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The Impact of Collaborative Curriculum Design on Teacher Professional Learning

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Abstract

Effective professional development programs for science teachers provide opportunities for active learning and teacher self-reflection on beliefs about science teaching, learning, and practice. One model that fosters active learning and promotes reflection is collaborative curriculum development, in which teachers work together with university facilitators to create curriculum materials. We used a two-case study design to investigate how teacher collaborative curriculum *design* (the first part of development, in which ideas for curriculum are created) impacted participant professional learning during a five-day summer institute. Interview or survey data were collected from 41 secondary biology teacher participants in two summer institutes. Results indicated that teachers experienced shifts in their science knowledge, beliefs about science, beliefs about science teaching and learning, and in their science teaching practice. We concluded that the curriculum design process, which can occur in a relatively short time period, can foster meaningful, task-oriented collaboration. The collaboration process provides the vehicle for active learning, where teachers can reflect on their beliefs while applying new knowledge to the classroom. Recommendations for other professional development programs along with a discussion of the program's unique philosophy are provided.

Key words: professional development, teacher learning, curriculum design, science teaching

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Introduction

Science teacher professional development (PD) has experienced a shift in agency, away from programs that focus on creating change in teachers to providing opportunities for active engagement, influencing teachers to take responsibility for their own learning and to reflect on their practice (Clarke & Hollingsworth, 2002; Hewson, 2007). One PD model that has been shown to foster active learning and promote reflection is collaborative curriculum development (CCD) (Coenders, Terlouw, Dijkstra & Pieters, 2010; Deketelaere & Kelchtermans, 2006; Tal, Dori, Keiny & Zoller, 2001). In CCD, teachers work together to develop or revise curriculum materials such as student activities, lessons, modules or courses (Voogt, Westbroek, Handelzalts, Walraven, McKenney, Pieters, & de Vries, 2011), often in response to national reforms. Teachers' work is frequently done in collaboration with expert facilitators or university faculty, such as scientists or educational researchers who facilitate the process. In many science-based CCD programs, scientists inform curriculum development by providing scientific content, placing phenomena and details within the larger context of the field or by elucidating scientific processes (Drayton & Falk, 2006). CCD programs typically engage teachers for long-term periods. For example, in Voogt et al.'s (2011) review of nine CCD programs, eight programs ranged from 3 months to 2 years. Only one program engaged teachers for four days (see George & Lubben, 2002). Some of these programs included enactment of the curricula in the classroom.

Teacher Learning through Professional Development and CCD

CCD often incorporates the elements of effective inservice science teacher PD programs, which include providing opportunities for (a) examination of teachers' beliefs, including their role as science teachers, how students learn science, and the benefits of certain instructional strategies; (b) examination of teachers' classroom science teaching practice; and (c) increase in science content knowledge (Fishman, Marx, Best, & Tal, 2003; Gess-Newsome, 2001; van Driel, Beijaard, & Verloop, 2001). Impacting teachers' science content knowledge during PD is straightforward. Beliefs and practice, by comparison, are more resistant to change (Loucks - Horsley, Love, Stiles, Mundry, & Hewson, 2003; Pajares, 1992; Thompson & Zeuli, 1999). PD that offers opportunities to examine beliefs and practice does so by engaging teachers in active learning about subject matter, focuses on how students learn that subject matter, and promotes collective participation or collaboration, (Borko, 2004; Gess-Newsome, 2001; Guskey, 2003).

The process of CCD can provide the environment and structure for shifts in beliefs and practice, along with content knowledge increase (Coenders, et al., 2010; Deketelaere & Kelchtermans, 2006; George & Lubben, 2002; Parke & Coble, 1997; Tal et al. 2001). By placing teachers in the role of curriculum developers, their beliefs about student learning and curriculum materials are made explicit (Coenders et al., 2010). This process fosters deliberative reflection, which involves consideration of students, instructional strategies, and teaching contexts through the lens of teachers' beliefs and values (Valli, 1992; 1997). Deliberative reflection also encompasses consideration of research findings and other teachers' opinions (Minott, 2008).

The literature describes the impacts of CCD on short-term and long-term teacher professional change. In their review, Voogt et al. (2011) found that when teachers were involved in curriculum development (which the authors defined as activities related to problem analysis, design and development, and evaluation of the design) they experienced short-term changes. These changes included increased self-confidence, increased pedagogical content knowledge, a deeper understanding of subject matter content, refined ideas of curriculum development in their personal practice, and perceptions of good teaching and being a good teacher. The authors suggested that some of these changes may be long-term.

Other impacts of CCD on teacher change include increased self-esteem, motivation, and job satisfaction, and an enhanced awareness of one's values and norms about teaching (Deketelaere & Kelchtermans, 2006) as well as an understanding of how to enact reforms in science classrooms (Coenders, et al., 2010). In one study on a "short term" (four days) CCD program, George and Lubben (2002) found that teachers gained confidence in making necessary changes to curriculum and making decisions about the types of external sources of information they needed to complete their task. Parke and Coble (1997) found that collaboratively working toward improving the science curriculum with other professionals built competence, trust, and empowerment. They concluded that the process of articulation of personal beliefs and collaboratively creating lesson plans consistent with these beliefs can "alter the demeaning, de-skilling, and demoralizing effect of the continuous barrage of top-down mandates visited upon teachers" (p. 784).

Research has also shown that CCD promotes teacher acceptance of reform-based curriculum initiatives (Coenders et al., 2010; Huffman, Thomas & Lawrenz, 2003), which are often met with resistance when delivered as top-down mandates (Oloruntegbe, 2011). For example, Huffman et al. (2003) examined the effects of different kinds of professional development models on teachers' instructional practices, and on the achievement of students in science and mathematics. The professional development models included immersion (teachers practice doing science or math), examining practice (teachers discuss classroom scenarios or examine instruction), curriculum implementation (teachers use and refine instructional materials in their classrooms), curriculum development (teachers participate in creating new instructional materials), and collaborative work (study groups, peer coaching). The results indicated that for both science and mathematics teachers, examining practice and curriculum development were significantly related to the use of standards-based instructional practices. This finding is congruent with Parke and Coble's (1997) conclusion that CCD creates ownership over the materials being developed, contributing to acceptance of the reforms the curriculum is reflecting.

Research Purpose and Objectives

Achieving national goals for science education starts with teachers. To achieve these goals for student science understanding (e.g., National Research Council, 2011; NGSS Lead States, 2013) it is important for educational researchers and PD providers to understand the various types of PD experiences that can facilitate teachers' growth throughout their careers and why. In a review of research of science education PD programs, Hewson (2007) called for more studies of science teacher PD in order to "paint a coherent picture of the field" (p. 1201).

