CENTER FOR Children & Technology

Year Two Report: Evaluation of the Maryland Virtual High Schools CoreModels Project

September 1999

Wendy Friedman
Katherine McMillan Culp

Review Paper

Educational Technology Research and Development

Table of Contents

Introduction

The CoreModels Project brings together, into a single program, a range of challenges that are often addressed individually: technology integration, standards-based science curriculum development, and peer-supported professional development. CoreModels is run by and for classroom teachers, and it involves teachers in a range of activities, including writing curriculum, building expertise with classroom technology, enhancing science pedagogy, and building peer support skills. By blending these components, CoreModels moves beyond being only a technology-focused project or only a curriculum development project, and becomes an innovative model of how teachers can, given appropriate supports, work together to improve and expand upon their practices, their resources, and their expectations for themselves and their students.

The specific challenge addressed by the CoreModels team is creating an effective infrastructure to support the broad-based adoption of computer-based modeling tools and curricula that support students and teachers in engaging in systems thinking. A wide range of research projects as well as theoretical perspectives on science learning suggest that systems thinking, supported by computer-based model construction, is a promising approach to engaging students in critical inquiry into the dynamics of complex systems (Forrester, 1994; Gordin & Pea, 1995; Krajcik, Soloway, Blumenfeld, & Marx, 1998; Mandinach, 1994). Previous research has also found, however, that introducing modeling into science classrooms is impeded by the need to connect systems thinking concepts to existing curricular content, teachers' lack of familiarity with the systems thinking approach, and inadequate access to appropriate technologies (Mandinach, 1994). A key goal of the CoreModels program is to implement a multifaceted program that invites teachers into systems thinking, and provides them with the appropriate supports as they begin to implement it in their classrooms.

CoreModels builds on previous experiences of the Maryland Virtual High School (MVHS) staff.[1] The CoreModels project was designed to build on what had been learned through the MVHS project and to emphasize three features that were judged to be of particular promise but had been lacking in that project.

The CoreModels project invites teachers into using modeling for science learning by *providing examples*. In previous experiences with MVHS and other programs, the CoreModels staff had found that even teachers who had received extensive training with STELLA (a modeling tool that supports systems thinking) or other pieces of software rarely integrated them extensively into their curriculum or their day-to-day classroom practice. Teachers reported that while they could see the usefulness of these tools in the abstract, they had not been exposed to any of their concrete applications that were directly applicable to their classroom circumstances. In response to this obstacle to leveraging change in teachers' classroom practice through the introduction of new software tools, the CoreModels project provides its participating teachers with a suite of "packets," or units, of curriculum materials that address diverse content areas through modeling and systems thinking.

CoreModels training and materials development is all done *by teachers* in peer-to-peer teams and groups. Research on professional development strongly suggests that teachers want to learn, and learn best, from other teachers (National Foundation for the Improvement of Education, 1996). The CoreModels project builds on the experiences of the Maryland Virtual High School, which has always been teacher-run, and responds to the need for more peer-to-peer professional development opportunities. The project is designed as a three-tiered organization of teachers, all within the state of Maryland. In addition to a Project Director, the project has three Center Directors, each responsible for one region of the state of Maryland (Western, Central, and Northern); 8 Supporting Teachers, spread across the three regions, who are expected to help the Center Directors develop materials and provide one-on-one peer support to project participants; and 30 Participating Teachers, who are trained in using STELLA, make use of the CoreModels packets, and are invited to participate in one-on-one peer-support relationships with Supporting Teachers. Two of the Center Directors have each received half-time relief from teaching, but continue to work half-time in their own classrooms, while the Project Director and one Center Director are released full-time from teaching.

The CoreModels materials are keyed to the *Maryland Core Learning Goals* and are designed to help teachers meet these learning goals in their teaching. The MVHS project, and many others, have found that teachers often see technology-rich tools and curricular components to be interesting, but fundamentally peripheral to the "business" of teaching a core curriculum. However, expectations of teachers and curriculum are changing in many ways. One of the central shifts is the dramatic growth in interest, nationwide, in setting standards for what and how students should learn.

Like other states across the country, Maryland is placing an increasing emphasis on state standards as a means to increase uniformity and rigor in standards and expectations for student learning across the state. Teachers in Maryland, like other teachers confronted with increasing pressure to demonstrate the fit between their curriculum and the standards, are in urgent need of new materials, resources, and teaching methods that will help them to engage with a range of content with their students in ways that are, and can be demonstrated to be, consistent with the state learning standards.

The CoreModels project responds to this need by providing teachers with a set of exemplary curricular units, which can be pursued on their own or in the context of existing curricula, and were specifically designed to meet state standards and to produce student work which can be evaluated according to those standards.

Consequently, teachers understand the materials and software they are exposed to through this program to be immediately relevant to their current curricular concerns and are more likely to integrate them into their overall curriculum.

The Evaluation of CoreModels

The evaluation of CoreModels focuses on three main themes, corresponding to the key features of the CoreModels program

- **Changes in teacher practices.** CoreModels is designed to introduce teachers to new resources, new curricular materials, and new ways of approaching traditional science concepts. If teachers engage deeply with the systems thinking approach embodied in STELLA and the CoreModels curricular units, and implement them extensively, these changes should have a demonstrable impact on their beliefs and practices.
- **The efficacy of the program's key components – mentoring relationships, workshops, and online discussions – as professional development mechanisms for teachers.** The CoreModels program offers multiple sources of support to teachers. If these supports are logistically viable and appropriately tailored to the needs and interests of the teachers, they should lead teachers to engage with one another constructively and substantively; to explore new concepts, materials, and skills; and to feel comfortable experimenting with unfamiliar techniques in their classrooms.
- **The impact of the program on student learning.** If the teacher development model, the modeling and simulation tools, and the sample curriculum units being developed are working together effectively, it should be possible to demonstrate in a sample of classes that students are engaging with and understanding certain key concepts about the nature of dynamic systems and of modeling as a methodology for exploration and analysis.

Key evaluation tasks for Year 2 included the following:

- **Interviews with key project team members and observations of workshops and meetings;**
- **Periodic interviews and classroom visits with a subgroup of participating teachers;**
- **Administration of a survey in fall 1998 and spring 1999;**

- **Continued support of discussions of student learning goals and the development of assessment components for CoreModels curriculum units.**

The following sections will outline tasks accomplished to date in each of these areas and discuss relevant findings from Year 2 related to each area. Because this is the final formative evaluation report for this program (before a summative evaluation report in Year 3), this report will place a primary emphasis on findings related to the *efficacy of the program components*, with the intention of providing the project team with information that can help them to continue to refine and improve the program during Year 3. The other two project goals will be discussed in terms of progress being made and preliminary evidence of impact of the program.

In the final section of the report, plans for Year 3 research are outlined, followed by a discussion and recommendations for further program refinement and development.

Findings

Surveys of Program Participants

This section of the report summarizes findings from a survey mailed to project participants at the close of the 1998-99 school year, and compares teacher responses to findings from the Fall 1998 survey. The goal of this survey was to collect information from participants about their teaching practices, how successful they feel they were in meeting specific goals for participation in the CoreModels project and their experiences with the peer-support component of the project this year. To this end, the Spring survey contained questions from three of the seven sections from the Fall survey: the CoreModels program; peer support relationships; and classroom practices. Ten additional questions were included that were not part of the Fall survey.

Methods

The Spring survey was mailed to 43 teachers participating in the CoreModels program during the 1998-99 school year, including two Center Directors who were each teaching part time. Almost all of the survey questions were forced-choice. Exceptions to this were questions asking teachers to provide specific information, such as number of years teaching; number of visits they made to their peer-support partner's classroom; and number and kinds of project dissemination activities they engaged in over the year.

The Results section below summarizes the survey responses of the 31 teachers—9 Supporting and 21 Participating—who returned their completed surveys. This group contained representatives from all three geographic regions. Specifically, 5 were from the Northern region, 18 were from the Central region and 7 were from the Western region.

Teacher Background

Two questions were asked to gather background information on the teachers participating in the CoreModels program: number of years teaching and highest degree earned.

Of the 28 teachers who indicated the number of years they have been teaching, 9 have been educators for 6 to 10 years; 7 have been teaching for 24 to 40 years; 6 have been teaching for 1 to 5 years; and 6 have been educators for 11 to 23 years. See Figure 1 for a comparison of Fall and Spring respondents.

Of the teachers who indicated the highest degree they have earned (N=29), 13 selected Bachelor's degree; 13 selected Master's degree; 2 selected education specialist or professional diploma; and 1 selected Doctorate (Figure 2).

The CoreModels Program

Building on questions from the Fall survey about teachers' reasons for participation in CoreModels, their expectations about what aspects of the program would be most useful to them, and their personal and classroom goals, this section of the Spring survey sought to gauge the degree to which teachers' expectations and goals were met. In all but one of the questions in this section, teachers were asked to rate answers on a scale from 1 ("not useful" or "did not achieve the goal") to 4 ("extremely useful" or "totally achieved the goal"). Mean responses were calculated for Supporting Teachers and Participating Teachers, as well as for the group as a whole. For questions about achieving goals, teachers could also indicate that the statement was "not a goal for me." An open-ended question also asked teachers, "How have you shared CoreModels ideas and practices with others?"

Useful aspects of CoreModels for the classroom. In the Spring survey, teachers were asked to rate how useful each of six specific aspects of the CoreModels program *were* in their classrooms this year, and answers were compared with the degree to which teachers *anticipated* they would be useful on the fall survey. Respondents were relatively consistent in their Fall and Spring responses. Two features of the program that the group indicated were particularly useful, "technical skills learned during summer training" (fall=3.6, n=33; spring=3.6, n=29) and "CoreModels workshops" (fall=3.4, n=34; spring=3.6, n=30), were two of the three elements anticipated to be most useful in the fall. The third component rated highly in the fall, "content-focused activities that I can use to meet the Maryland Core Learning Goals" was also rated highly in the spring (fall=3.5, n=35; spring=3.3, n=30), but

Figure 1
Teaching Experience and Spring Comparison

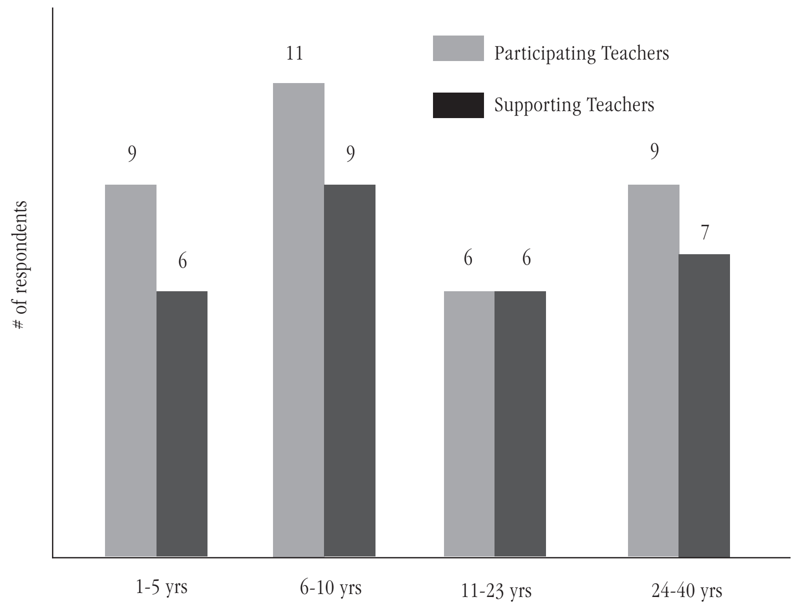


Figure 2
Teacher Education

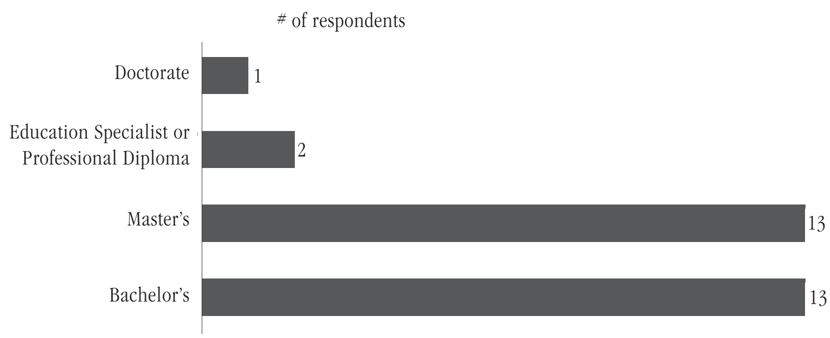


Figure 3
Most Useful Aspects of CoreModels

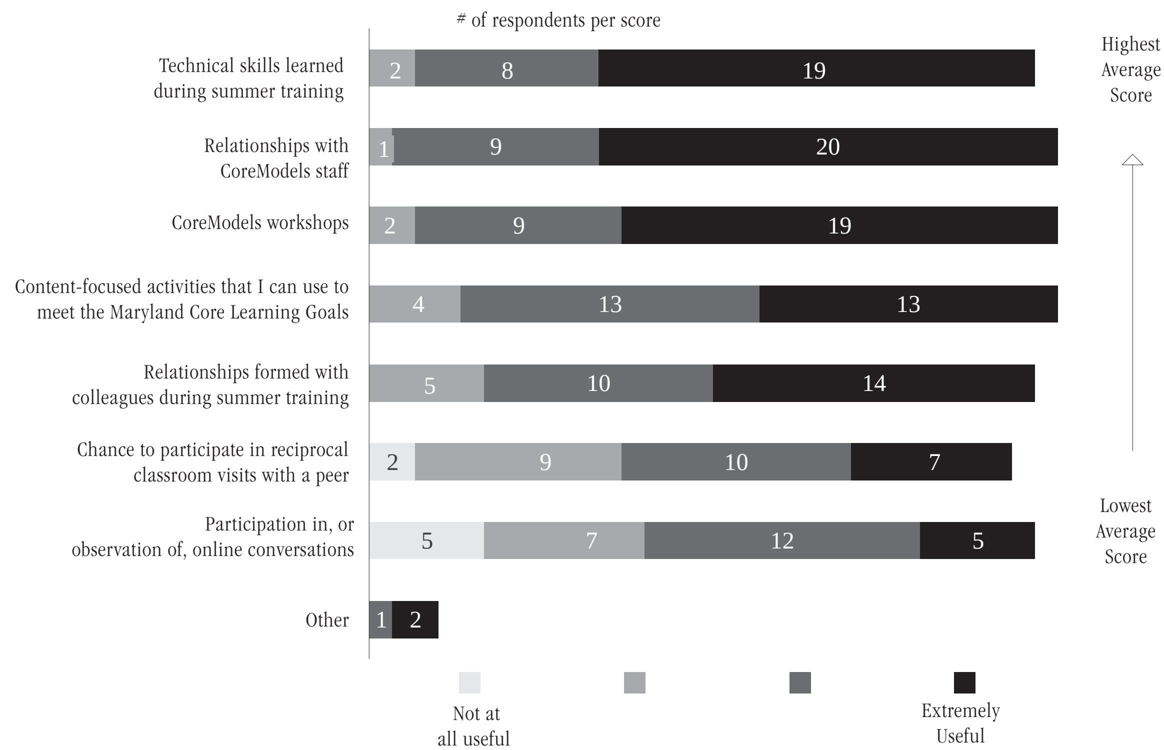


Table 1
Most Useful Aspects of CoreModels for the Classroom
Rated 1 (not at all useful) to 4 (extremely useful)

	Participating Teachers		Supporting Teachers		Total	
	Fall 1998	Spring 1999	Fall 1998	Spring 1999	Fall 1998	Spring 1999
Technical skills from summer training	3.6	3.6	3.0	3.6	3.5	3.6
Relationships formed in summer training	3.3	3.4	3.0	3.2	3.2	3.3
CoreModels workshops	3.4	3.6	3.6	3.6	3.4	3.6
Content-focused activities	3.4	3.3	3.9	3.6	3.5	3.3
Relationships with staff	3.3	3.5	3.6	3.9	3.3	3.6
Reciprocal classroom visits	2.6	2.7	3.3	3.0	2.8	2.8
Online conversations	NA	2.5	NA	2.8	NA	2.6

fell below "relationships with CoreModels staff" (fall=3.3, n=35; spring=3.6, n=30). See Figure 3 for individual Spring replies.

When mean ratings are broken down into Participating and Supporting Teacher groups, a number of shifts occur for Supporting Teachers. Specifically, mean ratings for Supporting Teachers decreased between the fall and spring for "chance to participate in reciprocal classroom visits with a peer" (3.3, n=7 to 3.0, n=9) and "content-focused activities that I can use to meet the Maryland Core Learning Goals" (3.9, n=7 to 3.6, n=9), while they increased for "relationships with CoreModels staff" (3.6, n=7 to 3.9, n=9) and "technical skills learned during summer training" (3.0, n=6 to 3.6, n=9).

No changes for Participating Teachers occurred that were greater than 0.2. See Table 1 for Spring and Fall comparisons by subgroup.

Goals related to professional growth. In the fall survey, teachers indicated the personal importance of nine statements about goals for their involvement in the CoreModels program specifically related to their *professional growth*. In the spring survey they were asked to indicate the degree to which they felt they had achieved these goals. The two goals rated in the fall survey as being very important (≥3.0) were rated as having been nearly achieved in the spring survey: "to have more confidence in my own capabilities in utilizing technology" (fall=3.5, n=35; spring=3.2, n=30, and "not a goal"=2) and "to have more content-focused activities that I can use to meet the Maryland Core Learning Goals" (fall=3.3, n=35; spring=3.1, n=29). See Figure 4 for individual spring replies.

When these two goals are broken down into subgroup responses, Supporting Teachers' average ratings indicate that they feel they have been more successful at achieving these goals than Participating Teachers feel they have been. This difference may reflect the Supporting Teachers' lengthier experience with the CoreModels program. Specifically, Participating Teachers rate the degree to which they now have more content-focused activities to use to meet the Maryland Core Learning Goals at 2.9 (n=20) while Supporting Teachers rate this at 3.4 (n=9). Similarly, Participating Teacher rate the degree to which they now have more confidence in their own capabilities in utilizing technology at 3.0 (n=21, and selected "not a goal") while the mean rating for Supporting Teachers was 3.7 (n=9). See Table 2 for Spring and Fall comparisons by subgroup.

