachers' study group discussions were analyzed and reported in Year 3. Below we describe our approach for data analysis in Year 4.

In general, an inductive approach was used to examine the data qualitatively and to code the data. Further, in case of data from interviews on teachers' understandings of the science and from their facilitation of classroom discussions, the coded data were quantified to identify key patterns. We present separately the analysis for each type of data.

Teachers' Understandings of Core Science Ideas: A three level coding rubric was developed inductively after preliminary examination of teachers' responses. The rubric focused on understanding and elaboration in teachers' responses. Each response by each teacher was coded separately on the pre- and post-interviews. (see coding rubric in Appendix). The rubric allowed us to determine whether teachers had accurate understanding of the concepts, and whether they could provide explicit and accurate scientific reasoning, i.e., they could identify appropriate evidence, or refer to ideas from the curriculum to justify their response.

Two researchers coded independently a randomly selected subset of responses to establish inter-coder agreement. They clarified the codes and resolved disagreements mutually. One of the researchers then coded the remaining responses.

All coded responses of each teacher were quantified. For each teacher, quantification generated four types of scores separately for the pre- and post-interviews: (i) overall scores; (ii) the total number of level 2 responses; (iii) the total score for each of the six content areas from the curriculum; and (iv) the total number of level 2 responses for each content area.

Teachers' Perspectives on Classroom Science Discourse: Post interviews with Grade 4 teachers and pre-and post-interviews with Grade 5 teachers were studied inductively to identify main themes in the data. With Grade 4 teachers, the analysis focused on: (i) teachers' reported use of classroom science discussions; (ii) perceived benefits of whole group discussions; (iii) experiences teaching the *Inquiry Project* curriculum; and (iv) challenges in facilitating classroom discussions. With Grade 5 teachers, the central themes were: (i) teachers' reported use of whole group discussions in science lessons; (ii) perceived benefits of whole group discussions; (iii) reported characteristics of whole group discussions in their own classrooms; and (iv) factors affecting teachers' continued use of whole group science discussions. Furthermore, with Grade 5 interviews, we attempted to corroborate wherever possible the teachers' reported accounts with findings from the analysis of their classroom discussions.

Teachers' Facilitation of Classroom Science Discussions: Pre- and post-concept cartoon discussions from Grades 4 and 5, and make-meaning discussions in Grade 5 were examined to study changes in the culture of classroom science talk. Below we describe first the analytic procedure for Grade 4 data and next the Grade 5 data. In general, qualitative coding was undertaken first, followed by quantification of the coded data.

Grade 4 Pre-and Post-Concept Cartoon Discussions: The purpose of this analysis was to study teachers' use of *academically productive talk moves* (APT moves) to facilitate classroom discussions; students' engagement in the discussions; and with a subset of teachers who were participating in the *Talk Science* program for the second time, we wanted to also compare teachers' practice over the two years of their experience with using APT moves to guide discussions. Similar to the coding scheme and procedure in analysis of Grade 4 data in Year 2, we coded and counted teachers' turns at talk to examine their use of APT moves. Students' turns at talk were coded and counted separately to identify the ways in which they attempted to make sense of the science, and to co-construct science understandings with their peers. Multiple codes were assigned wherever appropriate for both teacher and student turns (see Appendix for coding scheme).

Grade 5 Pre-and Post-Concept Cartoon Discussions and Make-Meaning Discussions: Pre-and post-concept cartoon discussions and a subset of videotaped make-meaning discussions were analyzed to study teachers' facilitation of and students' participation during the discussions. For data analysis, we refined and developed a set of codes to explore teachers' and students' talk. For teachers' talk, we drew on the literature on *accountable* and *academically productive talk*, and on our previous work on the *Talk Science* project to study teachers' use of nine APT moves introduced to them in the program. For students' talk, codes were generated inductively to examine (i) students' attempts at co-constructing science understandings with peers; (ii) students' reasoning in terms of various efforts to make sense of the science, their use of core science ideas (classroom investigations and scientific principles from the curriculum), and their use of ideas outside of formal scientific understandings (see Appendix for coding rubric).