Our study addresses two gaps in the literature. First, in CCD-based PD, teachers participate in curriculum *design* and *development,* (and often enactment of the curriculum in the classroom). In our study, we operationalize *design* as identification of curriculum learning objectives and curriculum idea creation. Meanwhile, curriculum *development* encompasses these steps plus creating final or near-final curriculum materials. While research has revealed the effectiveness of involvement in curriculum *development* for teachers' change and growth, there is a gap in the literature on the role of the curriculum *design.* Curriculum design is of particular interest since it occurs in significantly less time than curriculum development. For a variety of reasons, PD programs that last a week or less continue to be the norm across the U.S. (Darling-Hammond, Wei, Andree, Richardson & Orphanos, 2009). Therefore, for each type of PD experience it is important to identify the elements that have the highest impact on teacher learning, growth and change.

Second, in their review Voogt et al. (2011) noted that most studies of teacher CCD programs focus on measuring program effects on teacher learning and on the implementation of the curriculum. They do not examine the processes during CCD that promote teacher learning, such as the "interaction with peers, facilitators, and external stimuli, the experimentation in classroom practice, and the factors in the environment that hinder or facilitate teachers' curriculum [development]" (p. 1236).

To address these gaps, we conducted an exploratory study in which we investigated how the relatively short experience of collaborative curriculum design impacted teachers' professional learning during a summer institute. In addition, we examined the processes that promoted this learning. This 4.5-day PD experience consisted of interactive scientist lectures, hands-on activities, laboratory investigations or field experiences that could be translated into the classroom, collaborative identification of student learning objectives, and teacher collaboration in curriculum design. The research questions that drove our study were: a) in what ways do teachers experience professional learning through participation in the Master Teacher Summer Institutes (MTSI) and b) which features and processes of the MTSI contribute the most to teacher learning?

We define *teacher professional learning* as changes in teachers' beliefs, practice, or content knowledge. Clarke and Hollingsworth (2002) distinguish between *change* as short term and *growth* as more long lasting. In this study, we focus our investigation on short-term teacher change and mention possible growth outcomes.

Theoretical Framework

We framed our understanding and examination of teacher learning through participation in collaborative curriculum design on the Interconnected Model of Teacher Professional Growth (Clarke & Hollingsworth, 2002), a model grounded in both cognitive and situated perspectives on learning (Cobb & Bowers, 1999). According to the model, teacher change can occur in four different domains: (a) external (becoming familiar with outside sources of information or stimulus); (b) personal (teachers' knowledge and beliefs); (c) practice (professional experimentation, both inside and outside of the classroom setting); and (d) consequence (outcomes of new practices for the teachers and students, which the teachers perceive as salient) (see Figure 1). The personal domain and the domains of practice and consequence are considered the professional day-to-day world of the teacher while the external domain provides teachers with external stimulus and new information. Change in one domain can influence change in another. Reflection (objectively examining one's assumptions and beliefs and the practices associated with them) (Valli, 1997) and enaction (putting a new idea, belief, or practice into action) are mediators of change and growth in this non-linear model. Experiences in a professional development program can contribute to change and growth in one or several domains.

In a review of research on teacher learning through CCD programs, Voogt et al. (2011) found that the Interconnected Model is appropriate for examining the processes behind teacher learning through CCD. They further concluded that although the model is typically used to identify the learning of individual teachers, it is also an appropriate model for identifying learning patterns of teachers involved in PD programs such as CCD.

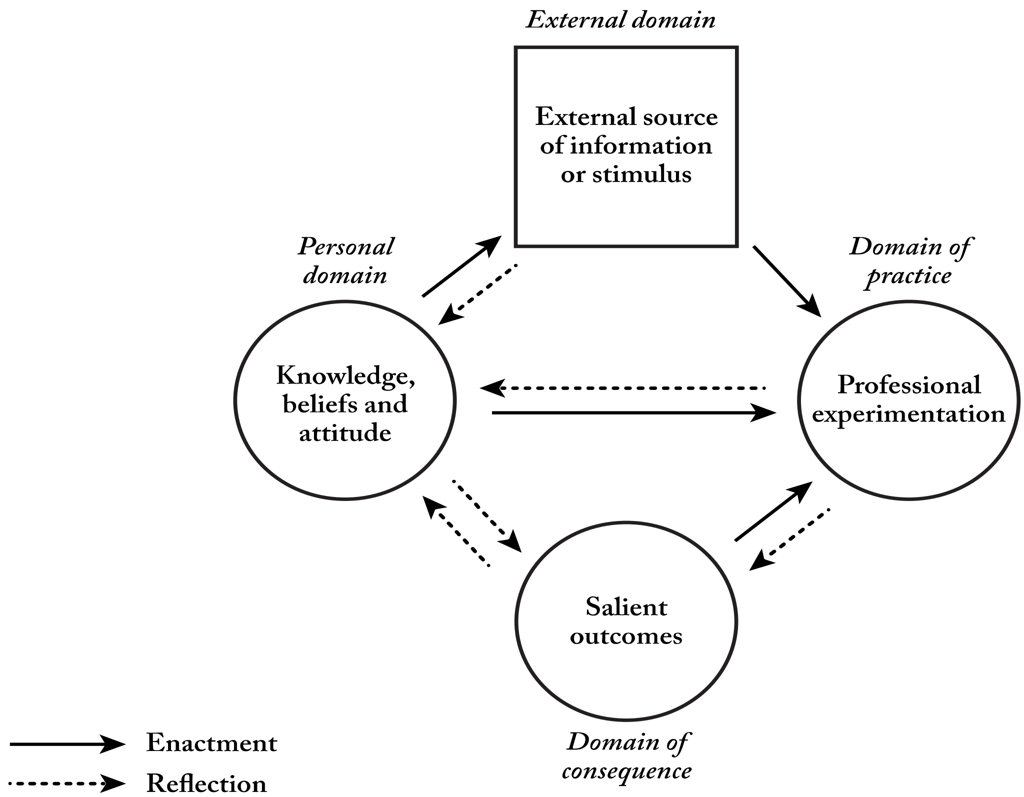

Figure 1. The Interconnected Model of Professional Growth. Redrawn from Clarke & Hollingsworth, 2002.

Methods

Professional Development Context

The Genetic Science Learning Center (GSLC) at the University of Utah has been holding MTSI programs since 2001, modifying and refining the process each year based on feedback from participating teachers. One or two 4.5-day institutes are held per summer, each focusing on a different cutting-edge topic in biology that has connections to U.S. national science standards. The curricula designed through the MTSIs consist primarily of interactive, multimedia materials with supporting non-technology-based activities. Multimedia materials are the focus of MTSI institutes since teachers generally do not have the resources or the technical expertise to develop these types of materials on their own. Such materials facilitate learning by magnifying phenomena that occur at the molecular level so that students can observe them. They also enable students to observe or interact with complex and dynamic biological processes, and allow students to control the timing and rate of information they access (reviewed in McElhaney, Chang, Chiu, & Linn, 2015). The curricula are developed and produced by the Center, which makes them freely available on its Learn.Genetics and Teach.Genetics websites. Teachers use the materials to support their practice, primarily as supplements to their existing biology units or as the foundation for units on cutting-edge biology topics.