Teachers also indicated that two goals included in the fall survey and rated as relatively low priorities were to a large extent achieved by the spring. These were, "I have provided training and support to others" (fall=2.7, n=35; spring=3.0, n=30, 3 selected "not a goal") and "I have contributed to state-level education projects because of my increased content expertise" (fall=2.3, n=35; spring=2.9, n=30, 9 selected "not a goal").

Goals related to classroom practices. All but one of the six statements offered in the fall survey as potential goals for teachers' involvement in CoreModels related to *classroom practices* were rated by teachers on average as being very important (>3.0), and the single exception fell just below this mark (2.9). Asked in the spring to indicate the degree to which they felt these goals were achieved, teachers rated three of them, on average, as being almost achieved (ratings of 3.0 or more). These goals were: "I am more familiar with using technology as an integral part of my curriculum." (spring=3.2, n=30); "My students engaged with more complex concepts and systems than I had previously been able to address." (spring=3.0, n=30, 1 selected "not a goal"); and "My students learned that real-world problems are complex." (spring=3.0, n=30, 1 selected "not a goal"). The first two of these received the highest mean ratings in the fall (3.8 and 3.7, respectively, n=35 for both), while the mean rating in the fall for the last one fell slightly lower in the list at 3.3 (n=35). See Figure 5 for all statements and individual replies.

As with goals related to *professional growth*, Supporting Teachers as a group seem to feel more successful than Participating Teachers do as a group at achieving goals related to *classroom practice*. There were strong differences between Supporting and Participating Teacher groups in the degree to which they felt they achieved three goals in particular: "I was able to more completely meet the Maryland Core Learning Goals for my discipline." (Supporting Teachers=3.3, n=9; Participating Teachers=2.8, n=21, and 1 selected "not a goal"); "My students engaged with more complex concepts and systems than I have previously been able to address." (Supporting Teachers=3.3, n=9; Participating Teachers=2.9, n=21; 1 selected "not a goal"); and "My students got better at working with one another collaboratively." (Supporting Teachers=3.0, n=9; Participating Teachers=2.7, n=21). Again, these differences are likely to be a reflection on how much overall experience each group has had with the program. See Table 3 for Spring and Fall comparisons by subgroup.

Current conceptual hurdles to implementation. Similar to responses in the fall, the spring survey findings suggested that none of the four conceptual hurdles to implementing CoreModels curricula in their classrooms listed in the survey were major obstacles for the group this year (all mean ratings were below 3.0). The range of averages, from 1.3 to 2.1, varied only slightly from the fall range of 1.4 to 1.9, and remained in the same order. The hurdle identified as most significant in the spring (2.1, n=20), "being able to think in terms of models but having trouble representing the images in my head with the images and functions in STELLA," received the highest rating in the fall as well (1.9, n=35). See Figure 6 for individual replies and Table 4 for Spring and Fall comparisons by subgroup.

Figure 4
Goals Related to Professional Growth

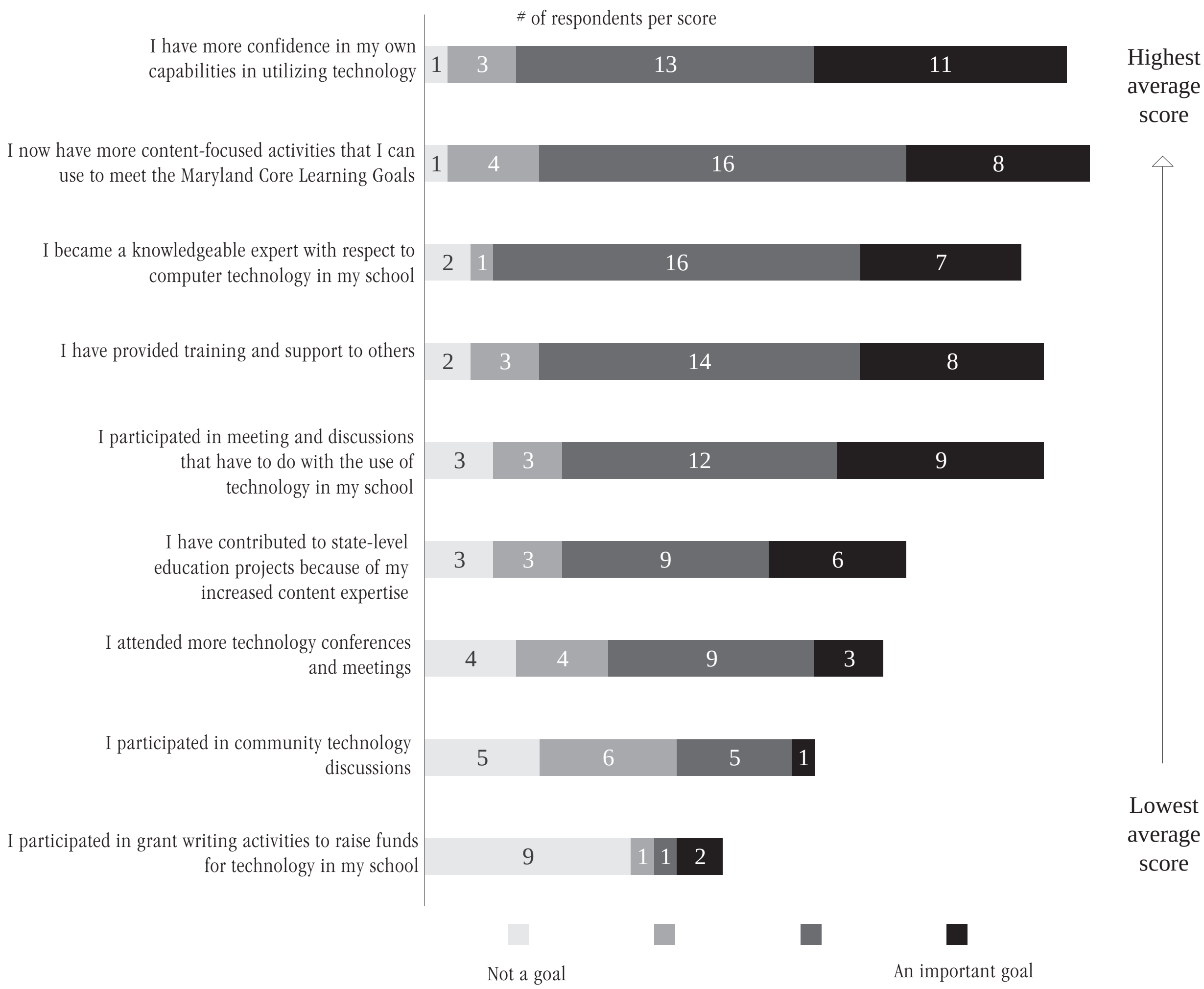


Table 2
Goals Related to Professional Growth

Rated 1 (didn't achieve) to 4 (totally achieved)
* Note that this question was phrased in the fall in terms of goals
and in the spring in terms of the degree to which the goal was achieved.

	Participating Teachers		Supporting Teachers		Total	
	Fall 1998	Spring 1999	Fall 1998	Spring 1999	Fall 1998	Spring 1999
More confidence in using technology	3.5	3.0	3.3	3.7	3.5	3.2
More content-focused activities related to MD Core Learning Goals	3.3	2.9	3.4	3.4	3.3	3.1
Knowledgeable technology expert in my school	2.8	2.8	3.4	3.7	2.9	3.1
Provide training and support to others	2.6	3.0	3.0	3.1	2.7	3.0
Participate in technology meetings at my school	2.8	2.8	3.6	3.4	2.9	3.0
Contribute to state-level education projects	2.1	2.7	3.3	3.1	2.3	2.9
Participate in grant-writing for technology at my school	2.1	1.4	2.4	2.2	2.1	1.7
Attend more technology conferences or meetings	2.0	2.3	2.6	3.0	2.1	2.6
Participate in community technology discussions	2.1	2.2	2.1	2.0	2.1	2.1

Figure 5
Goals Related to Classroom Practice

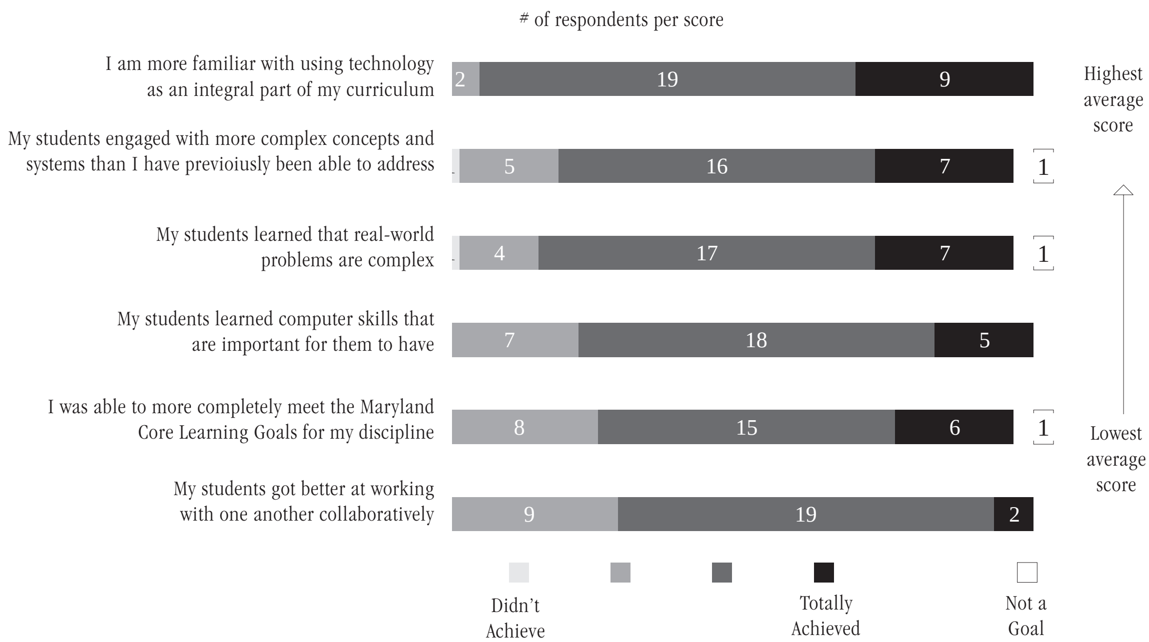


Table 3
Changes in Classroom Practices

Rated 1 (didn't achieve) to 4 (totally achieved)

* Note that this question was phrased in terms of goals in the fall, and in terms of degree the goal was achieved in the spring.

	Participating Teachers		Supporting Teachers		Total	
	Fall 1998	Spring 1999	Fall 1998	Spring 1999	Fall 1998	Spring 1999
More familiar with using technology in the curriculum	3.8	3.2	3.9	3.3	3.8	3.2
Students engage with more complex concepts and systems	3.6	2.9	3.9	3.3	3.7	3.0
Students learn real-world problems are complex	3.4	3.0	3.1	3.2	3.3	3.0
Students learn computer skills	3.4	2.9	3.4	3.1	3.4	2.9
More able to meet Maryland Core Learning Goals	3.0	2.8	3.1	3.3	3.1	2.9
Students better at working collaboratively	3.0	2.7	3.0	3.0	2.9	2.8

Figure 6
Conceptual Hurdles to Curricular Implementation

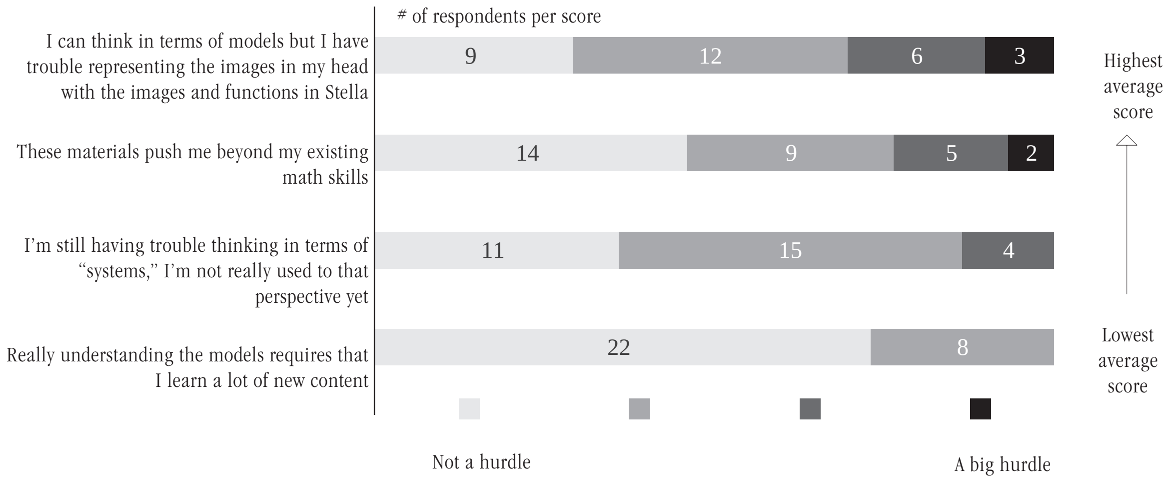
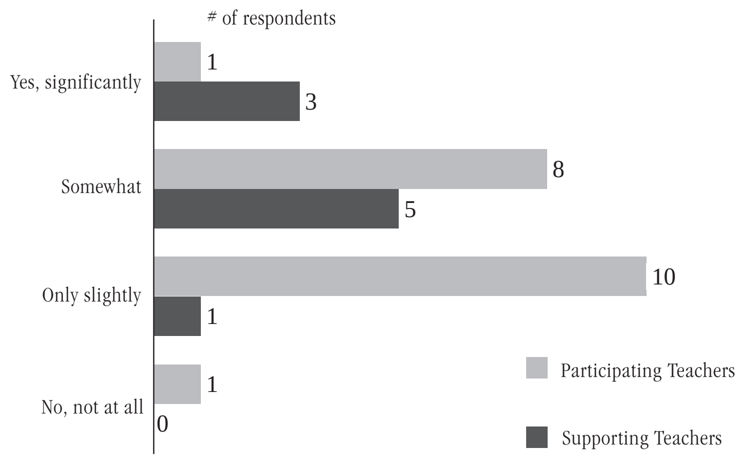


Table 4
Current Conceptual Hurdles to Implementation
Rated 1 (not a hurdle for me) to 4 (a big hurdle)

	Participating Teachers		**Supporting Teachers**		**Total**	
	Fall 1998	**Spring 1999**	**Fall 1998**	**Spring 1999**	**Fall 1998**	**Spring 1999**
Trouble representing models in terms of STELLA images	1.9	2.1	2.1	2.0	1.9	2.1
Materials push me beyond my existing math skills	1.8	1.9	2.1	1.7	1.9	1.8
Trouble thinking in terms of "systems"	1.6	1.8	1.6	1.7	1.6	1.8
Understanding models requires learning new content	1.4	1.3	1.3	1.1	1.4	1.3

Figure 7
Influence of CoreModels on Becoming More Interdisciplinary in Participants' Teaching Strategies



Effect of CoreModels participation on more interdisciplinary teaching. Teachers were asked on the spring survey to indicate the degree to which they feel that their participation in the CoreModels project has influenced them to be more interdisciplinary in their teaching this year. On a scale from 1 to 4, with 1 being "no, not at all," and 4 being "yes, significantly," the total mean rating was 2.7 (n=29), falling between "only slightly" and "somewhat." When broken down into Supporting and Participating Teacher subgroups, the Supporting Teachers' mean responses was somewhat higher, at 3.2 (n=9), compared to 2.5 (n=20) for the Participating Teachers. Again, the difference between Supporting and Participating Teachers is likely to be related to their time in the program and comfort with the materials. See Figure 7 for individual replies by subgroup.

Peer Support Relationships

This section of the survey gathered information about teachers' experiences with the peer-support component of the project this year. Questions specifically focused on gauging the types of support given and received; the prominence of peer-support in teachers' overall experiences with the program; comfort levels with peer-support; successes and obstacles encountered; and level of peer interaction.

In most of these questions teachers were either asked to select one reply from a list of choices or to rate on a scale the degree to which various statements applied to their particular situation. Different scales were used for different questions, and are described below with their findings. In each case, however, individual answers were averaged to yield group ratings for reporting purposes. Additionally, three questions asked teachers to fill in the number of times they engaged in a particular interaction.

Importance of Peer-Support component to CoreModels program. Respondents (N=29) consider peer-support a relatively important component of the CoreModels program. Specifically, 6 teachers (2 Supporting Teachers; 4 Participating Teachers) selected "very important; it is the most important component of the program" and 15 teachers (7 Supporting Teachers; 8 Participating Teachers) selected "quite important" as their reply. The remaining 8 teachers, all of whom were Participating Teachers, indicated that they "see the value of it, but it is not important to them personally." See Figures 8a for spring replies by subgroup.

On the fall survey (n=35), prior to engaging in peer support relationships, teachers were asked to indicate how important to them the peer-support component of CoreModels was given their understanding of it at that time. 2 teachers (both Participating) selected "very important; it is the most important component of the program," 18 teachers (4 Supporting; 14 Participating) selected "quite important" and 1 teacher (Participating) selected "not very important" to describe their feelings about peer support. Perhaps reflecting their inexperience with these relationships, 14 teachers at this time selected, "unclear; I'm not sure how much it will matter to me." See Figure 8b for fall replies by sub-group.