In coding classroom talk, the procedure was similar to the coding of Grade 4 data described before. We coded and counted teachers' and students' turns separately to determine the proportion of teacher and student talk in the coded categories. Multiple codes were assigned wherever appropriate.

The analysis of pre-and post- discussions examined also the accuracy of students' ideas as they contributed to the discussions. One set of pre- and post-discussions each from two teachers was studied to determine the extent to which students offered correct ideas to the discussions.

B. Completion of the professional development program and web-presence based on the research results. Changes include:

Re-sequencing program experiences. We shifted the order of experiences so that trying new learning in the classroom preceeded the study group meeting. This change was meant to increase teachers' sharing and reflection with colleagues, support sharper analysis of practice, and motivate teachers to continually refine their teaching.

Redesign study guides to encourage teachers to ground their professional discussions in evidence from the classroom. Analysis of study group meetings revealed that specific classroom experiences were often missing in teachers' peer conversations. Without reference to explicit classroom incidents, conversation tended to remain at a general, non-problem solving level. The new guidelines encouraged teachers to bring classroom evidence, e.g., audio or video for discussion.

Refining the teacher "Reflection Tool" to emphasize students' progress toward scientific understanding. While analysis of classroom video indicated that there were changes in teacher talk, changes in student talk were less common. This may mean that teachers incorporate strategies without heightened attention to students' ideas and how their ideas are building. The reflection tool was re-crafted to help teachers notice and work with students' ideas.

C. Dissemination (See "How have the results been disseminated to communities of interest.")

Specific Objectives:
Our objectives were to:

1. Develop, pilot-test, and refine *Talk Science,* a professional development program to promote scientific discourse in the classroom. The resulting program is a hybrid model in which teachers engage in web-based independent study, try out ideas learned in the classroom, and share successes and dilemmas with grade level colleagues in study group meetings. The program is aligned with the NSF-funded *Inquiry curriculum* and is deployed on the *Inquiry Curriculum* website (inquiryproject.terc.edu). The web-based resources include scientist video cases, classroom video cases, and multi-media talk strategies. The resources are also embedded in the curriculum so that teachers re-encounter them each time they teach the curriculum. Our aim was to design professional learning that would be

scalable, accessible, of consistent quality, and meet the varying needs of teachers and schools.

2. Investigate the development of teachers' skills with regard to facilitating productive discourse in the science classroom. We *hypothesized* that aligning professional learning with conceptually-driven curriculum and emphasizing development of scientific discourse would promote changes in classroom culture and increase student learning. We further *hypothesized* that as teachers implement strategies for scientific discourse, the nature of talk in classrooms and classroom culture would shift toward shared scientific meaning-making. Our research questions were:

- How do teachers' understanding of the nature and importance of science talk and their skill at orchestrating science talk change as they participate in the *Talk Science Professional Pathway while implementing the Inquiry Curriculum?*
- How do teachers' understanding of the core science concepts in the Inquiry Curriculum change as they participate in the *Talk Science Professional Pathway while implementing the Inquiry Curriculum?*
- How does student talk (amount and quality of scientific reasoning and co-construction with peers) change from early to late as their teachers participate in *Talk Science Professional Pathway while implementing the Inquiry Curriculum?*
- How do classroom discourse patterns change as a result of changes in the teachers' actions? That is, do we see less I-R-E recitation and more evidence-based reasoning and argument?

Significant Results:
Major findings from Grade 5:

<u>Teachers' Knowledge of Core Science Ideas</u>

1. Teachers' knowledge of core ideas regarding matter improved after they participated in the *Talk Science* program aligned with the *Inquiry Project* curriculum. All teachers obtained higher scores, and presented more elaborate explanations of concepts within the curriculum in the post-interviews than in the pre-interviews. A careful examination showed that they increasingly drew on the particle model to explain processes of dissolving, evaporation and condensation in the post-interviews than the pre-interviews.

2. While teachers focused more often to the core ideas in the post-interviews, when asked to think about hypothetical student ideas and how students would respond, they generally commented on the *accuracy* of the ideas rather pondering on the rationale behind the student's idea, or describing how they might probe the student's reasoning.