The institutes have become highly selective, with over 450 applications from across the U.S. and other countries for the 20-25 spaces in each institute. The secondary biology teachers who are selected to participate represent variation in student demographics (racial/ethnic and SES levels), location (rural, urban, and suburban), and school type (public and private). They include both teachers who are new to MTSI and those who have attended previous institutes. The Center funds teachers' U.S. airfare, accommodations and most meals, and provides a stipend for participation.

The Center's two-fold philosophy—respect the experience each teacher brings and curricula should originate from teachers (*for* teachers *by* teachers)—permeates each institute. The structure of the MTSI is grounded in research-based models and approaches for designing science professional development. In the Loucks-Horsley, Hewson, Love, and Stiles (1998) and Loucks-Horsley, Love, Stiles, Mundry, and Hewson (2003) models, institute goals and specific context (the particular group of teachers, scientists, topics, the institute staff, and other specific circumstances unique to an institute) are aligned in the design process in order to maximize outcomes for the professional developers and for participants. Reflecting this, the Center's goals for producing high-quality curricula and for facilitating high-quality teacher PD are aligned with the specific context of the program. The MTSI follows Wiggins and McTighe's (1998) approach, in which enduring understandings for students (or student learning goals) are established through an iterative process of learning goal and objective identification before curriculum design begins.

The structure of the institute has become fairly standardized, incorporating best practice experiences from previous institutes. Several weeks before an institute, teachers are sent readings relevant to the topic. During the first two institute days, scientists provide interactive lectures that provide adequate time (1.5-2 hours) for responses to teachers' questions throughout. The goal of these presentations is to expand and update teachers' content knowledge about the cutting edge science of the focal topic. Institute facilitators, who are education specialists, lead teachers in collaborative distillation of key ideas from each of the readings and lectures. Scientists also engage teachers in hands-on activities, laboratory investigations (such as analyzing samples of microbes taken from locations around the body), or field-based experiences, all of which can be translated directly into curricula for the classroom. Since the institutes have limited time and the focus is on enhancing content knowledge and designing multimedia materials, activities taking place during an institute are limited to those that can be adapted to the classroom within the constraints of cost and equipment availability.

In the next phase of the institute the facilitators guide teachers through protocols for establishing student learning goals and objectives for the content. The key ideas from the first two days of the institute are discussed and grouped into overarching themes. A self-selected, small group of teachers works with each theme, identifying the "big ideas" (Wiggins & McTighe, 2005) and drafting student learning goals. These are revised after receiving feedback from the whole group via a silent conversation process (National School Reform Faculty, 2014). In the final 2.5 days, teachers work in their groups to draft curriculum ideas that address these learning goals. Center staff, including the education specialists, instructional designers, members of the visualization and multimedia team, science writers, and web developers, circulate among groups to discuss science questions or activity ideas. Most teachers have used the Center's websites so they are familiar with the types of materials the Center has previously produced. However, teachers are encouraged to think creatively without the constraint of considering the logistics and feasibility of multimedia development. Each group records curriculum design ideas for its learning goals and objectives in a section of the institute online wiki; this also facilitates comments and feedback by others within and outside the group. The groups use the wiki to present their curriculum design ideas to each other and the Center staff for discussion and feedback twice during this process. Appendix A provides an overview of a typical 4.5-day institute.

Following the institute, the Center's staff select curriculum ideas for online interactive multimedia and non-technology-based activities that address each of the learning goals and that can be developed within the Center's budget for the project. They then refine and build on the teachers' ideas to produce the materials. The materials are field tested with students (teachers involved in the MTSI often participate) and revised. The final materials are freely disseminated via the Center's Learn.Genetics (http://learn.genetics.utah.edu/) and Teach.Genetics (http://teach.genetics.utah.edu/) websites that are used by teachers around the world.

Study Design

We used a two-case study design (Yin, 2014) to examine the professional learning of participants in two institutes in summer 2011: *Multitasking, Attention, and Memory: The Science of Learning* and *The Human Microbiome*. Each institute represents a separate, but related case. Using Merriam's (1998) criteria, we deemed this the appropriate design as each institute constitutes a bounded system, our research focused on a specific phenomenon, and our data collection using qualitative methods would provide thick and rich evidence. Finally, the findings are intended to provide readers with new understandings or insights.

Participants

Data were collected from all 41 teachers participating in the two 2011 courses. *Multitasking, Attention, and Memory* (20 participants) and *The Human Microbiome* (21 participants). Participants had 1 to 31 years of teaching experience and represented 20 U.S. states, Canada, and the Netherlands. Their highest academic degrees ranged from B.S. to Ph.D. Teachers were selected from 771 online applications (many teachers applied for both institutes). They were considered to be "master" teachers, defined by the Center as having high content knowledge in biology, teaching from a student-centered orientation and using teaching approaches that show evidence of curricular creativity, which was conceptualized as designing new learning experiences or integrating materials from multiple sources. Teaching orientation and approaches were evaluated based on a lesson plan teachers submitted with their application. Additional criteria for selection included having: the ability to communicate effectively in writing, a passion for translating topics in science to the classroom, familiarity with the Center's websites and experience working collaboratively with other teachers. Other factors that influenced the selection process included maintaining diversity in years of experience, gender, region, student demographics, and school contexts.

Data Collection and Procedure

Instruments, which consisted of interviews and surveys, were developed to provide a comprehensive examination of the research questions and validation of the study claims through triangulation of data sources and data types. The instruments and the numbers of individuals from whom data were collected with each instrument were:

- *Teacher interview* (n=15, six from *Multitasking, Attention, and Memory* participants and nine from *The Human Microbiome* participants). This semi-structured in-person or telephone interview lasted 25-35 minutes. The questions examined teachers' learning and experience including assessing changes in content knowledge, instructional approaches, perception toward student science learning, self as professional, and attributions for effective institute components. Interviews were conducted by the first author on the final day of the institute or by telephone within three weeks following institute participation. Interviews were audiotaped and transcribed.
- *Follow-up teacher interview* (n=15 attempted, 13 received – 6 from *Multitasking* and 7 from *Microbiome* institutes). Two open-ended questions were sent to the teachers who participated in the first teacher interview. These questions examined impacts on teachers' practice that they attributed to institute participation. The questions were sent by email to teachers six months after participation. Participants chose to respond by email (n=11) or through a telephone interview (n=2), which was audiotaped and transcribed.
- *Anonymous end-of-institute teacher survey* (n=41). Open-ended questions were intended to uncover the learning and experience from institute participation for *all* participants. Closed-ended items measured teachers' general satisfaction with the institute and its structure. We used descriptive statistics to calculate the means and standard deviations for the closed-ended questions. Additional questions offered teachers opportunities to comment on how the institute could be improved. The survey was administered by the first author at the end of the final day of an institute.
- *Institute lead facilitator interview* (n=1). This semi-structured, in-person interview with the primary institute facilitator lasted 30 minutes. Questions aimed to uncover the facilitator's impression of how institute participation impacted teacher learning. The interview was conducted by the first author by telephone one week after the institute. The interview was audiotaped and transcribed.