Prominence of peer support partner in CoreModels experience. In addition to being asked how important the peer support component is to CoreModels as a whole, the spring survey asked an additional question to determine how prominent a part each teacher's peer support partner played in her or his personal experience of the program during the year (n=28). None of the teachers replied that collaboration with their partner was "very prominent; it was the main thing I did through CoreModels this year." 8 teachers (2 Supporting Teachers and 6 Participating Teachers) did, however, select "quite prominent; it was a major part of the program for me." 9 teachers (2 Supporting Teachers; 7 Participating Teachers) selected "it was one among many pieces of the program for me," and 8 teachers (3 Supporting Teachers; 5

Figure 8a
Importance of Peer Support Spring Survey

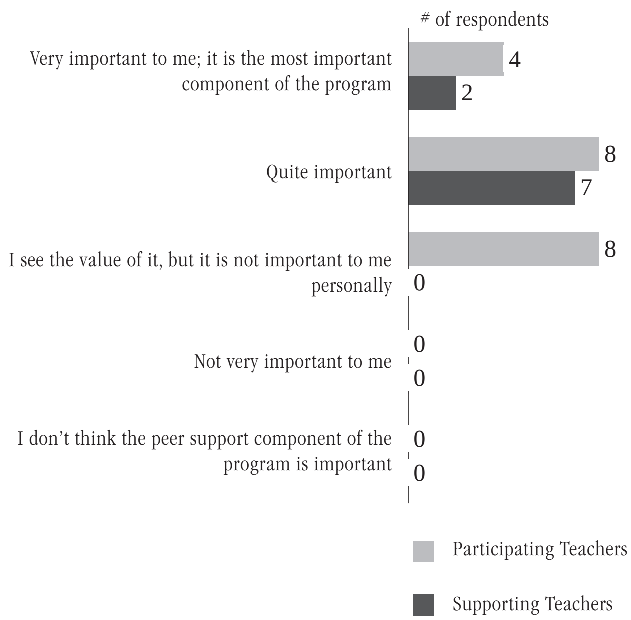
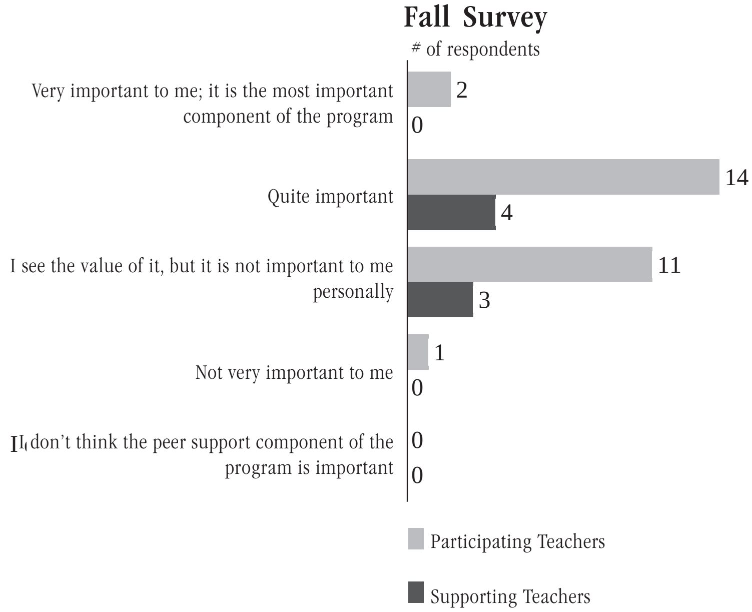


Figure 8b
Importance of Peer Support
Fall Survey



Participating Teachers) selected "a very minor part of the program for me this year" as their answers. 3 teachers (2 Supporting Teachers; 1 Participating Teacher) answered that they "did not work with their peer support partner at all this year." See Figure 9 for individual replies by subgroup.

Goals for future support from colleagues. Teachers were asked to indicate, using a scale from 1 to 4, how interested they would be in receiving various types of support from a colleague *in the future*. Of the ten statements listed, respondents indicated that they would be interested in primarily three things: "Working with someone on developing new STELLA models and/or related curricula." (3.2 for both Supporting Teachers, n=9, and Participating Teachers, n=20); "Working with someone on developing assessments for modeling activities (test questions, formats for student presentations, etc.)" (overall mean=3.2; Supporting Teachers=3.6, n=9; Participating Teachers=3.0, n=20); "Getting answers to questions about how to use STELLA." (overall mean=3.1; Supporting Teachers=2.9, n=9; Participating Teachers=3.3, n=20). See Figure 10 for a complete list of statements and individual replies, and Table 5 for a comparison of subgroup means.

Help from Supporting Teachers this year (Participating Teachers only). Eight statements about what *Participating Teachers* might *hope* to gain from their peer partners over the year were listed on the fall survey, and respondents were asked to indicate how important they expected each kind of support to be during the school year, using a scale from 1 to 4. At that time, Participating Teachers as a group felt that Supporting Teachers could be particularly helpful in four ways: "By being a sounding-board for my observations, difficulties, etc., before I discuss them with the group or group leaders" (3.2, n=28); "By helping out in my classroom (answering student question, etc.) when he/she visits" (3.2, n=28); "By answering questions about how to use Stella, via email and phone" (3.0, n=28); and "By talking with me online and in person about my progress in using CoreModels materials with my students" (3.0, n=27).

The same eight statements were listed on the spring survey and *Participating Teachers* were asked to indicate how important each kind of help *actually was* to them over the year. The same scale of 1 to 4 was used, and there was an additional option to select NA for items that were not applicable to the respondent's situation. In contrast to their fall expectations, none of the types of support received a mean rating above 2.9, and six of the ratings fell only between 2.0 to 2.4. The statements with the highest mean ratings were "By answering questions about how to use STELLA." (2.9, with 4 "NA," n=18), and "By helping out in my classroom (answering students' questions, etc.), when he/she visits." (2.9, with 2 "NA," n=18). See Figure 11 for a complete list of statements and individual replies and Table 6 for a fall and spring comparison of subgroup means.

Figure 9
Prominence of Peer-Support Partner

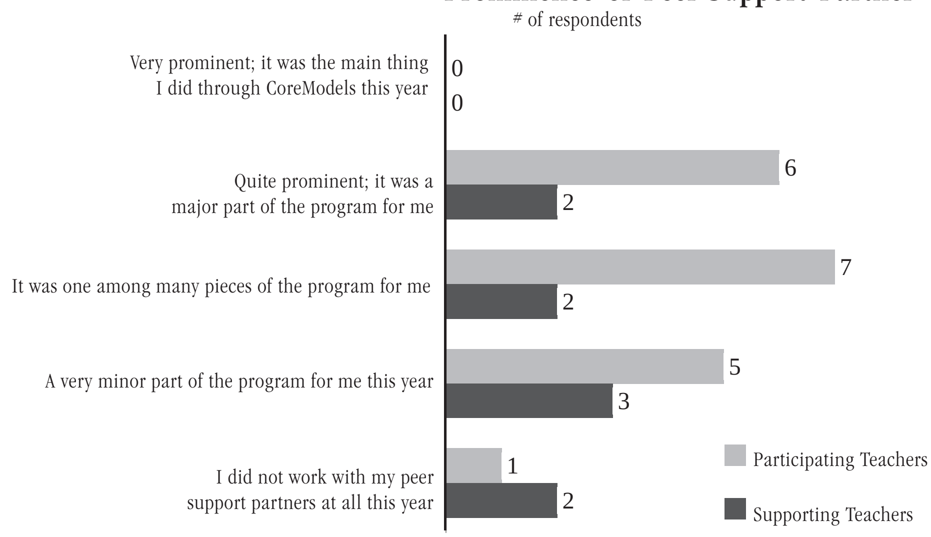


Table 5
Goals for Future Support from Colleagues
Rated 1 (not interested) to 4 (very interested)

	Participating Teachers	Supporting Teachers	Total
Working with someone on new STELLA models and curriculum	3.2	3.2	3.2
Working with someone on assessments for modelling activities	3.0	3.6	3.2
Getting answers to questions about using STELLA	3.3	2.9	3.1
Getting feedback on teaching practices	2.8	2.6	2.7
Having someone to talk with about progress in using CoreModels materials	2.8	2.7	2.7
Having someone be a sounding board about difficulties, ideas	2.7	2.7	2.7
Having someone help out in my classroom when he/she visits	2.8	2.3	2.7
Having someone model teaching with CoreModels materials in their classroom	2.1	2.6	2.2
Having someone model teaching with CoreModels materials in my classroom	2.4	1.9	2.2
Having someone explain CoreModels to others at my school	2.3	1.8	2.1

Figure 10
Goals for Future Peer Support

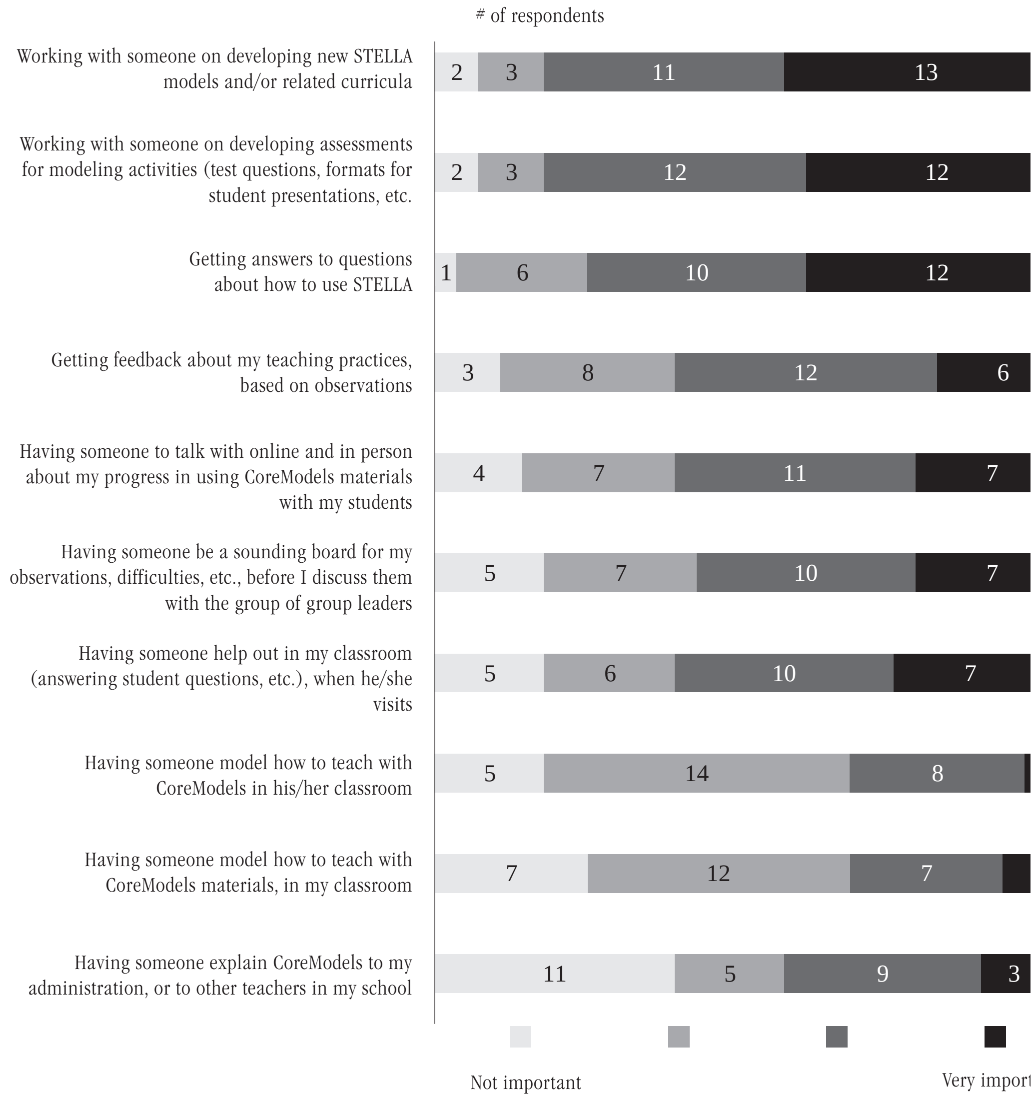


Figure 11
Help from Supporting Teachers (Participating Teachers only)

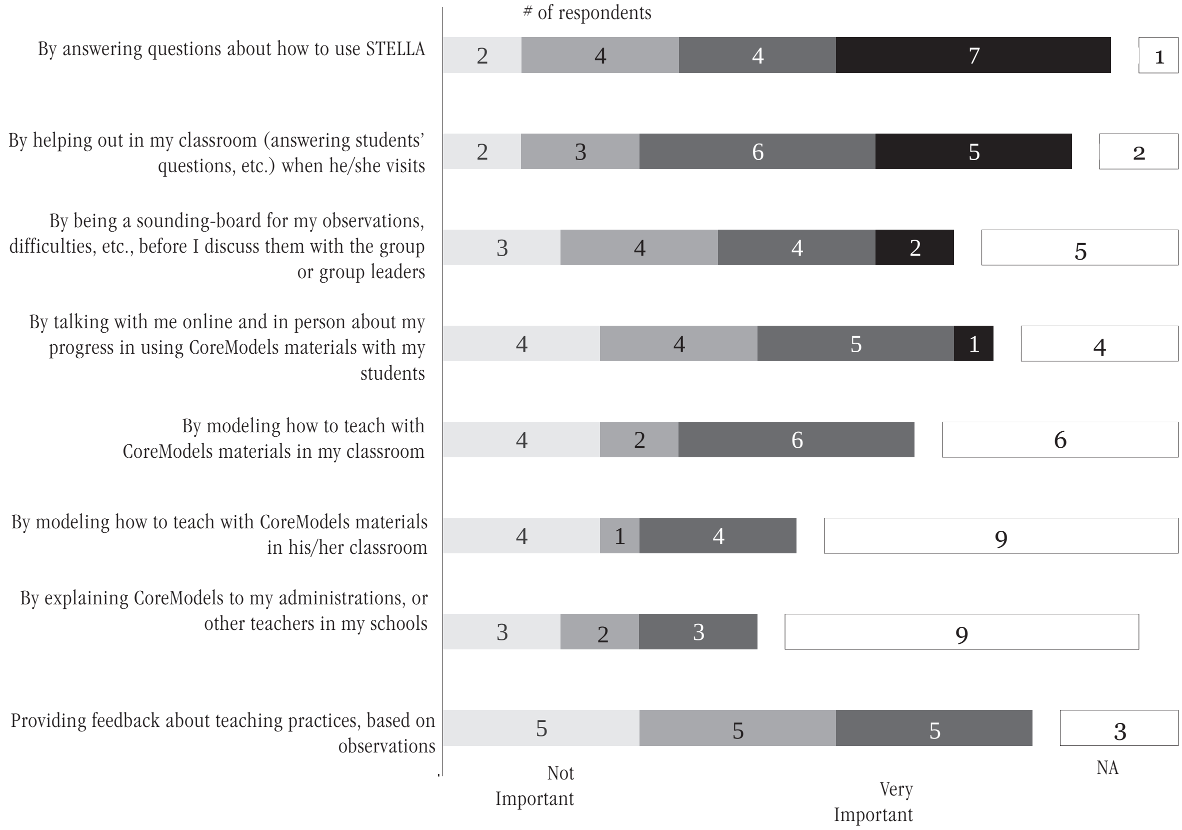


Table 6
Help from Supporting Teachers This Year
Rated 1 (not at all useful) to 4 (extremely useful)

	Participating Teachers	
	Fall 1998	Spring 1999
Getting answers to questions about using STELLA	3.0	2.9
Having someone help out in my classroom when he/she visits	3.2	2.9
Having someone be a sounding board about observations, difficulties, etc.	3.2	2.4
Having someone to talk with about progress in using CoreModels materials	3.0	2.2
Having someone model teaching with CoreModels materials in my classroom	2.8	2.2
Having someone model teaching with CoreModels materials in their classroom	2.7	2.0
Having someone explain CoreModels to others at my school	2.3	2.0
Getting feedback on teaching practices	2.8	2.0

Comfort providing help to peer support partners this year (Supporting Teachers only). In both the spring and fall surveys, Supporting Teachers were asked to indicate, on a scale from 1 to 4, how comfortable they feel providing various kinds of help to their Participating Teacher partners. The spring survey had the additional choice of selecting "NA" for items that did not apply to the respondent's situation. There was very little variation in ratings between the fall and spring surveys: no variation exceeded 0.2. As in the fall, Supporting Teachers indicated in the spring that they felt comfortable providing each type of help listed (mean ratings ranged from 3.0 to 3.9, with five of the eight statements scoring 3.5 or higher). The three kinds of help that this group of teachers seems to feel most comfortable providing are: "helping out in my partners' classrooms (answering student questions, etc.) when I visit" (fall=4.0, n=7; spring=3.9, n=9, "NA"=1); "being a sounding board for my partners' observations, difficulties, etc." (fall=3.7, n=7; spring=3.9, n=9, "NA"=1); and "modeling how to teach with CoreModels materials in my own classroom" (fall=3.9, n=7; spring=3.8, n=9, "na"=1). Note that only one of these three items corresponds to the Participating Teachers' reports in the Spring survey of what kinds of assistance were most helpful to them this year (having the Supporting Teacher help out in the classroom during visits; see question above). See Figure 12 for a complete list of statements and individual replies and Table 7 for a fall and spring comparison of subgroup means.

Benefits of peer support this year. When asked in the fall how important four potential benefits of peer-support are to teachers in general, each option received a mean rating (on a scale from 1 to 4) above 3.5. Answers ranged from 3.6 to 3.9. The benefit considered most important at that time was "being exposed to new ideas about teaching by seeing and hearing other teachers' methods" (3.9).

Using a scale from 1 to 4 (with an "NA" option), teachers were asked in the spring to indicate how important each of four benefits of peer-support *had been* to them this year (N=28). The two benefits rated as being most important were "Being exposed to new ideas about teaching by seeing and hearing other teachers' methods" (3.3, 6 selected "NA"), and "Having an out-of-school colleague to turn to for help and ideas about using technology." (3.0, 4 answered "NA"). However, these ratings were noticeably lower than the ratings these options had received in the fall, when "Being exposed to new ideas..." was rated 3.9 and "Having an out-of-school colleague..." was rated 3.6. Additionally, "Having a colleague to talk with on a regular basis who understands the challenges being faced" and "Getting some 'constructive criticism' now and then" received mean ratings of 2.9 (4 answered "NA," fall rating=3.7) and 2.6 (8 answered "NA," fall rating=3.6), respectively.