<u>Teachers' Perspectives on Classroom Science Discourse</u>

1. Shifts were observed in teachers' perspectives on the role of classroom discussions. Before the program, teachers mainly viewed discussions as

opportunities for students to share their individual ideas, hear ideas from peers, and as a means to assess students' understandings. After the program, increasingly viewed discussions as opportunities to co-construct ideas with peers, think collectively and develop understandings together..

2. Several shifts were noted in teachers' accounts of the nature and use of their classroom discussions. Initially teachers would use discussions to introduce and wrap up lessons. After the program, teachers reported making discussions an integral part of their science lessons. They revealed greater willingness and confidence in facilitating discussions not only for introduction and wrap-up but also for continued learning. Most teachers, however, continued to describe their current practice for conducting discussions in terms of an introduction and wrap-up structure.

3. Teachers reported shifts in the culture of classroom talk. Specifically, teachers reported that they were talking less and providing fewer directions, and that there was increased student initiative in discussions. Specifically, students were listening and responding to peers' ideas, and using evidence to reason about the science.

4. Although teachers reported changes in facilitating discussions, they did not always articulate how they planned to guide the discussion or to respond to student ideas during discussions. They rarely described their own role, how they were listening to students' ideas, and how they might improve their facilitation to promote students' scientific reasoning.

<u>Teachers' Facilitation of Classroom Science Discussions</u>

1. Teachers' facilitation of discussions changed after the *Talk Science* program. Teachers utilized the Academically Productive Talk moves more often in the post-discussions then pre-discussions. Specifically, they drew prominently on Expand moves to elicit students' thinking, and made a greater use of Dig Deeper moves to probe and deepen students' reasoning with data and evidence from their investigations.

2. In the case of two of the three teachers who were examined for their make-meaning discussions, we found their use of Expand and Dig Deeper moves was aligned with the purpose of the discussions. When the purpose was to elicit students' initial ideas about a process, the teachers utilized Expand strategies to draw out students' preliminary thinking, and probed students less often with Dig Deeper strategies for evidence and explanations. By contrast, when the purpose was to construct scientific explanations, the teachers utilized Dig Deeper moves frequently to help students reason with evidence and scientific principles. These findings suggest that the two teachers may have begun to understand the different science discussions in the program, and used strategies differently to address the learning goals.

3. Overall, although teachers employed different talk strategies, they most often utilized strategies to help individual students externalize and elaborate on their

ideas (Expand and Dig Deeper moves). On the other hand, they less often used strategies to foster active listening and co-construction (Listen and Think With Others moves).

4. There were various changes in students' participation. Students in several classes made slightly greater attempts at co-construction in post-discussions than pre-discussions. Students' attempts at reasoning also changed. After engaging with investigations and the particle model of matter, students tried to draw on core ideas from the curriculum while reasoning about the concept cartoon problem. In the post-discussions students' reasoning with the help of core ideas increased in all classes.

5. Furthermore, in make-meaning discussions in two of the three classes that were examined, we found that students' reasoning was fairly consistent with the type of discussion and investigation framing the discussion. When the students did not have measurement data and scientific models to generate explanations (Investigation 6), they tended to invoke their everyday experiences and opinions to formulate their ideas. By contrast, when students had measurement data and a computer-based particle model (Investigation 5 and Investigation 16 respectively), they recruited these resources more often to construct explanations and reasoned less with the help of ideas outside the curriculum.

Major Findings from Grade 4

1. After the *Talk Science* program, almost all teachers used more APT moves, in particular, to deepen students' reasoning and to promote active listening than in pre-discussions. Furthermore, a comparative analysis of the teachers who participated twice revealed that during both years teachers used more APT moves after the program. After the second time, teachers' use of the strategies was the greatest.

2. Post interviews indicated a commitment among teachers to conducting discussions; an awareness of the importance of the discussion component of the Inquiry curriculum, and of how the discussions differed from those in their other science units; and finally, evidence of changes in their discussion practices based on their experiences with Talk Science and the curriculum.