Teachers were purposefully selected (Stake, 2005) for the teacher interview and follow-up teacher survey to represent variation in gender, ethnicity, years of teaching experience, and previous MTSI participation. The instruments were developed by the study researchers and were informed by the literature on teacher professional learning, PD, and CCD (e.g., Coenders et al., 2010; Guskey, 2000). The exception was the closed-ended items in the anonymous end-of-institute survey, which were developed by an external evaluator two years prior to the study and had been administered regularly in prior institutes.

Data Analysis and Validation

Responses from new teachers and from those who had attended previous institutes were combined in the analysis. Future analysis will involve investigating the differences between these two groups.

The first author, along with an external researcher who was uninvolved in the study and in the MTSIs, worked independently to organize the teacher interview, follow-up teacher survey, and end-of-course teacher survey data. Each researcher identified broad categories that focused on initial patterns and perceptions of critical issues by reviewing interview transcripts and teacher surveys (Miles & Huberman, 1994). Through re-reading the transcripts, we refined the broad categories. We engaged in a cyclical process of analyzing the data, ‘‘refining and modifying the data at multiple levels of complexity in order to locate the main essence or meaning’’ (Stake, 2005, p. 389). Finally, we developed memos for each institute.

Following the analysis of each case, the researchers worked together to conduct a cross-case analysis (Miles & Huberman, 1994; Stake, 2005) to identify broader themes and issues of teacher learning that existed across the two institutes. We carefully assessed overlap between the ideas reflected in each case, and further refined themes. Finally, we used the institute lead facilitator interview data to further triangulate the data on teachers' learning and experiences along with their attributions about the factors that led to the learning.

To establish the trustworthiness and credibility of the findings we used data triangulation, analysis conducted by an external researcher, and member checking (Creswell, 2003; Guba & Lincoln, 1989). Member checking involved sending the written results to the 15 teachers involved in the primary interviews and incorporating these participants' feedback. The feedback in all cases included approval of themes and, in some cases, some explanation of why certain themes were found. This feedback is mentioned in some of the results below.

Results

This study investigated the ways in which teachers experienced professional learning through participation in 4.5-day science teacher collaborative curriculum design institutes and sought to identify the features and processes of the institutes that impacted teachers' learning. This section describes program impacts on teachers' professional learning (research question #1) and impactful program features and processes (research question #2).

Research Question 1: MTSI Impacts on Teacher Learning

Three categories emerged from this research question: (a) learning and change in teachers' science teaching practice (b) influences on teachers' professionalism, confidence, and motivation, and (c) what teachers intended to take back to their home school. We relied on the data from the six-month follow-up interviews along with interview and survey data from experienced teachers (those who had attended previous institutes) to inform us on *enacted* teacher learning and practice change as opposed to *intended* learning and change. Thus, the quotations cited are from 18 teachers (pseudonyms are used), either from interviews or surveys with experienced teachers (those who had attended at least two MTSI) or from follow-up interviews with novice teachers (those for whom this was the first MTSI).

Learning and change in teachers' science teaching practice and knowledge

"I believe these workshops have directly altered how I teach even more than what I teach" (Min, five-time MTSI participant). The data revealed self-reported shifts in teachers' practice and knowledge that they attributed to participating in one or more MTSI. The reported shifts in practice and knowledge are:

Teachers experienced advances in understanding institute-specific content knowledge and science processes. All teachers described gaining cutting-edge knowledge through the institute and explained that gaining new knowledge this way is critical for busy teachers who want the science knowledge but do not have time to seek it out themselves. Rebekka, a two-time MTSI teacher, explained, “The exposure to current research and discoveries is critical in my aim to keep science relevant/applicable and interesting.” Further, eleven teachers reported using the science content gained from MTSI in their classrooms. For example, “I have been incorporating the knowledge I gained from the scientist talks into my classrooms from previous institutes, such as Epigenetics and Evolution This is additional information that has not made it into textbooks yet” (Tina, attended four MTSI).

Even more important was teachers’ reported greater depth of understanding of science processes. Nine teachers explained that the experience helped put science content into a broader perspective and that they gained a clearer understanding of how connections are made in science. For example, Rudy, a novice MTSI participant, explained, “After the MTSI, I now have a greater knowledge base that allows me to expand typical biology content areas into new and relevant research areas.” Five teachers, mostly experienced participants, indicated that as a result of their increased understanding of science content and processes they felt they could move away from a reliance on textbooks. For example:

> My microbiology course just started. I ditched any formal textbook this year and the only thing they are reading is [a research article]. The course no longer is called “infectious disease” with an emphasis on microbial pathogens. Instead, it is “microbes and disease” with an emphasis on the ecology of the human body. The students are fascinated and I am energized. (Joanna, attended three MTSI)

Teachers used intended learning outcomes to frame lesson planning. Teachers reported having learned how to distill content into big ideas during the MTSI. Seven teachers reported applying the strategy of using intended learning outcomes (big ideas or enduring understandings) to frame their unit and lesson planning. For example, as Tina explained, “I currently have a student teacher and I am trying to keep in mind some of the processes we went through during the MTSI while working with him to help him determine what is ‘Enduring Understanding’ content”.

Teachers incorporated new instructional strategies modeled at the institutes. Eleven participants described gaining insight into how to help guide students in their understanding of new or complex information along with how to best represent information to students. For example, five teachers noted that their institute experience helped them realize that merely presenting information is not the most effective approach; rather, teachers can guide students through the process of pulling out important information, categorizing it, and then developing their own understanding of it. Tina explained:

> [Going through the curriculum design process] makes me realize that just throwing something at students isn't going to work. You have to help guide them through, like we're guided through. Students also have to pull out the important information and then they're

> going to learn best if they're able to group it together and then develop their own understanding of it.

Eight teachers described incorporating instructional strategies such as using protocols to distill learning goals and objectives, and using group feedback protocols. When asked what was most beneficial about the MTSI experience, Stephan, a novice MTSI teacher explained:

> Most beneficial was the methods used to teach us new material and then working in our groups to develop understanding of the major concepts. Then beginning to plan how to convert those topics into lessons. I am applying those methods in my classroom as we approach a new project. I give students background information and allow the students to digest that information together to elucidate the major concepts and then build my project around the most important ideas.

Further, eight participants indicated that they incorporate collaboration strategies and strategies for grouping students modeled at the institutes. For example,

> Now I use more collaborative groups, being back in collaborative working groups at the MTSI helped me to take a step back with my students and put myself in their shoes. It helped me to be patient and understanding of what goes on in their groups. (Knut, novice MTSI teacher)

Teachers shifted toward more student-centered instruction. Five teachers reported shifts or intended shifts toward increased student-centered teaching. As Karen, a four-time MTSI teacher explained, "My lessons are more inquiry-based than they were before and I use more activities that span learning styles." These teachers described coming to the realization that it is difficult to learn new material through lecture and were determined to provide students with experiences to work collaboratively and constructively with new information. Valerie explained, "I have moved away from the traditional sort-of lecture and become much more activity-based (Valerie, attended three MTSI).