When spring ratings are broken down into Participating and Supporting Teacher subgroups, the means for Supporting Teachers are greater than for Participating Teachers on three of the four statements. The largest disparities were for "Being exposed to new ideas about teaching by seeing and hearing other teachers' methods"

Figure 12
Comfort Providing Help to Peer-Support Partners (Supporting Teachers only)

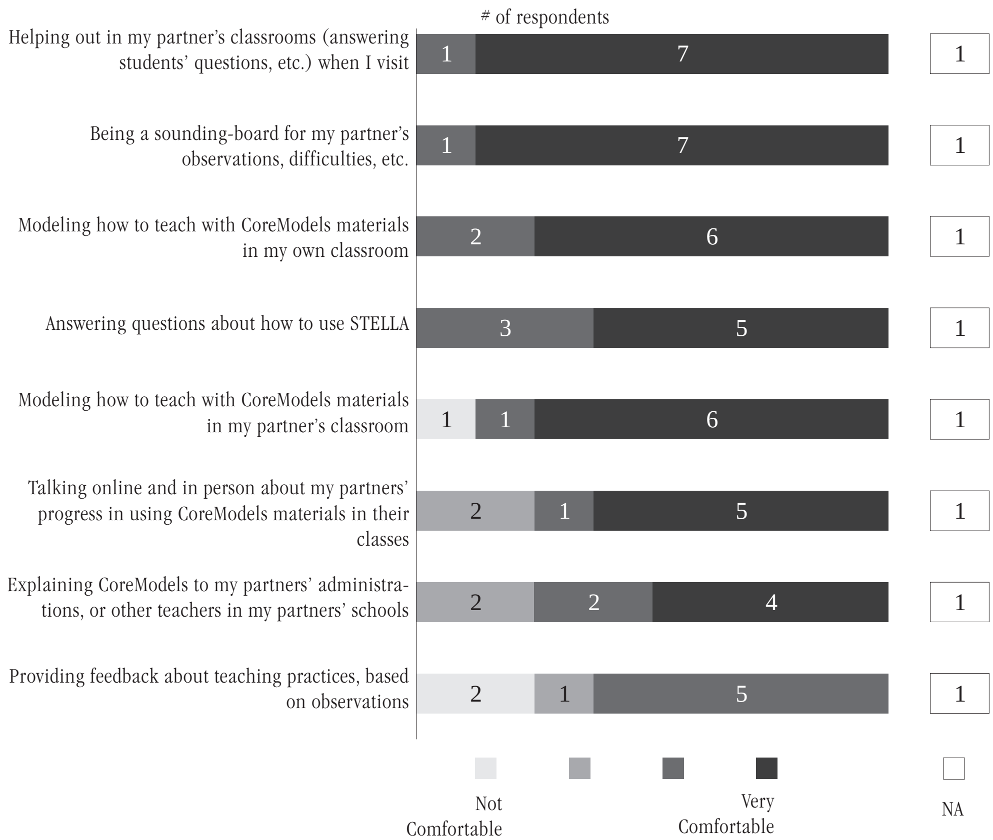


Table 7
Comfort in Providing Help to Peer Support Partners This Year

Rated 1 (not at all useful) to 4 (extremely useful)

	Participating Teachers		Supporting Teachers		Total	
	Fall 1998	Spring 1999	Fall 1998	Spring 1999	Fall 1998	Spring 1999
Being exposed to new ideas about teaching by observing other teachers' methods	3.9	3.1	3.9	3.7	3.9	3.3
Having an out-of-school colleague to help with technology	3.4	3.0	3.9	2.9	3.6	3.0
Having a colleague to talk with on a regular basis who understands the challenges	3.7	2.8	3.7	3.0	3.7	2.9
Getting some constructive criticism now and then	3.6	2.4	3.3	2.8	3.6	2.6

(Supporting Teachers=3.7; Participating Teachers=3.1) and "Getting some 'constructive criticism' now and then." (Supporting Teachers =2.8; Participating Teachers =2.4). These differences are larger than they were in the Fall survey, and in the case of "Getting some 'constructive criticism' now and then" the Participating Teachers were actually the more interested group in the Fall (Fall survey, Supporting Teachers =3.3; Participating Teachers =3.6). There was also a difference in the fall on the option "Having an out-of-school colleague to turn to for help and ideas about using technology." (Fall survey, Supporting Teachers =3.9; Participating Teachers=3.4). See Figure 13 for individual ratings. See Table 8 for a spring and fall comparison of subgroup means.

Drawbacks of peer support this year. Teachers were asked to indicate, using a scale from 1 to 4 (with an "NA" option), what the drawbacks of peer support had been for them this year. None of the four drawbacks listed in the spring survey were of great concern to these teachers (n=28), as mean ratings ranged from 1.0 (not concerned, in two cases) to only 1.3, with 5 "NA" ratings for each statement. When total ratings were disaggregated, differences between Supporting and Participating Teachers were small. The largest disparity between the subgroups was for the statement "I felt that my peer support partners' values or teaching style were imposed on me" (Supporting Teachers=1.0, n=7, "NA"=2; Participating Teachers=1.3, n=19, "NA"=3) but both of these ratings were still very low. See Figure 14 for individual ratings.

When teachers were asked in the fall to rate the degree to which they were concerned that these four were *would be* drawbacks, mean ratings were also consistently low (1.9-2.0), but higher than these extremely low spring ratings (Fall survey, n=35, 7 Supporting Teachers and 28 Participating Teachers). When these totals are disaggregated, however, the disparity between Supporting and Participating Teachers was greater than in the spring. Specifically, the largest differences between the groups in the fall were in their "Concern that teachers' performance might be judged unfairly by others." (total mean rating 1.9, Supporting Teachers=1.6; Participating Teachers=2.0) and their "Concern that teachers could feel attacked or under excessive scrutiny." (total mean rating 2.0, Supporting Teachers=2.3; Participating Teachers=2.0). These changes suggest that teachers had some concern in the fall about the risks associated with peer collaboration and that these concerns faded over the course of the year. See Table 9 for a comparison between the fall and spring for subgroup means.

Descriptions of peer support partners. Asked to indicate how well five titles described their peer support partner in relation to them, using a scale of 1 to 4 (with an "NA" option), "collaborator" was received the highest mean rating within each participant group (total=3.3; Supporting Teachers=3.4, n=9, "NA"=2; Participating Teachers=3.2, n=18, "NA"=3). "Advisor" was given a high mean rating by Participating Teachers (3.2, n=18, "NA"=3), but not by Supporting Teachers (1.7, n=9, "NA"=2), yielding a total mean rating of 2.7.

Figure 13
Benefits of Peer Support

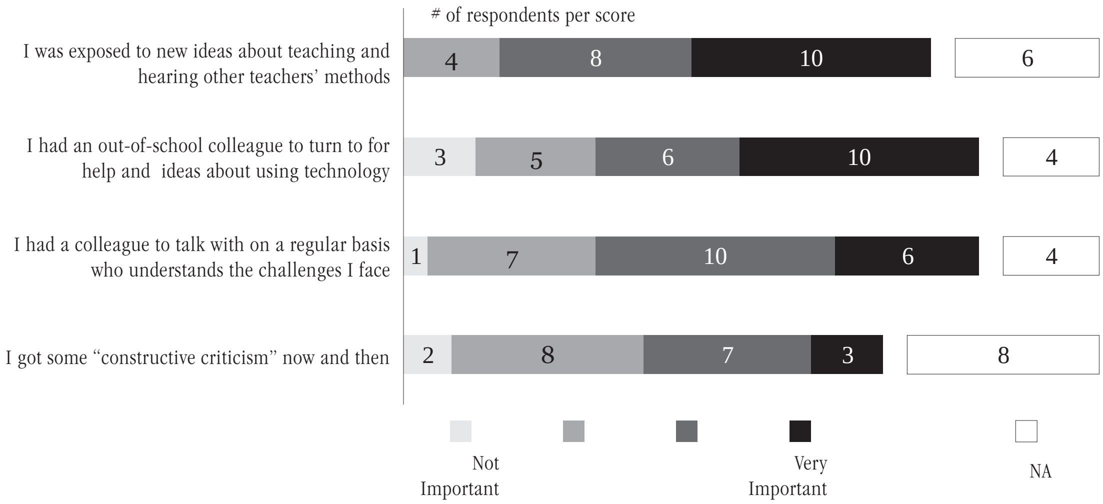


Table 8
Benefits of Peer Support This Year
Rated 1 (not at all useful) to 4 (extremely useful)

	Supporting Teachers	
	Fall 1998	**Spring 1999**
Helping out in my partner' s classroom when I visits	4.0	3.9
Being a sounding board about observations, difficulties, etc.	3.7	3.9
Modeling teaching with CoreModels materials in my partner' s classroom	3.3	3.5
Answering questions about using STELLA	3.6	3.6
Modeling teaching with CoreModels materials in my classroom	3.9	3.8
Talking about progress in using CoreModels materials	3.3	3.4
Explain CoreModels to others at my partner' s school	3.3	3.3
Giving feedback on teaching practices	2.9	3.0

Figure 14
Drawbacks of Peer Support

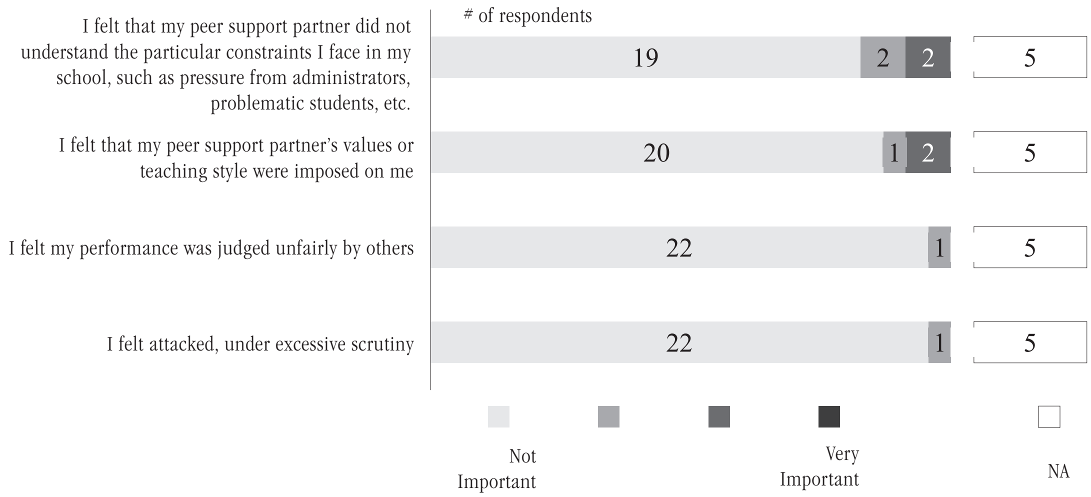


Table 9
Drawbacks of Peer Support This Year
Rated 1 (not at all useful) to 4 (extremely useful)

	Participating Teachers		Supporting Teachers		Total	
	Fall 1998	Spring 1999	Fall 1998	Spring 1999	Fall 1998	Spring 1999
Felt my partner did not understand the particular constraints of my school	2.2	1.3	2.4	1.1	2.2	1.3
Partner' s values or teaching style were imposed on me	1.9	1.3	2.1	1.0	1.9	1.2
My performance was judged unfairly	2.0	1.1	1.6	1.0	1.9	1.0
Felt attacked, or under excessive scrutiny	2.0	1.1	2.3	1.0	2.0	1.0

Figure 15a
Descriptions of Peer Support Partners by *Participating* Teachers

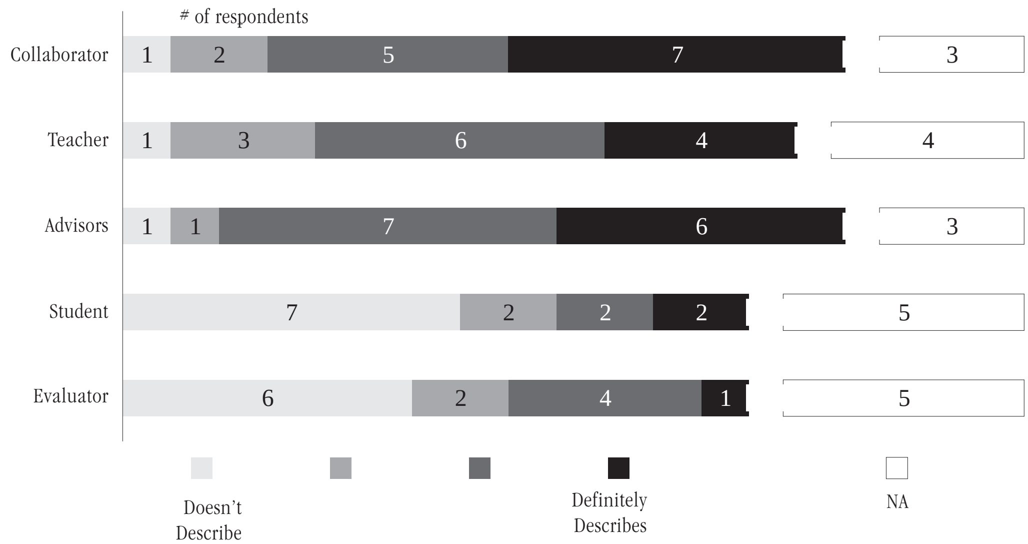
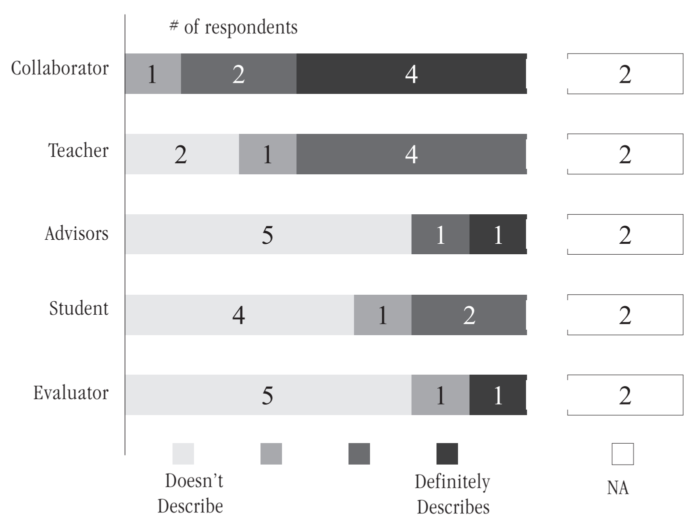


Figure 15b
Descriptions of Peer Support Partners by *Supporting* Teachers



The term "Teacher" received mean ratings of 2.3 (n=9, "NA"=2) and 2. 9 (n=18, "NA"=4) from Supporting and Participating Teachers respectively, with 6 respondents selecting "NA." See Figures 15a and 15b for individual subgroup ratings.

Obstacles to effective peer support. Teachers indicated that, of five obstacles to effective peer support in CoreModels listed in the spring survey, "finding the time for peer support pairs to meet" (total mean rating=3.5, n=27) was the most significant this year. This obstacle received the highest mean rating for both Supporting (3.7, n=9) and Participating (3.4, n=18) Teacher subgroups. The second most significant obstacle to peer support this year was "the difficulty of making contact reliably (missed phone messages, email not working, etc.)" (total mean rating=2.4; Supporting Teachers=2.3, n=9; Participating Teachers =2.5, n=18). Ratings were based on a scale from 1 to 4.

Teachers' experience this year closely matched their expectations, as indicated through a similar question on fall survey (n=35, 7 Supporting Teachers and 28 Participating Teachers). At that time, teachers replied that they *expected* finding time to meet in pairs to be the largest obstacle (total=3.6; Supporting Teachers=3.7; Participating Teachers=3.6), and the difficulty of making contact reliably to be the second biggest obstacle (total=2.7; Supporting Teachers=2.4; Participating Teachers=2.8).

Teachers also indicated in the fall that they *expected* "getting the technology to work on the days that a peer support partner is visiting" (2.6), and "getting permission from the administration to leave the building to visit other schools" (2.5) to be potential obstacles over the year. Based on spring survey replies, these expectations were not met. In the spring, when asked what had actually been experienced, "getting the technology to work..." was given a mean rating of only 1.9 (Supporting Teachers=1.4, n=9; Participating Teachers=2.1, n=18). The difference between the subgroups is likely to be due to the greater likelihood that Supporting Teachers were visiting others more frequently than they were being visited, and therefore were less likely than Participating Teachers to need to coordinate technology access during a visit by a colleague. "Getting permission from the administration to leave the building to visit other schools" was also rated as less of an obstacle than had been anticipated in the fall survey (total mean rating=1.8; Supporting Teachers=1.4, n=9; Participating Teachers=1.9, n=18). See Figure 16 for individual ratings, and Table 10 for a comparison of fall and spring subgroup means.

Number of visits to the classroom of peer support partners. Supporting Teachers (n=9) visited the classrooms of their Participating Teacher partners an average of 1.2 times this year; 3 was the most number of visits an Supporting Teacher reported making. *Participating Teachers* (n=17) visited the classrooms of their

Figure 16
Obstacles to Effective Peer Support

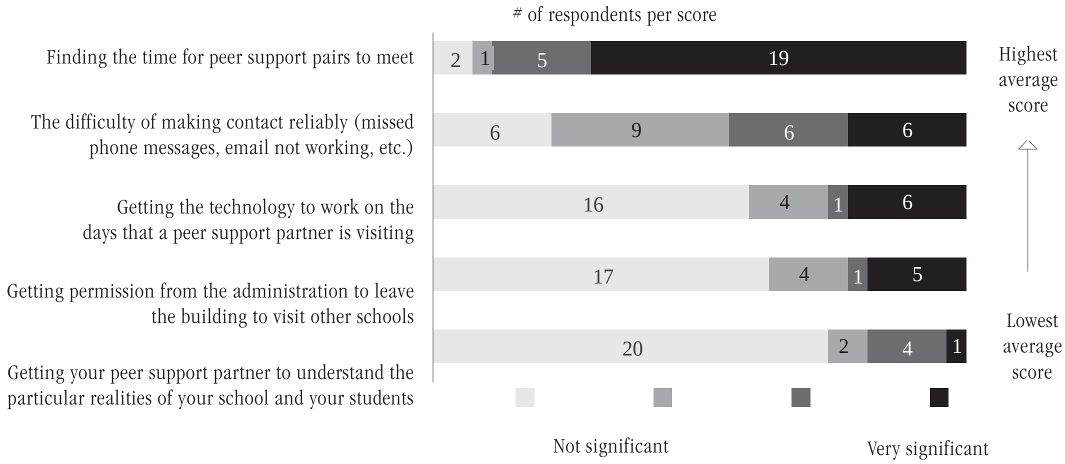


Table 10
Obstacles to Effective Peer Support

Rated 1 (not at all useful) to 4 (extremely useful)

	Participating Teachers		Supporting Teachers		Total	
	Fall 1998	Spring 1999	Fall 1998	Spring 1999	Fall 1998	Spring 1999
Finding time to meet	3.6	3.4	3.7	3.7	3.6	3.5
Difficulty of making contact	2.8	2.5	2.4	2.3	2.7	2.4
Getting technology to work during visits	2.6	2.1	2.6	1.4	2.6	1.9
Getting permission to leave my building	2.5	1.9	2.4	1.4	2.5	1.8
Getting partner to understand the particular realities of my school	1.8	1.7	1.4	1.1	1.7	1.5

Supporting Teacher partners an average of 0.4 times; 2 was the most number of visits any Participating Teacher reported making. See Figure 17 and Table 11 for complete details.