Key outcomes or other achievements:

1. The research suggests that the hybrid model used by *Talk Science* holds promise for effective professional development. Independent video-rich, web-based study provides teachers with vivid examples from the classroom and from science, and allows teachers to learn at their own pace. Meeting with colleagues in school-based study groups provides teachers with opportunity to share their insights, reflect on classroom experiences, and plan for teaching. Classroom trials encourage teachers to apply their learning to practice. Having all program resources readily accessible on the web

increased flexible use to meet the varying needs of teachers in different school settings.

2. The careful alignment of teachers' professional learning with the curriculum they teach, as reflected in the tight coupling of the *Talk Science* program with the *Inquiry Project* curriculum, allows teachers to develop both relevant subject matter knowledge and instructional practice to promote students' reasoning through discussions. Specifically, the aligning multimedia resources, collaboration with colleagues, and implementation of new learning within the curriculum teachers teach contributes to teachers' understanding of key scientific principles and practices needed to facilitate productive content rich discussions aligned with the curriculum.
3. Our research shows that in shifting the culture of classroom talk toward more productive science discourse and student reasoning, the *Talk Science* model enables teachers to incorporate new instructional strategies, develop their knowledge of core scientific ideas, and begin to conceptualize classroom discussions in more dialogic terms. The findings suggest that changes in all three aspects of teachers' professional learning—knowledge of the science, underlying perspectives on classroom discourse, and instructional practice--are critical for supporting teachers' facilitation of students reasoning.
4. The research also points to particular aspects of teachers' learning that may need more explicit guidance. Whereas teachers recognized the value of discussions for fostering co-construction of meaning, and began to draw increasingly on talk strategies to help students explicate their individual ideas and deepen their reasoning, teachers less frequently used strategies designed to foster co-construction of scientific knowledge. Limited use of strategies to support active listening and co-construction may indicate that these aspects of classroom discourse are more challenging for teachers. Strategies associated with dialogic discourse may be a departure from familiar, well-established discussion practices. Teachers may find it easier to use strategies like "Expand" and "Dig Deeper" that enable them to work with *individual* students' thinking, and are consistent with a *share out* model of discussion. Using the "Listen" and "Think with Others" strategies may require new teacher/student relationship. While teachers *recognize* the value of discussions for dialogic meaning making, they may need additional support in using strategies to *enact* such discussions. Future research could explore ways of helping teachers to foster students' scientific reasoning through dialogic, student-student exchanges.
5. Teachers need support in planning science discussions that deepen students' reasoning through analysis of data and evidence-based explanations. Teachers' post-interviews suggest that although they devote time to discussions at the beginning and end of lessons, they seldom plan their facilitation of these discussions or anticipate the ideas students might have, and how they, in turn, might respond to particular ideas.
6. *Talk Science* calls for an *analytic/reflective teacher stance* toward students' learning. Across the multiple sources data examined, we found only modest evidence of teachers analyzing their practice and their students'

> understandings. For example, during study group meetings teachers seldom articulated issues and challenges while supporting students' scientific reasoning through discussions. They rarely examined carefully how their students' learning was progressing, and the impact of their practice on the development of their students' scientific reasoning. Similarly, during interviews, teachers did not always ponder how they might improve their facilitation to generate more robust discussions, or how they might probe into and follow up on students' understandings about the science. Our findings suggest that teachers may need more support for reflecting on their practice and their students' learning. We surmise that objective, verifiable feedback from teachers' own classrooms may facilitate teachers' reflection and critical analyses. Artifacts of teaching and learning processes from their own classrooms may allow teachers to scrutinize the particulars of their classroom that are meaningful to them, and to use the feedback to inform their pedagogical decisions.

The present research informed the final revisions of the *Talk Science* pathway. To promote deeper reflection among teachers, the *Talk Science* pathway has been reordered to provide teachers with feedback from their own classrooms. Teachers participating in the research study met in study groups, but they did not have continual evidence from their classroom for sustained reflection and planning. They may have found it difficult to analyze their instruction in the absence of objective feedback. Hence, in future research, we hope to develop a software-based tool to provide teachers with ongoing video records of their own classroom interactions. The records will offer timely, objective, verifiable evidence of the interactions, and enable teachers to identify how they might lead rigorous, coherent science discussions to deepen students' learning.