Teachers increased their use of technology. Eleven participants reported an increased use of web-based technologies, including the Center's website and other instruction-based technologies, such as wikis. Five teachers reported gaining a better understanding of how to incorporate technology in the classroom, which has impacted student science learning. For example:

> Participation has greatly increased my understanding of science content and website development and technology. This has led to my inclusion of more technology in the classroom and better use of resources, which has led to better science understanding by my students. (Sandra, attended two MTSI)

Teachers gained resources and lesson ideas. Ten described learning about new resources, new lessons, and new ways of teaching topics they were currently teaching. As Joanna described, "I'm influenced greatly by having that opportunity to learn what teachers are doing at other schools."

Influences on teachers' professionalism, confidence, and motivation

Teachers felt valued as a professional. Ten teachers described the institutes as the only or among the only places where they feel valued as a professional. For example, "The GSLC involves teachers authentically…there aren't a lot of places that honor teacher input this way" (Valerie). Several teachers reported that this feeling of being valued continued when they returned to their classrooms.

Teachers felt a renewed enthusiasm for teaching and a greater sense of professionalism. Eleven participants described feeling invigorated, rejuvenated, and enthusiastic to teach in the coming year as a result of MTSI participation. "Since I've gotten home I've been working really hard at revamping my curriculum for this year. And I feel more creative than I've ever been (Joanna). Some indicted that they were reminded of their love of learning and their desire to inspire this in their students. For example:

> These institutes reinvigorate my love for learning. I think one of the most valuable things a teacher can bring to the classroom, on topics of content knowledge, is an enthusiasm for what they are teaching and a transparency that they are interested in improving their own understanding of science. (Rebekka)

Teachers felt validated and affirmed for their teaching values and approaches. Nine teachers described feeling encouraged and validated for the approaches they had taken previously in the classroom and for their teaching values. "It's nice to get that broader scope of whatever people are doing that reaffirms that my format is right and my focus and thoughts are on track" (Rebekka).

Teachers felt their contribution to science education was larger than on the classroom or school level. Because the activities they designed during the institutes would be available internationally through the Center's websites, eight teachers reported feeling they contributed to education on a large scale. As Joanna explained, "If I can help out on projects like the GSLC's, it allows me to have a bigger impact on education in a much wider community than my own."

Teachers felt they had gained a sense of community. All of the returning teachers reported looking forward to working with the Center's staff and other experienced teachers each time they were selected for an institute. "I just really, really enjoy the time I get to spend with the GSLC's team" (Joanna). Another teacher explained, "The ability to talk with these other teachers who are so passionate about what they're doing from all over the country …you hear about new ideas, see things in different ways, different contents" (Tina). Further, four novice teachers indicated feeling that they had developed a community of teachers with whom they could consult throughout the year.

What teachers take back to their home school

While teachers indicated an intention to collaborate and share institute learning with colleagues at their home school, the majority of the participants did not engage in these types of interactions. This may be due to interview questions that did not address these changes directly enough or the MTSI may not have fostered enacted changes in this area. Results from member checking suggested that opportunities for collaboration are often not afforded to teachers in the

U.S. As Min explained in an email correspondence, "How non-student contact times are used by teachers is often predetermined by administration trying to meet school, district, state, or federal mandates."

In sum, teachers reported that they experienced a breadth of professional learning during their participation in MTSI. The learning and change in practice included increased science content and a greater understanding of science processes. Teachers also gained new teaching strategies, approaches to framing curriculum and lesson planning, and increases in student-centered learning. While the data revealed intentions for increased collaboration at teachers' home schools, the data did not reveal shifts in these practices. Finally, teachers expressed an increased or renewed sense of professionalism and enthusiasm for their craft. These findings suggest change occurred in teachers' beliefs, knowledge, and practice. Further, some of these changes may evolve into longer-term growth, which will be further explored in the Discussion section.

Research Question 2: MTSI Program Features that Impacted Teacher Learning

This research question identified the program features and processes that facilitated teacher learning. Four program categories emerged from the data: (a) collaboration with other teachers that focused on student learning of new content, (b) scientist lectures and pre-institute readings, (c) facilitation by Center staff, and (d) program organization and culture.

Collaboration with other teachers

The data suggest that collaborating with other teachers had the greatest impact on teacher learning. Two aspects of teachers' collaboration were most important. First, engaging in meaningful discussions about science content, science processes, and classroom application of the content and processes with high-quality biology teachers from across the country. Second, focusing on how to achieve student learning of this science content.

Teachers reported that being afforded sufficient time to digest new science content together with other teachers was key for their professional learning. During the MTSI, teachers worked together in whole and small groups, and with staff facilitators to distill the content from the pre-institute readings and scientist lectures into big ideas, or learning goals and objectives. Further, during the curriculum design phase, teachers' primary objective was to work collaboratively with other teachers to translate this new content into lessons that would be effective for student learning. The program, then, provided ample time for teachers to understand the new science content and to begin planning how they would bring it to their classrooms. As Karen described, "The process makes you think in concrete and specific terms about what you're going to do with the information and how you're going to get students to the point where they are understanding the information."

Teachers attributed working with teachers with similar expertise (biology) to fostering their learning. Specifically, working with teachers of equal (high) caliber, equal (high) background knowledge, and with similar values and attitudes toward teaching (holding themselves and students to high standards) contributed to their ability to collaborate productively. Teachers described learning the most though exposure to other people's ideas and ways of doing things.

Further, the discussions gave teachers insight into how to present complex information to students.

Some teachers attributed teaching in more student-centered ways to discussions with other teachers. For example, "To hear other teachers share how they've presented information in the past is really helpful…. The light bulb just goes off in your head…it helps you to approach information and different ways to teaching it… I incorporate more inquiry in my classroom as a result" (Karen).

Teachers found other teachers inspiring and creative. For example, "Being surrounded by a group of creative thinkers who don't rely on the textbooks and are really willing and actually embrace the opportunity to create. It challenges me to see content from multiple perspectives and inspires me…which I know ultimately benefits my students" (Valerie).

Teachers indicated that collaborating fulfilled a professional need. Some teachers reported that they had few opportunities to collaborate at their home schools. Several teachers indicated that the process contributed to building ongoing relationships. New teachers appreciated the mentorship they received from experienced teachers. Finally, many described collaborating with new people as freeing, without the restraints and restrictions imposed by school culture and context.

Scientist lectures and pre-institute readings

The data indicated that scientist involvement and pre-institute readings impacted teachers' professional learning. Teachers reported that learning content directly from scientists working in that field was exciting and enhanced their sense of being part of a science community. Further, learning cutting-edge science directly from scientists contributed to their enthusiasm for taking the content back to their students. Tina described her experience as, "The fact that we get to talk to the scientists as opposed to just reading the research papers. You can see their enthusiasm and I can pass it on to my students."