Number of times visited by a peer support partner. *Supporting Teachers* (n=9) reported being visited by their Participating Teacher partners 0.4 times on average. The maximum number of times any Supporting Teacher reported being visited by a Participating Teacher was 2. The maximum number of times any *Participating Teacher* (n=17) reported being visited by a Supporting Teacher was 3. One Participating Teacher also reported that her Center Director, who was also a teacher at her school, visited her classroom 9 times. This reply was not included in determining the average number of visits, which was 1.2. See Figure 18 and Table 12 for complete details.

Number of times peer support partners met to work on or discuss CoreModels outside of the classroom. *Supporting Teachers* (n=8) reported that they met with their peer support partners outside of the classroom an average of 1.6 times over the year; the maximum number of meetings reported by any Supporting Teacher was 4. The average number of outside meetings reported amongst *Participating Teachers* (n=15) was 1.9, and the maximum number of visits reported by any *Participating Teacher* was 6. 9 Supporting Teachers and 18 Participating Teachers replied to this question. See Figure 19 and Table 13 for complete details.

Frequency of email contact between peer support partners. When asked whether they email their peer support partners "never," "once a month or less," "every month, but not every week," "at least once a week" or "several times a week or more," 19 teachers replied that they email their partner once a month or less (Supporting Teachers=8; Participating Teachers=11). Only 2 teachers indicated that they email their peer partners "at least once a week." 9 Supporting Teachers and 18 Participating Teachers replied to this question. See Figure 20 for full details.

Frequency of phone contact between peer support partners. When asked whether they talk on the telephone with their peer-support partners "never," "once a month or less," "every month, but not every week," "at least once a week" or "several times a week or more," 14 teachers answered "never" (Supporting Teachers=5; Participating Teachers=9) and 12 teachers answered "once a month or less" (Supporting Teachers=4; Participating Teachers=8). 9 Supporting Teachers and 18 Participating Teachers replied to this question. See Figure 21 for full details.

Figure 17
Number of Visits to the Classroom of Peer Support Partners During the 1998-99 School Year

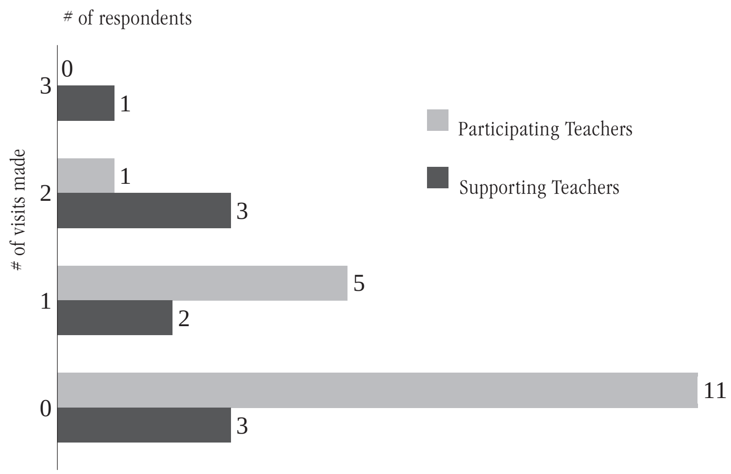


Table 11
Average Number of *Visits to* the Classroom of Peer Support Partners

Participating Teachers	Supporting Teachers
0.4 maximum=2	1.2 maximum=3

Figure 18
Number of Times Visited by a Peer-Support Partner During the 1998-99 School Year

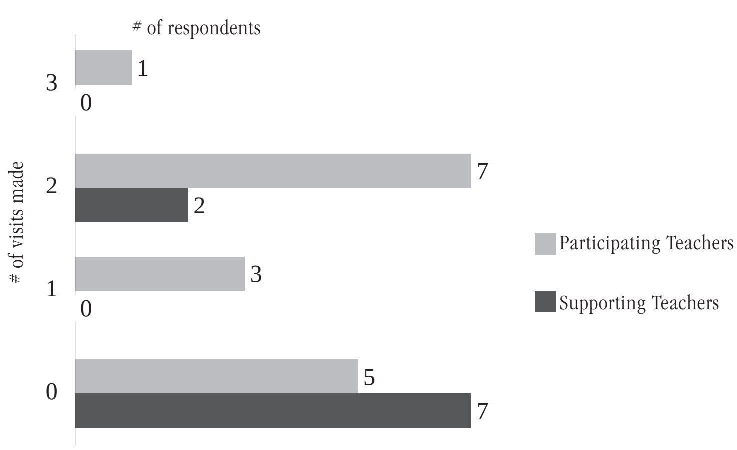


Table 12
Number of Times *Visited by* a Peer Support Partner

Participating Teachers	Supporting Teachers
1.2 maximum=3	0.4 maximum=2

Figure 19
Number of Times Peer-Support Partners Met Outside the Classroom

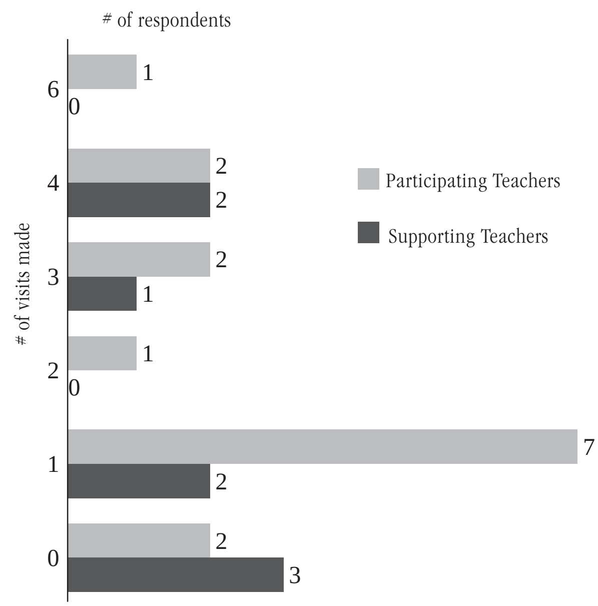


Table 13
Number of Times Met Outside Classroom with Peer Support Partner

Participating Teachers	Supporting Teachers
1.9 maximum=6	1.6 maximum=4

Figure 20
Frequency of Email Contact between Peer-Support Partners

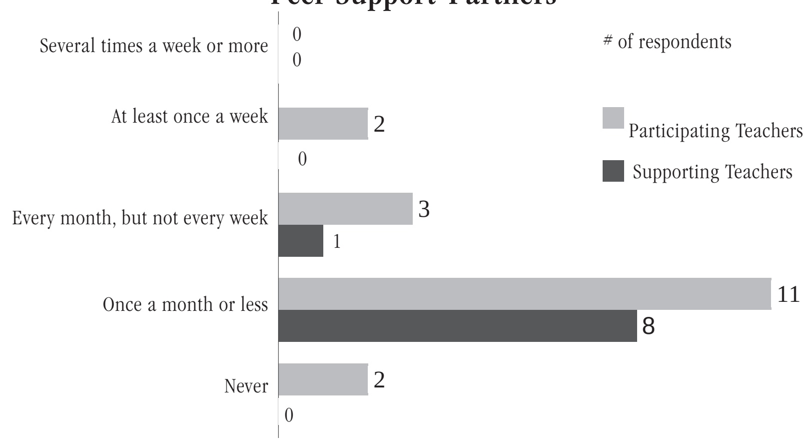
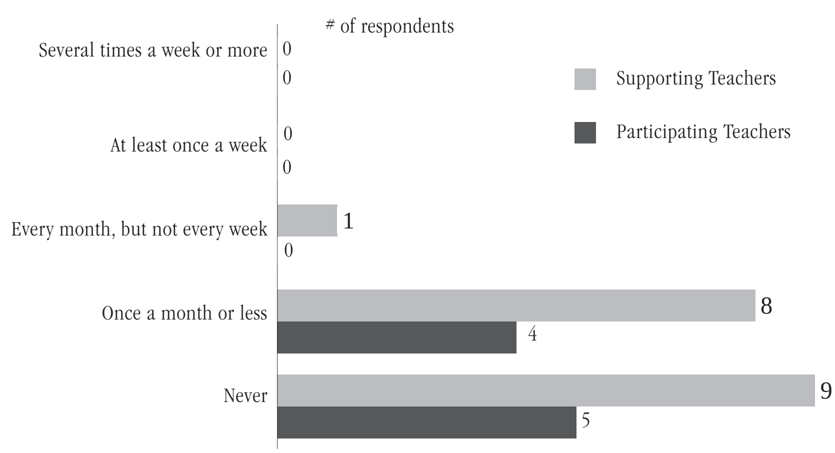


Figure 21
Frequency of Telephone Contact between Peer-Support Partners



Classroom Practices

This section contained three questions about teachers' goals for their students and their teaching. All three questions had been included in the fall survey. Questions in this section used one of two answer formats: rating scales and "check all that apply." The format used will be described for individual questions.

Classroom goals. The spring survey listed fourteen statements that described possible classroom goals for these teachers. Respondents were asked to rate the degree to which each of these goals is a priority to them, using a scale from 1 (not a priority) to 6 (a top priority).

Five of the fourteen statements were rated, on average, as high priorities by this group of teachers. The two highest rated goals were the same in both the fall and spring surveys. These were "Developing students' ability to understand and make use of scientific methods of inquiry," (fall=5.6, n =35; spring=5.6, n=29) and "Encouraging students to take responsibility for their own learning," (fall=5.6, n=35; spring=5.6, n=29).

Three other goals were rated as high priorities in both the spring and fall. These were "Developing students' skills with the equipment and techniques of the laboratory" (5.3 in spring, n=29, and 5.3 fall, n=35); "Modeling inquiry, curiosity, openness, and skepticism in my own scientific inquiry" (fall=5.3, n=29; spring=5.2, n=35); and "Identifying students' strengths, and encouraging participation by all students" (fall=5.1; n=35, spring=5.0, n=29).

Looking at responses for each subgroup, Supporting and Participating Teachers rated "Identifying students' strengths, and encouraging participation by all students" differently in both surveys. Specifically, in the fall Supporting Teachers' (n=7) mean rating for this item was 4.9, while Participating Teachers' (n=28) was 5.2. In the spring the mean rating for Supporting Teachers (n=9) increased to 5.4, while the mean rating for Participating Teachers (n=20) decreased to 4.8.

A shift in mean ratings occurred between the fall and spring surveys for two other goals in the list. In both the fall and spring "Ensuring that students master a uniform body of core content" received a total mean rating of 4.8. However, Supporting Teachers (n=7), on average, rated this goal at 4.0 in the fall, when Participating Teachers (n=28) rated it at 5.0. In the spring, however, Supporting Teachers (n=9) gave it a mean rating of 4.6 while Participating Teachers (n=20) remained fairly consistent with a mean rating of 4.9. "Preparing students for future professional training" received a total mean rating of 4.8 (n=35) in the fall and of 4.1 (n=29) in the spring. This shift was due to a substantial drop in ratings from Participating Teachers (from 5.0, n=28 to 4.2, n=20) and a small increase among Supporting Teachers (from 3.7, n=7 to 4.0, n=9). See Figure 22 for full statements and individual ratings, and Table 14 for comparisons of fall and spring subgroup averages.

Importance of various components of student learning. Teachers rated the degree to which six different components were considered important in their assessments of their students' learning. A scale from 1 to 6 was used, with 1 representing "not important" and 6 representing "very important." In both the spring (n=29) and fall (n=35) surveys, three components of student learning fell on average between the ratings of 5 and 6: "problem-solving ability" (spring=5.6; fall=5.7); "knowledge/mastery of content" (spring=5.1; fall=5.2); and "knowledge of/fluency with the scientific method" (spring=5.0; fall=5.2). In only one of these cases, "problem-solving ability," was there a noticeable shift in a teacher subgroup average between the fall (Supporting Teachers=5.7, n=7; Participating Teachers=5.8, n=28) and spring (Supporting Teachers=5.8, n=9; Participating Teachers=5.5, n=20) surveys.

Two other noticeable teacher subgroup shifts occurred. "Precision/accuracy in research results" received similar total mean ratings in the spring (4.6) and in the fall (4.7), though the Supporting Teacher averages increased from the fall (4.4, n=7) to the spring (4.8, n=9). Similarly, "ratings on standardized tests" received a total mean rating of 3.7 in both the fall and spring, but the mean rating by Supporting Teachers increased from fall (2.7, n=6) to spring (3.8, n=9) and the Participating Teacher mean rating dropped slightly from fall (3.9, n=27) to spring (3.7, n=20). See Figure 23 for full statements and individual ratings, and Table 15 for comparisons of fall and spring subgroup means.

Personal teaching goals. Teachers were asked to choose, from a list of twenty-one statements describing changes in teaching practice, the four they consider the most important goals for them personally. The three most frequently selected statements were: "I want to become better at diagnosing problems students are having in conceptual understanding. I want them to be able to explain their own thinking to me." (Supporting Teachers=6; Participating Teachers=11); "I want my students to review and revise their work more often." (Supporting Teachers=5; Participating Teachers=5); and "I would like to have fewer technical difficulties impede my use of technology in the classroom." (Supporting Teachers=3; Participating Teachers=6). "I want to become better at diagnosing problems students' are having in conceptual understanding. I want them to be able to explain their own thinking to me." was chosen by the largest number of teachers in the fall as well (Supporting Teachers=3; Participating Teachers=17).

In terms of differences between fall and spring answers, "I would like to teach more units and lessons that are interdisciplinary and that build on topics from other courses of subjects." was selected by 15 teachers in the fall (Supporting Teachers=3; Participating Teachers=12), but by only 8 in the spring (Supporting Teachers=2; Participating Teachers=6). "I want to spend more time working with other teachers on curriculum and instructional planning." was chosen by 13 teachers in the fall

(Supporting Teachers=4; Participating Teachers=9) and only 5 in the spring (Supporting Teachers=1; Participating Teachers=4). "I would like to have fewer technical difficulties impede my use of technology in the classroom." decreased from 14 teachers in the fall (Supporting Teachers=2; Participating Teachers=12) to 9 in the spring (Supporting Teachers=3; Participating Teachers=6). See Figure 24 for full statements and individual ratings, and Table 16 for comparisons of fall and spring subgroup means.

Figure 22
Classroom Goals

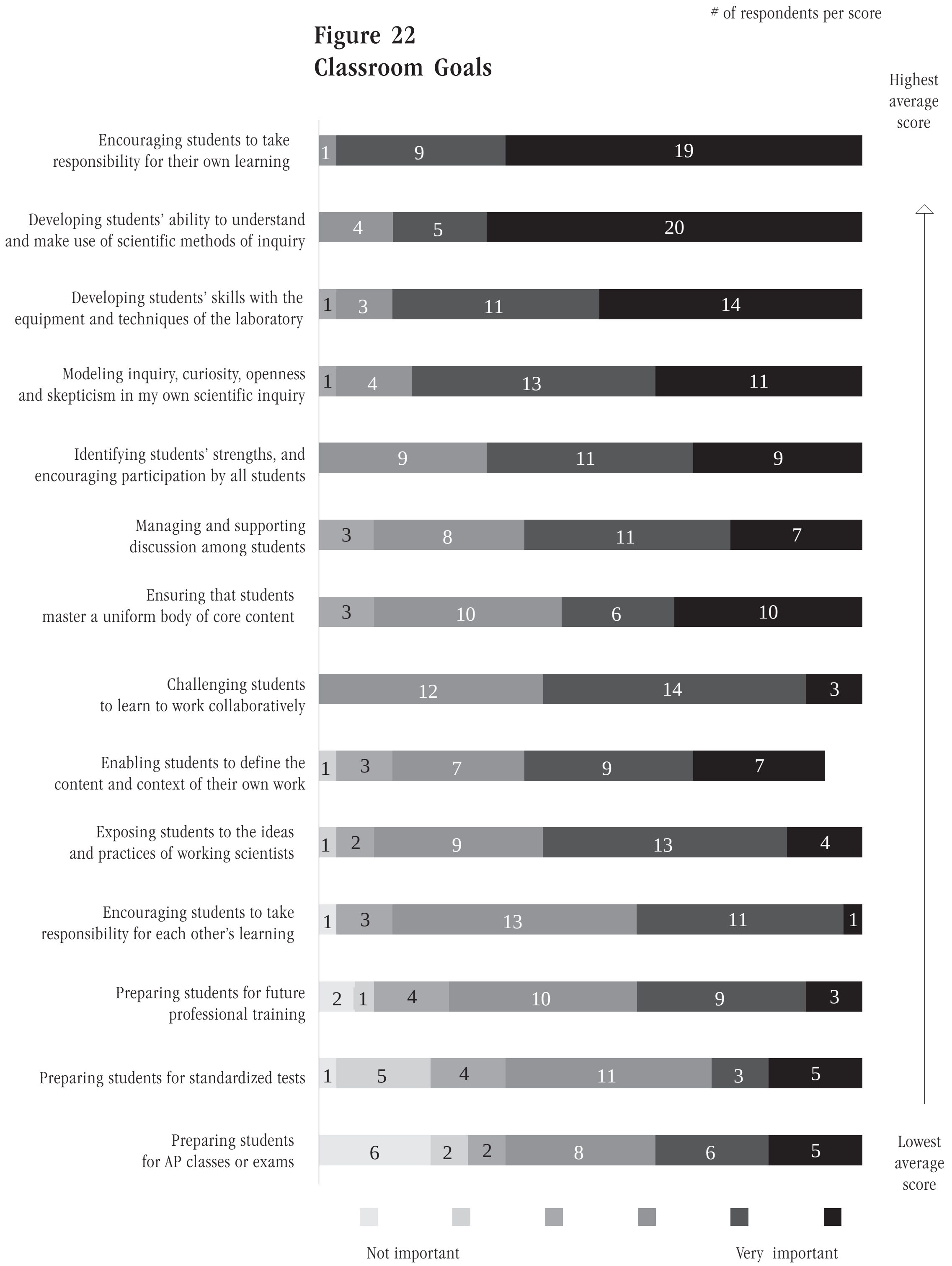


Table 14
Classroom Goals

	Participating Teachers		Supporting Teachers		Total	
	Fall 1998	Spring 1999	Fall 1998	Spring 1999	Fall 1998	Spring 1999
Encouraging students to take responsibility for their own learning	5.6	5.6	5.7	5.8	5.6	5.6
Developing students' ability to use methods of scientific inquiry	5.6	5.4	5.9	5.9	5.6	5.6
Developing students' laboratory skills	5.3	5.2	5.4	5.6	5.3	5.3
Modeling inquiry, curiosity in my own scientific work	5.3	5.1	5.1	5.3	5.3	5.2
Encouraging participation by all students	5.2	4.8	4.9	5.4	5.1	5.0
Supporting discussion among students	4.7	4.7	5.0	5.0	4.7	4.8
Ensuring students master a uniform body of content	5.0	4.9	4.0	4.6	4.8	4.8
Challenging students learning to work collaboratively	4.8	4.7	5.0	4.8	4.8	4.7
Enabling students to define the content and context of their work	4.6	4.6	4.7	4.9	4.6	4.7
Exposing students to the ideas and practices of working scientists	4.8	4.7	4.1	4.3	4.7	4.6
Encouraging students to take responsibility for each other' s learning	4.2	4.2	4.3	4.4	4.2	4.2
Preparing students for future professional training	5.0	4.2	3.7	4.0	4.8	4.1
Preparing students for standardized tests	4.1	4.1	3.1	3.3	3.9	3.9
Preparing students for AP classes or exams	3.8	3.6	3.8	4.0	3.8	3.7

Figure 23
Importance of Various Components of Student Learning

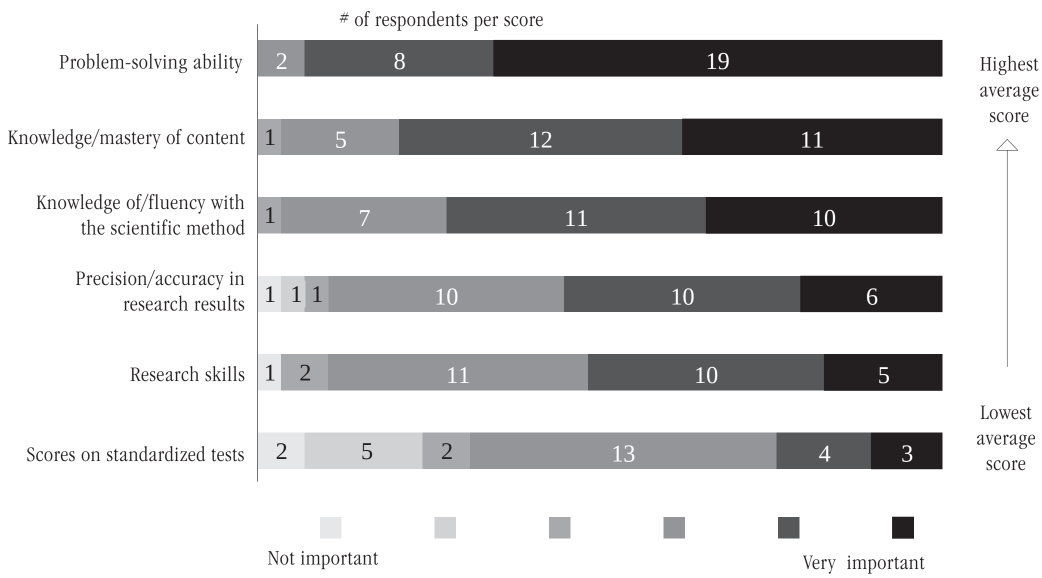


Table 15
Importance of Components of Student Learning

	Participating Teachers		Supporting Teachers		Total	
	Fall 1998	**Spring 1999**	**Fall 1998**	**Spring 1999**	**Fall 1998**	**Spring 1999**
Problem-solving ability	5.8	5.5	5.7	5.8	5.7	5.6
Knowledge/mastery of content	5.3	5.3	4.9	4.9	5.2	5.1
Knowledge of scientific method	5.2	5.0	5.1	5.2	5.2	5.0
Precision/accuracy in research results	4.5	4.5	4.4	4.8	4.5	4.6
Research skills	4.7	4.5	4.6	4.6	4.7	4.5
Scores on standardized tests	3.9	3.7	2.7	3.8	3.7	3.7

Figure 24
Personal Teaching Goals

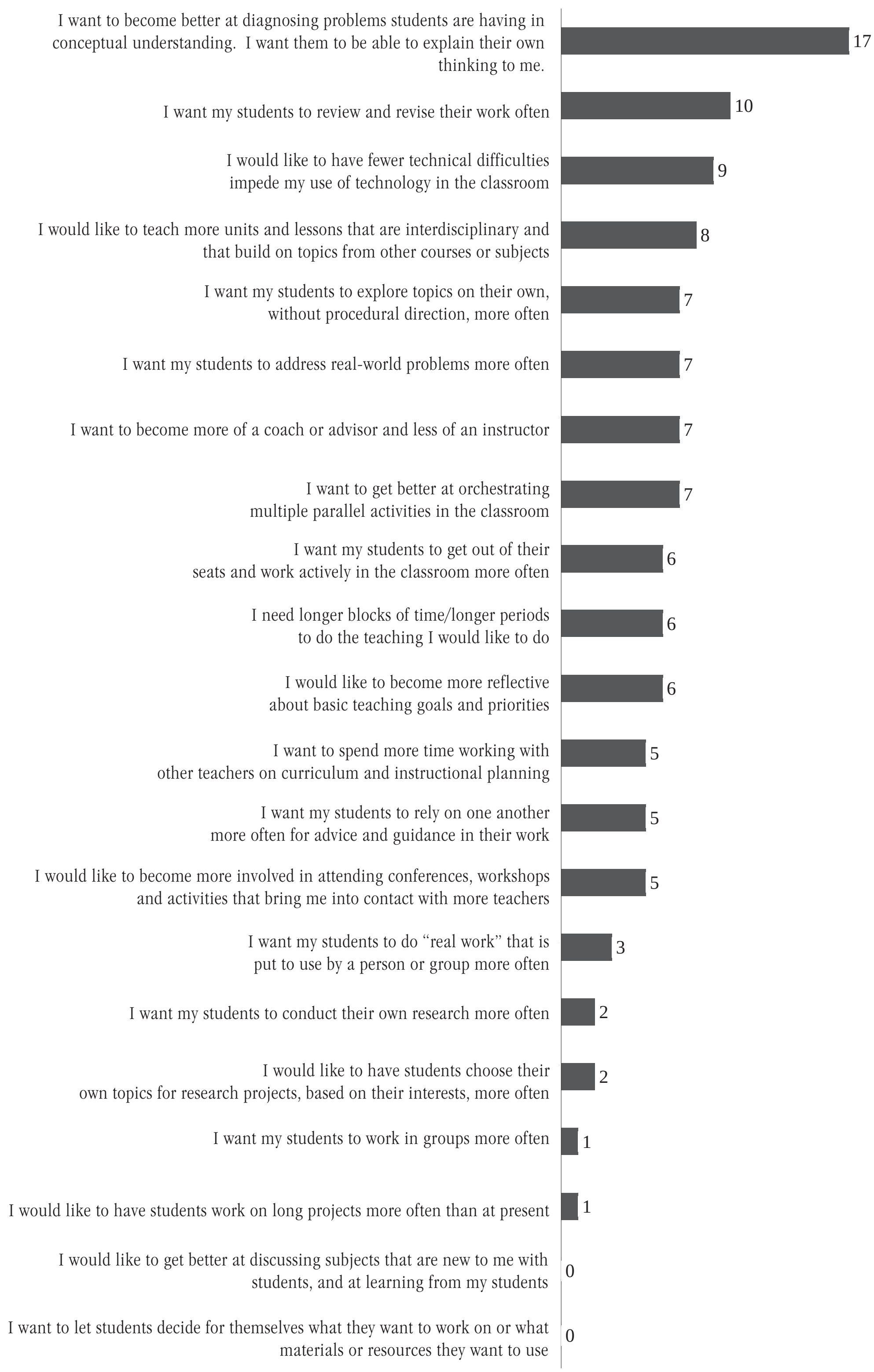


Table 16
Number of teachers who selected each statement as one of the top four changes they would like to see in their own teaching

	Participating Teachers		Supporting Teachers		Total	
	Fall 1998	Spring 1999	Fall 1998	Spring 1999	Fall 1998	Spring 1999
I want to become better at diagnosing problems students are having in conceptual understanding. I want them to be able to explain their own thinking to me.	17	11	3	6	20	17
I want my students to review and revise their work more often.	7	5	2	5	9	10
I would like to have fewer technical difficulties impede my use of technology in the classroom.	12	6	2	3	14	9
I would like to teach more units and lessons that are interdisciplinary and that build on topics from other courses or subjects.	12	6	3	2	15	8
I want my students to explore topics on their own, without procedural direction, more often.	7	3	3	4	10	7
I want my students to address real-world problems more often.	5	5	2	2	7	7
I want to become more of a coach or advisor and less of an instructor.	5	5	3	2	8	7
I want to get better at orchestrating multiple, parallel activities in the classroom.	7	5	1	2	8	7
I want my students get out of their seats and work actively in the classroom more often.	8	5	1	1	9	6
I need longer blocks of time/longer periods to do the teaching I would like to do.	5	4	2	2	7	6
I would like to become more reflective about basic teaching goals and priorities.	2	5	0	1	2	6
I want to spend more time working with other teachers on curriculum and instructional planning.	9	4	4	1	13	5
I want my students to rely on one another more often for advice and guidance in their work.	1	3	0	2	1	5
I would like to become more involved in attending conferences, workshops and activities that bring me into contact with more teachers.	2	5	1	0	3	5

Table 16 (continued)
Number of teachers who selected each statement as one of the top four changes they would like to see in their own teaching.

	Participating Teachers		Supporting Teachers		Total	
	Fall 1998	Spring 1999	Fall 1998	Spring 1999	Fall 1998	Spring 1999
I want my students to do "real work" that is put to use by a person or group more often.	1	2	0	1	1	3
I want my students to conduct their own research more often.	4	1	2	1	6	2
I would like to have students choose their own topics for research projects, based on their interests, more often.	1	2	1	0	2	2
I want my students to work in groups more often.	0	0	0	1	0	1
I would like to have students work on long projects more often than at present.	4	1	1	0	5	1
I would like to get better at discussing subjects that are new to me with students, and at learning from my students.	1	0	0	0	1	0
I want to let students decide for themselves what they want to work on or what materials or resources they want to use.	0	0	0	0	0	0

Discussion

In this section we summarize notable findings from teachers' responses across the fall and spring surveys as well as differences between the Participating and Supporting Teacher subgroups. Specifically, we focus on: how closely teachers' goals and expectations of the CoreModels program were met; teachers' experiences with peer-support; teachers' current thinking about peer-support; and changes in participants' professional and classroom goals.

- **Overall, teachers are positive about the benefits of the CoreModels project, and feel that their goals for their own professional development have been largely achieved.** Fall responses to questions about aspects of the program that teachers expected to be useful for own professional growth suggested that teachers were particularly focused on acquiring technology-related skills and content-related materials and activities through their involvement with CoreModels. Replies to spring survey questions suggest that these goals were largely met. Additionally, teachers feel that they have been successful in meeting their professional goals around skills and activities that they did not consider to be particularly high priorities in the fall
- **Teachers do not feel that they have fully met their goals for their involvement in CoreModels related to classroom practices.** Though teachers have been successful in acquiring technology-related skills, they do not feel familiar with using technology as an integral part of their curriculum to the degree that they would have liked. Additionally, these teachers do not feel that their students are engaging with more complex systems thinking, or grasping the complexity of "real-world problems," as much as they hoped for.
- **There are differences between the degree to which Participating and Supporting Teacher groups have found particular aspects of the program useful, and feel that they have met their goals for project involvement.** There are four main areas in which Supporting Teachers have found features of the program more useful, or have been more successful at meeting their goals for participation, than have Participating Teachers. Specifically, Supporting Teachers have closely matched their goals for becoming knowledgeable about technology, for having activities they can use to meet the Maryland Core Learning Goals, and for engaging their students in more complex systems thinking, and have found their relationships with CoreModels staff particularly useful. In addition, when asked about the types of

future support participants would be interested in receiving from their peer-partners *in the future*,Supporting Teachers felt strongly that they would like to work with someone on developing assessments for modeling activities. These differences most likely reflect the fact that Supporting Teachers have worked more closely with the program leadership, have been active participants in the development of activities and have had more experience implementing project materials. These differences, as well as conversations with the project leadership, suggest that Supporting Teachers are further along in a process of changing their beliefs and practices, and that Participating Teachers are at an earlier point in the same process of change.

- **Though teachers feel that peer-support is an important piece of the CoreModels project, for most it did not play a prominent role in their experience of the program overall and active participation in peer-support activities were generally minimal.** Additionally, replies to a survey question about future support suggest that participants do not have high expectations for the coming year *with regards to the kinds of support listed in the survey*. At the time of the fall survey, teachers were unclear about what value peer-support would have for them, or what roles it would play in their overall goals for the program; Participating Teachers did not view their peer-support partners as possible resources for learning technical skills, acquiring content-focused activities or learning to use modeling in their teaching (all goals for participation at the time). Given these expectations, it is not surprising that visits to partners' classrooms, meetings outside of school and communication online or by phone was on average infrequent, and therefore the importance of support received was reported to be low.

Interviews and Observations with a Subgroup of Program Participants

Methods

The Year 2 evaluation design involved collecting regular information from a subset of the project participants through interviews (both by telephone and online) and classroom visits. The goal of this component of the evaluation was to provide a body of detailed evidence about what teachers participating in the project were actually doing in their classrooms with CoreModels resources, and with one another through their peer-support relationships. The specific information that the group was asked to provide included regular progress reports on overall project participation and use of project materials; reports on classroom visits and outside meetings between paired Supporting Teachers and Participating Teachers; and collection of student work from specific CoreModels units. Based on recommendations made by the project's Center Directors, a group of ten Supporting and Participating Teachers was invited to join this subgroup, and eventually a total of eight from the group were able to participate. A meeting of the evaluation subgroup was held at the October CoreModels meeting, and responsibilities were reviewed with the group.

As the school year progressed, and the evaluation's focus on student learning evolved, the evaluation plan shifted away from the original expectation that teachers in the subgroup would score their students' work from the common CoreModels units with rubrics (see the Student Learning findings, PAGE# below, for further discussion of this issue). Instead, two roundtables were convened late in the school year (one for physics and one for biology), in collaboration with the project leadership. These roundtables had two goals. The first was to give this subgroup of teachers an opportunity to begin to elaborate a common understanding of their goals for student learning in the context of modeling activities, and to begin to share ideas about how to assess whether they were meeting these goals. The second goal was for the evaluation team to collect anecdotal evidence about how teachers' understanding of these issues were manifested in their classrooms—in other words, stories about actual experiences teachers were having with their students that led them to reflect on or reconceptualize their understanding of student learning in the context of modeling and systems thinking.

Subgroup Participants

The final evaluation subgroup included six biology teachers and two physics teachers. This section presents a brief overview of these teachers' backgrounds and the existing experience they brought to the CoreModels program. It is important to stress that the evaluation did not seek to pass judgment on the relative success or failure of these participants in relation to the CoreModels program, but rather to use their experiences to help us judge how successfully the CoreModels program components supported teachers with diverse backgrounds, beliefs, and priorities.

In her fourth year of teaching, *Laura* is a relatively new teacher at Watkins Mills High School. She grew up around computers and says that she feels completely at ease with technology. According to Laura, who describes herself as an independent teacher, she is unintimidated by computers and feels comfortable troubleshooting technical problems on her own until a solution is discovered. Laura was already familiar with STELLA when she joined the CoreModels program. This year Laura taught three biology classes, one honors anatomy and physiology class and one environmental science class (see Table 1 for CoreModels units used with each class).

Laura's Supporting Teacher is *Arthur*. A biology teacher at Churchill High School, Arthur has been teaching for 29 years. As a Supporting Teacher, this was Arthur's second year with the CoreModels program. Arthur says that he still feels relatively new to STELLA and modeling, and is less comfortable with technology than Laura. Arthur is active in the state of Maryland around curriculum and standards development. This year he taught an AP biology class, a biology I honors class and an English, Science, and Social Studies Opportunities (ESSO) biology class.

Johanna is a Participating Teacher at Crossland High School. Johanna has been teaching for five years, and this past year she taught biology and biology for Talented and Gifted (TAG) students. Crossland High School is the most urban and resource-poor of any of the schools in the subgroup. More than any of the other teachers in this group, Johanna's integration of CoreModels materials into her teaching was hindered by such logistical hurdles as having limited paper for copying worksheets for students, a frequently malfunctioning photocopy machine and limited access to her school's computer lab. Johanna was pregnant at the beginning of the school year and played a progressively smaller role in the evaluation as the year progressed—communication with her did not proceed past March, and she was not able to attend the May roundtables. Johanna will not be teaching during the 1999-2000 school year.