Many teachers expressed enjoyment and appreciation of being put back in the role of a student, which they reported contributed to their sensitivity and awareness of their students' learning processes. Further, they felt stimulated and intellectually challenged by the lectures and interactions with scientists. They described feeling ownership over the new content and their learning. Finally, they found the pre-institute readings useful and appropriate for their learning process (in some cases, the readings were written by the scientists involved in the institute).

Facilitation by Genetic Science Learning Center staff

Most of the teachers indicated having learned from the instructional techniques and strategies used by the Center facilitators during the institute. These strategies included protocols for distilling new content from readings and lectures into big ideas (learning goals and objectives), strategies for grouping students, and strategies for successful collaboration.

Using the protocols impacted teachers' learning in three primary ways: they helped teachers learn the content, they influenced the quality of the curriculum teachers designed, and the modeling of these strategies by facilitators provided teachers' with strategies that they used or intended to use in their classroom. Karen, for example, described, "So the way that we come up with the learning objectives, the big ideas, by sitting down and working in groups…those are extremely helpful in terms of both using them in the classroom and also helping to synthesize information after the lectures. I use a lot of those [protocols] in my classroom now, I use a lot of group work now, and I use readings where we find a sentence and discuss it." Further, many teachers described how the facilitators' process of allowing teachers the freedom to be creative without pushing them into something specific fostered their learning.

Program organization and culture

The results also revealed that the program organization and culture were linked to teachers' learning. Teachers indicated that the program is refined and exceptionally well organized, which maximized their time and efforts. For example, "the whole model was very fluid…. One can tell the program has gone through changes, a lot of maintenance, and revision" (Rudy). Many teachers described the importance of providing structure as well as adequate time for rumination and reflection. The closed-ended items on the end-of-institute teacher survey corroborated these findings. Likert-scale items had a 4-point scale with 1 being "strongly disagree" and 4 being "strongly agree." Average scores are reported for *Microbiome* teachers and *Multitasking* teachers in Table 1.

Table 1. *Closed-ended item results from end-of-institute teacher survey.*

Question	***Microbiome***	***Multitasking, Attention, and Memory***
The institute reflected careful planning and organization.	3.9	3.95
The facilitators were well prepared.	3.95	4.0
The experiences of participants were utilized as a resource for discussion and learning.	3.75	3.85
Questions and concerns were handled appropriately.	3.95	3.95
Our time was used appropriately and effectively.	3.9	3.85

In addition, teachers described the supplementary nature of the curriculum as facilitating teachers' creativity and professional learning. They felt unconstrained by state science standards, requirements from their home district, departmental politics, or colleague inflexibility. Teachers also indicated that they found the Center's content choice especially interesting.

Finally, teachers attributed program culture and philosophy to their learning. Being appreciated and treated as valued professionals increased their sense of professionalism and enthusiasm for their trade. Further, teachers reported feeling more motivated to learn the new materials and to produce high-quality ideas because they felt honored to be selected for the program.

In sum, the results revealed that teachers attributed their learning to various aspects of the program, including scientist lectures and pre-institute readings, program facilitation, and program organization and culture. The process of collaborating with other teachers was most impactful on teachers' learning, contributing to virtually every facet of their growth. Two aspects of teachers' collaboration appeared to be most important: a) engaging in meaningful discussions about teaching and content with high-level biology teachers from across the country and b) focusing on applying new content to students and classroom practice.

Overall, the results suggest that teachers experienced meaningful learning through participation in the MSTI, including content knowledge change, belief change, and enacted and intended practice change. Different elements of the MTSI program impacted these changes, especially productive collaboration. While somewhat short-term changes are reported in the data, the data suggest that long-term growth also occurred, especially among experienced teachers. Further study that looks in-depth into the growth of experienced teachers across years of participation is needed.

Discussion

The study results suggest that participation in the Master Teacher Summer Institutes fostered meaningful teacher learning. Teachers reported advancing in their understanding of science content and processes. They also described experiencing changes in their teaching practice, including gaining effective strategies for lesson development, grouping and collaboration strategies, and shifting toward using more student-centered teaching approaches. Teachers indicated an increased sense of value and worth as a professional, a renewed enthusiasm for science teaching, an affirmation of pre-existing teaching values and approaches. While teachers indicated an increased desire for more collaboration with colleagues at their home school, this did not occur. Teachers' reported changes were fostered by their engagement in collaboration with other high-caliber teachers, engagement with scientists and pre-course readings, and quality facilitation, along with efficient institute organization and a culture of valuing teachers as professionals.

These results suggest that the PD strategy of relatively short-term collaborative curriculum *design* can have similar impacts on teacher learning as the longer-term collaborative curriculum *development*. In this section, we unpack the processes through which the MTSI program aligns with and encompasses the effective strategies for PD described in the literature and discuss the "environmental features" that are unique to the MTSI program.

It is important to note that self-reported data were collected in this study, and that the results describing teacher professional learning are based on teachers' perceptions of their change. Self-reported data are commonly used in investigating the effects of PD. Further, these types of data have been shown to reflect accurate measures of teacher practices, though there is debate about this (Banilower, Heck, & Weiss, 2007; Supovitz & Turner, 2000).

How Does the MTSI Process Foster Teacher Learning?

The study results revealed that the MTSI programs incorporate key elements of successful PD found in the literature. Hewson (2007), in an extensive review of research in science PD, noted that any professional development "should have the purpose of supporting teachers in taking responsibility for their own learning, in making the topics of teacher professional development their own, and in being active learners" (pp. 1181-1182). The MTSIs encompass each of these goals. In addition, the MTSIs focus on subject matter, how students learn that subject matter, and collective participation (Borko, 2004; Guskey, 2003; Loucks-Horsley et al., 2003). These features can provide opportunities for changes in belief, knowledge, and practice (Fishman, et al., 2003; Gess-Newsome, 2001; Pajares, 1992; van Driel et al., 2001).

For MTSI participants, active learning was achieved through *meaningful* collaboration, which researchers have called the center of professional learning (Ball & Cohen, 1999). In order to be meaningful, collaboration with others should be structured to be productive, including focusing on a specific topic or goal (Allan & Miller, 1990; Gess-Newsome, 2001; Guskey, 2003) and should occur within the context of practice (Huffman et al., 2003). Collaboration without these elements has shown limited success (Huffman et al., 2003). In MTSI, the collaboration was structured to focus on subject matter, student learning and connectivity to classroom practices.

The Interconnected Model of Teacher Professional Growth (Clarke & Hollingsworth, 2002), introduced earlier, provides a framework for understanding the role of meaningful collaboration in impacting teacher learning and for interpreting our study findings. In this Model, *reflection* and *enaction* mediate teacher learning during PD in four domains: personal, practice, consequence and external. In the MTSIs, meaningful collaboration provided extensive opportunities for reflection and enaction, which mediated change and growth in several of the domains. Consequently, teacher learning could occur.