Johanna's Supporting Teacher, *Albert*, is a biology teacher at Wild Lake High School. Albert has been teaching for 8 years, and currently teaches two biology II (human anatomy & physiology) classes, two biology I honors classes, biology AP and environmental science (see Table 1 for units covered with each class). A teacher who describes himself as having a very idiosyncratic, atypical way of teaching, and who rejects what he calls the "cookbook" method of curriculum implementation, Albert has been an active materials developer within the CoreModels project, frequently revising activities developed by other teachers within the program As Albert described it, "since I believe that effective lesson design and execution cannot be segregated from teacher persona, I am probably one of the most active *re*-writers in the project." Albert feels extremely comfortable with STELLA and with modeling (15% of all his class time is in or around STELLA, according to Albert), and has become a strong advocate of using STELLA models to make connections among phenomena, models, graphs and math functions. Albert has also presented this approach to the larger CoreModels group, and it is beginning to be incorporated into their training efforts.

Robert and *Marty* are a peer-support pair from the Western Region. Robert, a relatively new teacher, teaches technology prep anatomy and physiology, and college preparatory anatomy and physiology at Boonsboro High School. Although Robert is positive about the potentials of modeling with students, he is also quite concerned about the differences between his tech prep and his college prep students, particularly regarding what he sees as the lack of basic skills and positive learning experiences amongst the tech prep students.

Marty, currently in his sixth year of teaching, teaches earth science, biology and chemistry at Allegany High School. Marty was out of the classroom due to medical problems quite a bit this past year, particularly during the first semester, and therefore his students used STELLA only intermittently for a large portion of the school year. Marty was also challenged by limited technology resources; his computer lab contained only 8 machines, which had to be shared by 22 to 25 students. Though the school also has computers in a media center, Marty explained that these are difficult to reserve, and that the STELLA software (received in November) was not loaded onto the media center machines until January. Despite these difficulties, Marty was able to eventually implement a number of CoreModels activities, and feels comfortable using and teaching STELLA. He is a more experienced STELLA user than Robert, his peer partner, but pointed out that Robert had done more modeling than he with his students this year.

Steven and *Jerry* are the only physics pair in the evaluation subgroup. Steven, a teacher at Great Mills High School, teaches physics AP and general physics. Though teaching physics for only two years, Steven has been familiar with STELLA and computers for some time, and feels at ease with technology. Steven also taught math prior to teaching physics, and has been teaching for a total of five years. Steven's classroom is connected to a large, modern computer lab with approximately 30 computers and an LCD.

In contrast to Steven, Jerry has access to a small computer lab with a number of older, less reliable machines. Jerry also reported that his school experienced a number of network crashes this year, as well as a computer security breach. Jerry has been teaching for 27 years, and has been consistently involved with a number of professional and materials development programs and research projects. Jerry teaches both general and honors physics at Arundel High School.

Teachers' Perceptions of the Value of Modeling

Teachers generally discuss the value of modeling with reference to a number of procedural skills and conceptual abilities. Relevant skills these teachers frequently discussed included basic mathematical and technological skills, higher order thinking skills, and communication skills. Conceptual issues they also discussed frequently included the ability to conceptualize dynamic systems and change over time, to think about equations as representations of patterns of change, and to consider the relative impact of multiple variables on one another. Their beliefs about the role modeling can play in developing these skills and conceptual abilities, mediated by logistical and curricular constraints, play an important part in shaping their decisions about how to implement modeling activities and about what goals they have for their students. This section of the report discusses how the different perceptions among this subgroup of teachers about the value of modeling for their students played a role in shaping their implementation of CoreModels materials and their participation in the CoreModels program overall.

The teachers in the evaluation subgroup were consistently active in their implementation of CoreModels materials. However, when asked about the role of these modeling units in their classes, a few indicated that, to them, STELLA units are "just another lab activity." At first, this phrase seems to suggest that they did not see using STELLA as a significant shift in their teaching or in their expectations for student learning, but simply as an enhancement or elaboration of their existing curriculum. Yet when we probed further, we found that their beliefs about the value of modeling and STELLA for student learning were complex.

Even though modeling units were often implemented in a brief time period and in relation to a larger exploration of a content area (like other labs), these teachers felt that modeling activities were having an impact on *how their students were learning* and on *which students were being reached*. This impact was often described with phrases that pointed towards specific advantages that STELLA offered, such as: "the models help students see relationships more clearly;" "it's always better to have multiple points of entry to a content area;" "the more ways there are to teach the same material, the more students you will ultimately reach;" "it helps my students become independent experimenters and learners;" and "it makes my students better at communicating what they do and don't know." All of these statements rely on general observations about students (the need to communicate effectively; the need to become independent learners) but locates the power to cause change entirely in STELLA. We found that it took time and further experience using modeling curricula for teachers to begin to shift their explanations away from describing the strengths of STELLA itself and toward a focus on articulating modeling an activity that occurs among students who are interaction with STELLA and with one another.

An intermediate step many teachers took as they developed their own understanding of the value of modeling involved identifying differences between covering a topic with and without a model, or differences between various types of models. In such statements, teachers were able to point to specific features of STELLA and modeling that enhanced their ability to teach particular concepts or skills. For instance, Marty explained that simulation models are good at reinforcing concepts by giving visual illustrations that students can go back to as often as necessary until they understand what they are observing. On the other hand, activities that require students to actually build a model, according to Marty, enable them to think about the roles (and relationships) of variables within systems that their limited math background previously precluded. In this example, Marty is articulating an interaction between specific affordances of STELLA and the existing knowledge and particular needs of his students.

Just as teachers distinguished between the values associated with different types of modeling activities (i.e., simulating versus constructing, as in Marty's example above), they also distinguished between the values different activities have for different levels of students. Arthur, for instance, explained that for his ESSO students, who are in a remedial academic program, these activities are often the only opportunity they have to do higher-order thinking. He feels that they are able to succeed because certain modeling activities (i.e., diffusion) provide a context of repetition of tasks and concepts that leads them through the unit. In contrast, he feels that these students might not have the attention span or math skills to work through the same material in the context of an independent, paper-and-pencil homework assignment. Arthur also explained that with other modeling units, such as the carbon cycle, students are required "to build a model, determine relationships, create feedback loops and watch a system return to equilibrium." They are engaged in activities such as coming up with a problem, making predictions and analyzing findings, all of which "are difficult to do with the basic skills approach that is generally taken with these students." For his AP students, who have more exposure to these types of investigations, modeling often acts to reinforce skills and concepts learned in other contexts.

As they gained experience with modeling, we found that these teachers began to focus more explicitly on understanding modeling as a unique conceptual approach, which facilitates exploration into new aspects of topics by students and which offers new opportunities for teachers to gain insight into what their students did and didn't understand about them. For instance, Steven explained that, "at first, [modeling] was just a different way of doing what was already being done," as it offered an opportunity to use computers and software (something different) to elicit concepts that he already planned to cover. But now, Steven went on, he sees modeling as allowing students to do and see things that they never had access to before, and helping him to "ask his students different questions and approach traditional concepts in new ways." As an example, Steven explained that he and Jerry developed a new approach in their gravitation model. Instead of looking at the effect gravitation has on an object, as they have done in the past, they realized that they could have their students model the gravitational forces at work between two objects – something that neither had considered covering with their students before they began to work with modeling curricula.

These teachers also identified valuable ways that modeling changed interpersonal dynamics in their classrooms, which in turn offered new insights into individual students strengths and weaknesses. For example, several teachers stated that because computer skills were important for using STELLA, students with those skills were now highly valued, and were often the same students who had previously contributed little to classroom activities. Other teachers, such as Jerry, reported that "I can see some quieter students moving into leadership roles, which is nice."

Finally, through the process of focusing on the pedagogical consequences of bringing modeling into their curriculum, some teachers are also raising new questions for themselves about student understanding and assessment. As their students gain increased opportunities to construct and explore models, and as the teachers gain insight into their students' misconceptions by observing this process and questioning their students, two questions are beginning to surface. First, teachers want to learn how to decide what ways of implementing these activities will work best—which ways of teaching are most effective, and which ways best uncover students' understanding and misunderstanding. Second, teachers are becoming more aware that their current assessment tools are not necessarily capturing what students are and are not learning. As Jerry and Steven wrote together, "we must consider what pedagogical technique(s) are most appropriate to getting the most out of our work with the modeling software. An example of this might be stopping a STELLA modeling lesson 'mid-stride' at an appropriate point to have a whiteboard discussion about the significance or interpretation of a graphical output associated with the model. In this way we more closely monitor the understanding [of] the students. The downside of this technique is that it requires breaking up the computer access time into much smaller chunks, which may not be possible for many teachers." Different teachers are taking different approaches to figuring out how to answer these questions for themselves, but all agree that the assessment tools they develop need to more closely match what they most value in modeling.

Implementation of CoreModels Curricula

Curriculum becomes meaningful or effective only when it is implemented by specific teachers in specific classrooms. How curricular materials are implemented can vary along many dimensions, including the amount of time spent on a unit; the learning goals teachers associate with the unit; the value teachers assign to particular materials; students' relative dependence on or independence from the teacher during activities; and the relative rigidity or flexibility of classroom procedures. All of these elements and many others then play a role in determining how meaningful or effective the curriculum will be, and all of these elements can change over time with changes in school circumstances or in teachers' beliefs and practices.

One important goal of this portion of the evaluation was to gain insight into the range of implementation strategies used by participants in this project. Further, it was important to understand what material circumstances or implicit or explicit beliefs or intentions on the part of the teachers worked to determine those implementation choices, and influenced their changes over time. This section of the report describes and explores some of the key issues we discovered related to teachers' implementation of the CoreModels curriculum units.

Although these teachers varied widely in their styles of implementation of the CoreModels materials, it is possible to generalize a "most typical" process of implementation of the units, and these general observations provide a basis for discussion of observed variations from one teacher to another.

Pre-lab activities. All of the teachers in the subgroup commented that the manner in which modeling activities were presented to their classes influenced how engaged students became with the materials and the degree to which they were able to connect the activities to other aspects of the class. Teachers generally began their coverage of a CoreModels unit by giving a brief "pre-lab" lesson either just prior to turning to the computers, or in the preceding class session. These lessons were often brief discussions during which teachers introduced a particular STELLA activity, reminded students about specific details of the software and helped the class connect the underlying model structure to the phenomena being modeled. Though these pre-labs tended to be brief, generally no more than 15 minutes, teachers commented that they believed the pre-labs were important bridges between regular lessons and modeling activities, and were critical moments in which to help students make sense of the work they were about to do. As Steven explained, "effective use of the materials requires some very important pre- and post-lab preparation. Many times I have found students trying to get through the material as quick as possible and they are not getting everything out of the experience that they should be getting. I have found that how I approach these labs also affects their mindset." He also noted that "if [students] don't see the importance or purpose of doing a modeling activity, then they're just going through the process. They don't think about why they are using the model at all, they're just following directions." At the same time, however, he is "still trying to figure out how to use pre-activities to make the units meaningful."

Not surprisingly, each teacher had a slightly different pre-lab method, based on the approach that they felt most successfully aided their students in understanding the relevance of the STELLA activity. Jerry, for instance, believes it important to connect specific models with the experimental process. Though he has done this using a physical demonstration (presented by him to his class) prior to beginning modeling, he reports that ideally he would like for students to carry out their own physical experiments, which could then be directly tied to the CoreModels materials. For example, Jerry explained that he was working to develop a variation on an existing parachute model. In this new activity, students would gather real-time measurements using probes from a Universal Lab Interface plugged into an actual parachute that the students could drop from the roof of their building.

Laura explained that while she rarely changed the content or structure of the models and packets themselves, she quite frequently used ancillary materials in the pre- and post-labs as a way to extend the reach of the models, particularly with her honors students. More generally, Laura saw pre-labs as an important opportunity to connect the lab to other content she was covering, and to pose questions that would help focus her students, as the lab progressed, on the elements of the model she felt were most important. However, Laura reported that the depth of her pre-labs varied from model to model depending on the prominence of the topic in her curriculum more generally; some lessons were implemented as quick lab activities while others were integral parts of larger units.

The modeling activity. The importance of various models to teachers' goals were reflected by the degree to which actual modeling activities were taught in relative isolation from or were integrated with other classroom activities in the same content area. The level and mode of integration used depended in part on the role teachers wanted a particular model to play in their classrooms. For some teachers, when CoreModels materials were used to cover a topic for which they already had a laboratory activity, the modeling activity complemented the pre-existing lab. This allowed students to explore the topic in a new way, while making a link to another, familiar activity. Arthur, for example, reported that in past years he has covered enzymes in a hands-on lab activity. This year, he implemented both his traditional lab and the CoreModels enzyme unit, and connected the two by using the same enzyme in the lab that was used in the CoreModels materials. When the class began their modeling, then, they found that they were studying a system containing a substance with which they were already familiar. Similarly, Laura explained that a close match between a STELLA unit and a content area already included in her curriculum allowed her to extend that unit into new areas and spend more time on it. Often, however, the curricular connections are not particularly strong and so STELLA units are taught as more isolated activities.

Almost all of the teachers described moving back and forth between whole-class discussions and individual or small-group work during a modeling unit. Arthur, for example, reported that during his CoreModels enzyme lab, he observed that students were not answering a worksheet question about the effects a fever might have on the body. He interpreted this to mean that most of the students did not understand the relationship between temperature and enzymes enough to be able to apply it to the context of a rise in body temperature due to a fever. Arthur responded to this by stopping the class and asking his students to change the model to represent a fever. As he explained, "Putting them in a novel situation to solve a problem revealed that they really didn't see the connection." Being able to alter the instructions in response to that discovery enabled him to "respond to what's taking place right now."

Most teachers in the group typically spent two to three class days on an actual STELLA activity. Some of the teachers—those who had an adequate ratio of computers to students—had students working individually at their own computers. More often, however, students were working in pairs or larger groups. Some teachers explained that because students, or student groups, tend to work at different paces, they sometimes asked students who completed the activity early in the period to extend their work by changing variables, altering initial conditions, and so forth. For example, when three students in Jerry's honor physics class completed the Applications of Force worksheet before the other students, Jerry asked them to change the friction variable and rerun the model (a variation that he had observed Steven, his peer support partner, use during a classroom visit). The students immediately recognized that the graphical output was counter to their intuition about force and friction, and did not seem to represent a physical behavior that would occur in the real world. Jerry proceeded to probe the students until they determined what the altered variable represented within the system, and then asked them to develop a way of ensuring that the model would not accept those values in the future.

Post-lab activities. Teachers reported that they typically did a post-lab activity once students had finished working through the model. These tended to be whole-class discussions of the model, with the teachers asking questions about the content covered, the graphs produced, the phenomenon modeled and/or the relationship between the model and the course topics that straddled the activity. For example, Arthur explained that he likes to use the post-lab to access and build upon cumulative classroom knowledge. To do this, Arthur tries to "defer questions" asked by students during the labs, but writes them in a notebook for later reference. During the post-lab, then, he will address these questions with the class as a whole as he prompts the students to contribute to the discussion by applying their newly acquired knowledge.

Altering or modifying units. As teachers took the same materials and fit them into their different classroom structures using their individual implementation styles, they naturally modified units as they each saw fit. The degree to which teachers altered or extended the models they used varied according to both teaching style and prominence of the model's content within their larger curriculum. A small number of the teachers explained that the activities offered a good starting point, but that they were more comfortable revising materials to meet their own personal needs. Most of the teachers, however, used the materials as they were developed, making changes only with regard to the amount of time the class spent on particular sections (i.e., truncating models that they felt contained numerous redundant tasks) or changing variable values to broaden the parameters being modeled. Laura, for example, included the STELLA stream model in a larger unit around streams this year in which the class collected actual data on temperature, pH, nitrogen levels, water clarity and biological indicators from a stream behind the school. Since some of the data being collected were the same as the variables used in the stream model (i.e., temperature and water quality), the class was able to use real data taken from a familiar environment. By making only slight changes in the STELLA model the students were then able to alter conditions (i.e., the number of trees or the amount of pollution), make predictions and study outcomes based on a real environment. More often, however, STELLA models were only peripherally connected to other curricular activities in Laura's classroom.

Although most of these teachers did not always integrate the modeling activities explicitly into other lessons, the conceptual processes involved in modeling and systems thinking were often integrated into these teachers' classes beyond the actual STELLA activities. For instance, a number of the teachers noted using STELLA terminology in their discussions of other topics, or of their discussions of topics that had a STELLA model tied to them, but before that model was introduced. As Johanna explained, she began to describe relationships between variables in terms of stocks and flows, terms specific to STELLA that represent particular relationships between variables in a model, a technique she learned from her Supporting Teacher. Other teachers reported changing or adding questions to CoreModels worksheets without altering the actual activities. Steven explained that he had "not been satisfied with responses that are required by students," and so rewrote many of the questions himself.

Obstacles to implementation. Though teachers often distinguished between more and less effective ways of implementing STELLA models, and said that they would have liked to expose their students regularly to modeling and STELLA, a number of different obstacles hindered teachers in achieving the level of implementation they wanted to reach. The most widespread problem was limited access to technology, due either to scheduling difficulties or to computer malfunctions. More significant, however, was the difficulty of finding appropriate ways to tie current curriculum to STELLA units. Some teachers developed strategies for this, such as adapting the model to make sense within the context of the current class content (i.e., Robert changed the deer population model to a human population model). Limited computer access, however, can compound issues of curricular fit when teachers have not identified a role for modeling to play in their teaching that is unique to that format. Finally, some teachers felt that units were too lengthy to fit easily into their pre-designed schedule ("subjects are now 3 to 4 days, rather than 15 minutes"), or were concerned that students were intimidated by the length of worksheets. The length of units was particularly of issue to teachers with AP classes, as they often felt responsible for "teaching to the test" and therefore had less flexibility with their scheduling.