Reflection. Reflection has been described in the literature as a cornerstone of teacher professional growth (Schön, 1983). “In the absence of sufficient reflection, a teacher will not be able to bring his or her knowledge to the appropriate professional level” (Shkedi, 1996, p. 699). Throughout the MTSI program, time and encouragement for reflection occurred continuously. Reflection was most prominent during the processes of distilling key ideas from the scientist lectures and pre-institute readings, developing learning goals and objectives, and curriculum design.

The results indicate that the MTSI process fostered *deliberative* reflection (Valli, 1992; 1997), which involves consideration of students, instructional strategies, and teaching contexts through the lens of teachers’ beliefs and values, along with consideration of research findings and other teachers’ opinions (Minott, 2008). Collaboration provided opportunities for teachers to examine their beliefs and teaching practices as they worked with facilitators and especially with other teachers, engaging in discussion toward a common goal. Similar to Deketelaere and Kelchtermans’ (2006) study of teachers participating in CCD, MTSI participants made their own beliefs explicit while recognizing others’ beliefs about teaching and learning. Making beliefs explicit allows recognition of routine behavior (Schön, 1983) and leads to “an enhanced awareness of one’s own norms and values concerning teaching (Deketelaere & Kelchtermans, 2006, p. 81). Supporting other research on teacher change and growth, the study results suggest that reflection on their own and colleagues’ beliefs and values during MTSI was directly linked to the learning teachers experienced during the institute (Fishman et al., 2003; Gess-Newsome, 2001; Pajares, 1992; van Driel et al., 2001).

Enaction. Enaction can take place inside and outside of the classroom—being centered in practice does not dictate that PD only take place inside of the classroom (Borko, 2004; Ball & Cohen, 1999). During MTSI participation, enaction occurred as teachers considered effective means for incorporating new knowledge into the classroom during curriculum design. In this task-oriented collaboration, teachers were constantly planning and considering how curriculum would be received in classrooms by students, how it connected to national standards, how it could connect to teachers' existing lessons, and how different teachers would perceive and implement the curriculum. Teachers reported that they were thinking *continuously* about how information could be used in the classroom.

Enaction also occurred in the classroom as participants applied new content and instructional strategies gleaned during the institute. In addition, it occurred as they applied the many other kinds of learning that they experienced, including new values and beliefs about how students learn science and associated practices. Teachers were not able to enact the curriculum they had designed since it takes at least a year for the Center's staff to develop each set of multimedia and other curriculum materials.

The Four Domains of the Interconnected Model

In their review of teacher learning in nine CCD programs, Voogt et al. (2011) used the Interconnected Model to interpret study results in terms of teacher learning and the processes involved in this learning. They found that during activities related to problem analysis, curriculum design and development, and evaluation of the design, teachers experienced change (and possibly growth) in three of the four domains. All of the studies showed change in the practice domain, many showed change in the personal domain, and some showed change in the external domain; none of the studies showed change in the consequence domain.

We had similar findings in the MTSI study—the program impacted the practice, personal, and external domains; there was little evidence of impact on the consequence domain. Changes in one domain influenced changes in others. Further, changes in the domains occurred in different ways and on different levels for each teacher participant; however, changes specific to individuals are a subject for future research and analysis.

The results indicated that changes in the *practice domain* occurred during the program and often in the months or years (for the experienced teachers) following the program. During the program, teachers engaged in professional experimentation, the hallmark of this domain, as they worked to make sense of the new content for themselves and then to conceptualize how this new content could be most effectively translated to the classroom context. In the months following the program, some teachers implemented new teaching strategies such as using feedback protocols; identifying and focusing on the learning goals and objectives they want their students to achieve; and increasing student-centered learning. Further, some teachers experienced change in their home schools such as increasing the amount and quality of collaboration with other teachers. Many other teachers indicated intent to change in these ways.

In the *personal domain*, teachers experienced changes in their science content knowledge, in their understanding of science processes, and in their views about science and scientists. Belief and attitude changes included how students learn science, the value and importance of science teaching, and more self-oriented beliefs such as self as a member of the science community, and self as a science teacher. Further, they acquired new instructional skills and strategies that they felt were effective (e.g., grouping students and other collaboration strategies; approaches to framing curriculum and lesson planning).

In the *external domain*, participants drew on multiple sources for new knowledge and ideas, including pre-course readings, scientist lectures, other teachers, Center facilitators and staff, and Internet sources. They grew to feel confident and empowered to find other external resources as needed and in their skills for interpreting the readings and lectures.

Some of these changes have the potential to be long-term, or to be indications of teacher growth, as defined in the Interconnected Model. A longitudinal study would be needed, however, in order to draw specific conclusions.

In sum, the findings suggest that the 4.5-day MTSI curriculum design program impacted teacher learning by providing time, structure, and opportunities within that structure to link new content to teachers' practice and to the classroom context. Providing the time and structure for reflection and enaction fostered meaningful collaboration. All of these program elements contributed to teacher change and potentially to teacher growth.

Environmental Factors Unique to MTSI Programs

Voogt et al. (2011) found that "environmental factors" can facilitate or hinder teachers' work and learning during PD programs. These factors may be present during collaborative curriculum development programs (e.g., methods of group communication) or in participants' home school or district (e.g., level of support).

Similarly, several environmental factors, or unique features, of the MTSI program contributed to the study findings. The curriculum materials that teachers design during a MTSI are intended to be supplementary rather than serve as a complete replacement unit. Because of this, teachers felt that they could "think big" and be creative without typical concerns about implementation practicalities and time limitations. MTSIs also provide teachers a rare opportunity to focus on exciting, cutting-edge topics in science and research processes, instead of the more common focus on content that is specifically delineated in science standards. In addition, teachers had the opportunity to be creative with their ideas without needing to be concerned about the practicalities of fully developing their ideas into curriculum. This is particularly relevant for the interactive multimedia materials that teachers usually do not have the expertise or resources to develop. Due to these factors the MTSI process allows teachers to be self sufficient in their curriculum design work. To encourage teachers' creativity, the Center's facilitators intentionally avoid offering explicit directions during this phase of the institutes.

The high selectivity of the MTSI participants in the two institutes we studied is also an unusual feature for a teacher PD program, and is a potential limitation to the generalizability of the study findings. Teachers were selected based on criteria that included high science content knowledge and ability to collaborate with others. We are in the process of extending this research to investigate the effects of this PD model on a wider range of teachers.

Conclusions and Implications

Our study findings suggest that collaborative curriculum design can be effective for advancing teachers' professional learning, largely because of its nature as a vehicle for productive teacher collaboration. Similar to collaborative curriculum development, collaborative curriculum design encompasses principles of effective PD, namely engaging teachers as active learners through the strategies of collaboration, focus on subject matter, and focus on student learning of specific subject matter.

The MTSIs include several unique features that are not found in most other PD programs; however, the key features that fostered teacher learning are generalizable to other programs. These features encompass the PD approach that teachers are active learners and are professionals with a range of experiences and ideas. To hold a relatively short-term PD experience based on these principles programs can:

- Create facilitated opportunities for teachers to distill key content from “fruitful” external sources of information such as lectures, readings, or new curricula.
- Create opportunities for teachers to apply, or enact, new knowledge directly to student learning during a PD program. This may include development of student learning goals and objectives and/or curriculum design, development or adaptation.
- Provide time for teachers to reflect on their knowledge, their practice, and their beliefs about teaching and student learning.
- Provide extensive opportunities for *meaningful* teacher collaboration; e.g., collaboration that is task-oriented and grounded in student learning.
- Refine the organization and structure of the PD so teachers feel their time is maximized.
- Incorporate a culture of valuing teachers’ professional experiences and contributions.

While longer-term and sustained PD is considered more effective for teacher learning (Akerson & Hanuscin, 2007; Gess-Newsome, 2001), most PD programs continue to provide short-term workshops or institutes that typically last a week or less (Darling-Hammond et al., 2009). Collaborative curriculum design can realistically be achieved during a relatively short-term PD experience compared to the longer amounts of time required for curriculum development. Thus substantial teacher learning can be provided by programs that do not have the resources for long-term engagement or for involving teachers in the full development of curriculum materials.

Further Study

Future research that builds on this study could investigate short-term change versus long-term growth by comparing the professional learning of teachers who have participated in one or several curriculum design institutes. Research could explore the impact of participation formats on professional learning, such as in-person and online. Finally, additional research could study the influence of curriculum design programs on students, which would address the domain of consequence (Clarke & Hollingsworth, 2002) and the influence of participation on teachers’ conceptualization and use of curriculum in the classroom.

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Appendix A
Overview of a Typical Master Teacher Summer Institute

Institute Component	Description	Purpose	Institute Day	Time allotted
Pre-course readings	Articles on the institute topic(s), sometimes authored by the scientist presenters	Familiarize teachers with the topic(s) before the institute begins	Any time before institute begins	Open
Working Styles protocol (NSRF)*	Exercise for identifying teachers' working styles	Facilitate teachers' identification of their own and others' working styles and build a value for working style diversity; informs staff about teachers' working styles Prepare for productive collaboration during later design process	Day 1	20 minutes
Interactive scientist presentations about current research	Scientists from the University of Utah and other institutions present their research related to the institute topic(s) 3-5 presentations/institute	For teachers to gain and clarify new knowledge and understandings about cutting-edge science (and research processes) Begin the process of making meaning of the new content, both individually and collaboratively	Days 1-2	1.5 hours or more/presentation, including embedded Q&A
Teachers distill key concepts from each presentation	After each presentation, teachers work collaboratively in small groups to distill the information into key concepts * 1 key concept is written on each sticky note * Sticky notes are grouped by key concepts (whole-group exercise)	Part of the sense-making process for the new content, both individually and collaboratively	Days 1-2	30 minutes/presentation
Hands-on activities, laboratory investigations and/or field experiences	Scientists and/or Center staff who are scientists engage teachers in activities related to the institute topic that could be translated into the classroom	Engage teachers in inquiry-based experiences related to the institute topic(s); model experiences they could use in their classrooms	Days 1-2; can extend into days 3-4 for multi-day laboratory investigations	30 minutes – 1 day
Main ideas about	Facilitators and teachers	Further processing and	Day 2, end	30 minutes

readings protocol	collaboratively distill key concepts from the readings using a text-based discussion protocol, chosen from NSRF* protocols; e.g., "Text-Rendering"; concepts are recorded on sticky notes	making meaning of the new content, both individually and collectively	of day	
Create preliminary key concept categories (topics for curriculum design)	Facilitators group key concepts on teachers' sticky notes from presentations and readings into broad categories/topics Further organizing key concepts from lectures and readings	Contributes to ensuring productive collaboration by teachers the following day.	Day 2, after teachers have left for the day	30-60 minutes
Discussion of key concept categories/topics	Teachers consider the facilitators' categories and suggest changes (whole group collaborative exercise)	Teachers and facilitators work collaboratively to define the topics for the next phase--curriculum design work	Day 3, at beginning	20-30 minutes
Curriculum design guidelines and process	Facilitators present guidelines and process for teachers' curriculum design work Teachers are introduced to: * what constitutes a learning goal * prioritizing key concepts for curriculum design * curriculum design guidelines and process * wiki training	Foster productive teacher collaboration during the design process and maximize quality of curriculum design	Day 3	1 hour
Choosing topics for curriculum design work	Teachers self-select a topic and/or group for curriculum design work by standing next to the topic on which they want to work. Teachers are reminded about working styles	Foster productive teacher collaboration during the design process through topic self-selection and awareness of working styles	Day 3	5–10 minutes
Developing student learning goals	Begin process of curriculum design by distilling big ideas from the key concepts and developing student learning goals Teachers work in their	Promote quality design through direct application of new information to student learning goals	Day 3	45-60 minutes

	curriculum design groups to distill big ideas from the key concept sticky notes for their category Teachers write student learning goals for each big idea Teachers post their big ideas and learning goals on a large white board			
Silent conversation (NSRF* "Chalk Talk" protocol)	Silent discussion of big ideas and learning goals via comments written on white board Individual teachers provide feedback to one another on their learning goals; also identify overlapping or identical learning goals	Maximize the quality of curriculum design by developing clear learning goals for each topic area	Day 3	15–20 minutes
Refining learning goals	Curriculum design groups use feedback from the silent conversation to refine their learning goals; Center staff facilitate discussions between groups about how to address any overlapping learning goals	Maximize the quality of curriculum design by refining clear learning goals for each topic area	Day 3	30 minutes
Curriculum design	Curriculum design groups draft initial ideas for activities that can facilitate students achieving the learning goals Teachers are asked to design ideas for computer-based, paper-based, and kinesthetic activities Each group records their ideas on the course wiki	Design quality curriculum through productive collaboration	Day 3	½ day
Curriculum design groups report to whole group	Each group briefly describes the ideas they are drafting	Identify any overlap in design ideas between groups	Day 3 (end) or Day 4 (beginning)	30 minutes
Commenting on wiki	Teachers comment on other groups' ideas on the wiki	Idea development through collaboration with other groups	Any time during days 3-5	Variable
Curriculum design	Teachers continue to design curricula	Further idea development and refinement	Day 4	All day
Curriculum design groups report to	Each group shares their ideas in detail with the	Teachers: Learn about activity ideas other groups	Day 5	½ day

whole group	entire group Process is videotaped	have drafted. Center: Clarify teachers' thinking for each idea to inform curriculum development and production		

*NSRF = National School Reform Faculty

Facilitation protocols used during institutes

Text protocols
http://www.nsrfharmony.org/free-resources/protocols/text

Working Styles Protocol
http://www.nsrfharmony.org/system/files/protocols/north_south_0.pdf

Chalk Talk (silent conversation)
http://www.nsrfharmony.org/system/files/protocols/chalk_talk_0.pdf