Teachers' Perceptions of Student Reactions to the Activities

Teachers' reflections about students' responses to CoreModels units were frequently framed in terms of differences between various groups of students. Teachers consistently compared and contrasted their classes based on level (for example, comparing a basic environmental science group to an AP biology group). Generally they explained that students at one level got more or less out of modeling than students at another level. However, teachers' beliefs about which students benefited most from modeling varied markedly.

The more commonly expressed view was that modeling worked most effectively with students taking higher-level classes. Students in lower-level classes were often identified as not having strong enough basic skills to be able to make the kinds of connections that modeling most effectively reinforces. Examples teachers used to explain this distinction included students' difficulty with ideas like interrelatedness, the compounded impact a small change in the value of a variable can have on a system, being able to think proportionally, and being able to move among various representations (graphical, mathematical, etc.) of the same system. One teacher explained that he felt that his students in lower-level classes needed to be taught more basic skills before moving on to more advanced concepts like those presented through modeling activities. Finally, several teachers noted that when working with lower-level students, procedural and technical questions dominated class time to such an extent that they were unable to discuss more substantive or conceptual issues with the students.

In contrast to these experiences, a few teachers felt strongly that modeling can play a valuable though different role for students in lower-level classes. For Arthur, modeling activities provide an opportunity for these students to begin to engage in forms of scientific thinking that they are not often asked to do in the context of basic skills courses. He focuses on using STELLA in his lower-level classes to help these students begin to make predictions, think about processes of change, and to understand the relationship among equations, graphs and real-world phenomena. A few teachers also pointed out that some features of STELLA and of the CoreModels units are particularly well suited to students in lower-level courses: the units often provide a certain amount of repetitive activity that provides these students with reinforcement; and STELLA helps to isolate specific functions within a system for study, giving students a chance to learn about these relationships before seeing them again in the context of a broader context.

Despite the distinctions made between students in different level classes, teachers did make positive statements about how their students have responded to modeling overall. As Albert wrote, "Many students are showing increased enthusiasm for and ability at predicting dynamic trends or outcomes. I think that the real-time experience of proposing model changes, predicting results, and then *immediately* learning the effects is a very powerful way to build students' interest and skill in this area." Albert also has discovered that "several students have 'gotten' certain algebraic relationships for the first time ever…[and] others have gotten over their 'graphiphobia.'"

All of the teachers in the subgroup believed strongly that modeling would benefit their students, and all are looking to varying degrees for the teaching strategies that will most effectively bring these benefits to fruition. Desire for change, however, must be looked at in the context of the realities of teachers' daily lives. None of these teachers saw CoreModels as a means through which they would totally reform their curriculum and their teaching. CoreModels and modeling have become highly valued as professional development and pedagogical tools, but to a certain degree these activities remain peripheral components within the larger, more demanding routine of covering required curricula and preparing students for testing.

Peer Support

The CoreModels project developed and implemented a peer-support network to facilitate the integration of project materials and strategies into the classrooms of new Participating Teachers this year. This support component grew out of the program leadership's belief in the value of its participants' own growing knowledge and experience around modeling, and the power of peer-to-peer professional development. Supporting Teachers, who are experienced CoreModels participants and some of whom were active collaborators in the development of CoreModels materials, were responsible for providing one-on-one support for incoming teachers who were trained in the use of STELLA and introduced to the project materials at summer and fall workshops.

The peer support component of the project was initially conceived as a mentoring dynamic in which Supporting Teachers would guide Participating Teachers this year as they began to use STELLA and project materials in their classrooms. However, some concern had been expressed among the program staff that these teachers were not provided with enough training during their first year to be able to provide this type of support. Additionally, there was an acknowledgment among the Supporting Teachers that after one year of program participation they might only just be starting to feel comfortable with modeling and with the teaching strategies they were developing to go along with that process. Supporting Teachers were concerned that they might be expected, for example, to tell another teacher how to teach or that they would be seen as evaluators by the teachers they were supposed to be mentoring.

In response to these issues, the terminology used to describe these relationships was shifted away from "mentoring" and towards "peer support." Implicit in this development was a conceptual change from asking teachers to act as mentors and mentees with one another to suggesting that they use the opportunity to form collaborative relationships with their colleagues. In the context of these relationships, teachers could address whatever issues they found most pressing (i.e., technical questions, pedagogical challenges) or simply have a partner to talk with on a regular basis about classroom experiences.

A major goal of our work with this subgroup was to follow the experiences of these four Supporting/Participating Teacher pairs in order to learn how the peer-support component of the program was interpreted and experienced by project participants. Not surprisingly, the relationships between each of the four pairs in the evaluation subgroup differed from each other in a number of ways. In the section below, we briefly introduce each pair in the subgroup, describe the sort of interactions each had and characterize the nature of each relationship. We then thematically summarize what we learned from this group with regard to: their perceptions of partnership goals and/or purpose; the successes experienced and lessons learned over the year; and the obstacles to effective partnering.

These descriptions of individual relationships, and the insights into peer partnering that they offer, do not necessarily represent the project group as a whole, nor even the relationships that any of these teachers might have with any other teachers in the project. Though these eight teachers are only a subset of the larger CoreModels group, the themes that emerged from their experiences are likely to be important within the larger group as well.

Subgroup Pairs *

Laura and Arthur – Laura and Arthur were never able to organize any visits to one another's classroom, though Susan Regan visited Laura in Arthur's stead two or three times. A major logistical hurdle was that Laura had an unusually difficult time receiving administrative permission to leave her school. Additionally, Laura is someone who does "a lot of last-minute planning," which precluded her and Arthur from having the advanced notice necessary to schedule a visit. Arthur and Laura did talk at workshops, however, and have at times emailed each other to find out what modeling activities they used with their classes.

In addition to finding the visits logistically difficult, Laura felt comfortable with the program materials and therefore did not perceive an immediate use for classroom visits. Laura saw these partnerships as a tool for addressing technical needs. Because she felt comfortable with computers and with STELLA (perhaps more than Arthur), and because she considers herself to be very independent in her teaching, she saw no real place for the partnership in her use of CoreModels materials. Arthur, who as a Supporting Teacher did work more closely with some of his other Participating Teachers not in the subgroup, wanted to support Laura in any way she might need, but believed it was important for Laura to define what that way would be. In the end, Arthur understood that Laura felt both technologically and pedagogically secure, and therefore did not suggest that she make use of him in any other capacity. This combination of strategies and perceptions kept the partnership from developing beyond sporadic communications.

Johanna and Albert – Johanna and Albert were familiar with one another from a previous program context. Like Laura and Arthur, Johanna and Albert had a difficult time planning mutually convenient visits to one another's school, which were a number of hours away from each other. Additionally, Albert was out sick for long stretches of time during the first part of the year, and therefore was not able to visit any of his Participating Teachers. Eventually Johanna did visit Albert's school, where she observed two of his classes.

In contrast to the process that occurred with Laura and Arthur, Johanna identified a need that she used Albert to address. Specifically, Johanna recognized that she had difficulty effectively moving between her regular lectures and modeling, and looked to Albert for ideas about developing and implementing pre-lab activities for a more seamless transition. In addition to finding a clear issue to address, Johanna is quite at ease with stepping into the role of the learner, and stating what she does and does not know or feel comfortable with. As a complement, Albert is a teacher secure in his own ability to develop effective teaching strategies, and proud of his willingness to replace traditional methods with his own innovations. Albert is also comfortable

* *See above for introduction to individual teachers.*

discussing his teaching with other teachers, and is willing to play the role of mentor if that is desired.

During Johanna's visit to Albert's class, the two teachers spoke about Johanna's interest in developing effective pre-lab activities, amongst other things, and then she observed his classes. Johanna was specifically impressed by Albert's integration of STELLA terminology into his classroom discussions. This technique, she said, differed from her own in that she introduced the STELLA application and its terminology, as well as the actual model, all at once during her prelab. She also noted Albert's use of a human model during a prelab, which she said helped the students ground the concepts they were learning in something concrete. Albert and Johanna also discussed what they saw as a need to cover pre- and post-lab implementation more thoroughly at project workshops.

Robert and Marty – Robert and Marty's schools, like Johanna and Robert's, are a number of hours apart, making regular visits difficult. Additionally, for personal reasons Marty was away from the classroom frequently during the first half of the year, though he did manage to make two visits to Robert's classroom to observe him teach STELLA units. In a reversal of what might be expected, Marty, the Supporting Teacher in this pair, commented that it is was nice for him to visit Robert's class and see the use of a unit that he had not yet implemented but was planning to use soon. Though Robert and Marty did occasionally email one another, this form of communication was generally brief and infrequent. As Marty described, he emailed Robert about the Blood Alcohol unit, but received back only a "one-sentence response."

In terms of his use of project materials, Robert was an active participant in the CoreModels program. In describing his view of the potential value of peer support, Robert said that it is useful to talk with other teachers, to share experiences and to observe others' teaching styles. However, while he did have some contact with Marty, he did not actively seek out collaborative interactions with his Supporting Teacher. Marty, who says that peer support is potentially a very strong component of this program, has not been satisfied with his experience of it thus far. According to Marty, Robert did not make a strong effort to utilize his Supporting Teacher in any particular way or to build on Marty's initial communications. As Marty explained, "When you reach out and nothing happens then you feel like you've wasted your time. Or when you get a response, sometimes it's not satisfying and so again you feel like you wasted time." Like the other Supporting Teachers in this group, Marty defined his role based on Robert's input—he was willing to be there if needed, and even willing to initiate contact. But what these teachers did or did not do as a pair was determined by Marty's interpretation of Robert's needs and desire for interaction, which he considered to be a low priority for Robert.

Jerry and Steven – Jerry is a much more experienced teacher than Steven, though both of them report that Steven is far more familiar and comfortable with STELLA. Jerry visited Steven's class two or three times, and the pair also met outside of the classroom two to three times. According to Jerry, Steven helps him with his STELLA skills while he helps Steven identify lesson objectives. Both teachers described their outside meetings as opportunities for collaborative development of materials, and as a time during which they could discuss learning goals and the role of various models in meeting those goals. Though Jerry and Steven did manage to meet more than any of the other pairs, they both also commented that the distance between their schools was prohibitive.

Perception of peer support goals. The subgroup teachers articulated a range of goals for the peer-support relationships. The goals were influenced by a range of variables, including their reasons for involvement in the project overall, individual pedagogical strategies, familiarity with technology, ideas about student learning, and the project leadership's presentation. In turn, their understanding of the goals of the peer-support relationships shaped the roles that they each took on and expectations they each had for one another.

Perceptions of peer support within the subgroup fell into three categories. One is the notion that Supporting Teachers should mentor, or support, Participating Teachers through the process of learning to use STELLA. In this scenario, the "mentorship" is around the technology, and the Supporting Teacher is only necessary to the degree that the Participating Teacher has not yet developed a sufficient level of comfort using STELLA with her or his students. A second interpretation is that the Participating Teacher is supposed to use the Supporting Teacher to help him or her address specific needs. In this relationship, the Participating Teacher gains knowledge and insight from the more experienced Supporting Teacher. The third interpretation is of peer support as a collaborative relationship in which both teachers contribute to the process of developing an understanding of both STELLA and modeling, and how they can best be put to use. In this latter vision, Supporting Teachers might or might not be the more experienced teacher playing the role of mentor, and both teachers do not necessarily benefit in the *same* ways. If a leadership role is taken, however, it is not in relation to STELLA but in relation to teaching and learning issues. Instead of technology being the centerpiece, conversations are focused on what modeling can bring to student learning, and how teaching can best facilitate that learning.

In most cases, the two teachers in a partnership did not share identical views of the goals of peer support. These differences, in each case, had consequences for the course of their relationship and the work they did together. A clear example of differing expectations is the partnership between Laura and Arthur. The shape of this relationship was largely a consequence of Laura's vision of peer support as primarily a technical mentorship. As someone who felt completely at ease with technology, and who was just as, if not more, familiar with STELLA than her Supporting Teacher, Laura did not have a particularly strong need to prioritize the peer-support component of the project. While Laura did comment that more could come out of these partnerships—that there's use in seeing another teacher teach and in discussing alternative teaching methods with colleagues—this was something that she felt would demand more time than she was able to contribute. Arthur, for his part, felt that peer partnerships were an opportunity to learn various techniques for integrating modeling into teaching through observation of other teachers' methods. However, what was most important to him was that the Participating Teacher define his or her own needs, and that those needs then define the scope of the relationship. Consequently, Arthur did not pose an alternative interpretation of the relationship in a way that pulled Laura into a broader collaboration.

Successes of peer support. We define success for peer support as the reported satisfaction of both partners with the relationship and the existence of strong evidence that one or both teachers gained new knowledge or experience as a result of the relationship. Given these criteria, the most successful relationships occurred when participants had clear, shared goals that were linked to their individual needs. For example, everyone in the group saw technical support as an inherent component of these relationships. For those teacher who did not feel the *need* for this type of support the partnerships became a low priority unless another need was identified. In cases where technical support was relevant, or some other goal was defined and sought out, these partnerships proved to be effective means of sharing ideas and facilitating the use of CoreModels materials in ways that made sense.

Johanna and Albert are an example of a partnership in which a specific pedagogical need was identified and addressed. Johanna reported feeling uncertain about the most effective way to integrate STELLA and modeling in a manner congruent with what students were already learning in her classroom. By discussing this issue with Albert, and by observing how he created bridges between his daily lectures and modeling activities, Johanna felt that she had acquired a new way of implementing the materials. Further, according to Johanna, prior to her contact with Albert, the role of mathematics within biology was something that she had never before emphasized in her classes and did not herself feel comfortable with. Through her visit to Albert's class, Johanna had a chance to observe how Albert emphasizes the relationships amongst mathematical functions, biological phenomena and STELLA models and output (i.e., graphs). Learning more about STELLA and STELLA structures, discussing with Albert his ideas about teaching modeling (however brief these conversations might have been) and observing Albert's teaching began a shift in Johanna's own thinking about the role of math in biology and in her teaching.

Jerry and Steven's relationship contain both elements of our definition of success – mutual satisfaction and evidence that both teachers gained new knowledge and experience. Unlike the other pairs in the subgroup, Jerry and Steven invested their time in both out of class meetings and classroom visits, and in making connections between these two types of interaction. Specifically, because the pair spent extensive time talking before their classroom visits, Jerry was able to play a useful role in Steven's classroom since he had helped to set the goals for the lesson. Their meeting prior to the classroom visit prepared Jerry to be an active observer because they had a shared understanding of what they wanted the lesson to accomplish. Further, classroom visits fed into later conversations because they were able to ground general conversation about teaching in their specific knowledge of individual practices. Jerry did recognize, however, that while acting as a participant in Steven's class lets him gauge how the students are doing with regard to those things he and Steven set as priorities, it limits the degree to which he can play the Supporting Teacher role of observing Steven's teaching. As Jerry explained, "As I experienced in the first visit with Mr. Skinner's classes it seems to me that I get a most clear grasp of how the students are interacting with STELLA by being an active helper-participant rather than just a distant observer. However that also limits the breadth of observation of the whole class. At a later date I am planning on adopting the 'more distant observer' approach in order to focus more on how Mr. Skinner is dealing with the students' problems than my own interaction with the students themselves."

Steven reported that through his conversations with Jerry about his classroom visits, he heard things about his students that he had never had direct insight into himself. For his part, Jerry began this year with concerns about his own skills with STELLA and questions about how best to use modeling in his teaching. Jerry reported that his conversations and collaborations with Steven gave him another perspective on how to use these tools and taught him a great deal about how modeling can fit into the physics curriculum.

Obstacles to effective peer support. Most of the teachers in this group did not begin their peer-support relationship a clear, personalized set of goals that they wanted to meet through this collaboration. Further, many of these teachers confined themselves to a relatively limited vision of the roles the Supporting Teacher could potentially play, by focussing primarily on the Supporting Teacher as someone who provides technical help. Consequently, unless they had an immediate, pressing need, these teachers felt little clear motivation to make the effort (which was significant in most cases) to visit one another's classrooms or to meet outside of the classroom.

Logistical barriers were quite real for this group and clearly limited teachers' classroom visits. Travel time between schools was often two hours or more; getting permission to leave during school and finding a substitute teacher were difficult; and coordinating schedules so that one teacher was using CoreModels materials at a time that her or his partner could leave their school was often a problem. Further, since classroom visits were rare and did not usually build on previous planning, there was little momentum in place and visits were often brief, and included little or no follow-up. The brevity of these initial meetings limited personal interaction or discussion, so teachers were left having "tried out" the classroom visit experience without further reinforcing the relationship with their partner. Without a strong foundation on which to develop the relationships or a clear set of goals and structures, personal needs were seldom articulated or addressed, mutual goals were seldom set, and there was little motivation for teachers to continue the practice.

Marty's experience as a Supporting Teacher illustrates these challenges. Marty's and Robert's school are far away from each other. In Marty's view, no strong signs were given that Robert placed a high value on having him visit his classroom. Not seeing it as his responsibility to insist on consistent contact, or to suggest ways to readjust the partnership to be more applicable to Robert's needs, Marty did not push the relationship to develop further. Marty thought these relationships were meant to focus on technology and that most teachers feel comfortable with the technology after only a short period of time.

Additionally, Marty experienced his own set of obstacles (present in all of his partnerships), such as the distance between schools, scheduling difficulties (he needed to take the whole day off to make a visit) and frequent cancellations by his Participating Teachers. According to Marty, his Participating Teachers did not inform him when they would be doing models in a consistent or timely manner. He reported feeling a responsibility to make visits to his Participating Teachers' classes, but also pointed out that some of his partners are physics teachers who, he feels, are more likely to contact Charlotte Trout, their Center Director, when they need support. As Marty explained, "When you reach out and nothing happens, you feel like you've wasted your time."

Jerry and Steven had a somewhat different experience; while they saw time and distance as their biggest obstacles, they did not feel that they lacked a perceived need or potential benefit to making the effort to work together. Both of these teachers, who worked together more than any of the other pairs in this subgroup, said they would have liked to work more with one another and to spend more time in each other's classrooms, but that conflicting demands limited the amount of time that they were able to expend. As Steven reported after one of their meetings, "The meeting left me thinking of how important and satisfying this kind of sharing and cooperation is to my teaching, but disappointed as to how hard it was to create and manage the time needed to undertake such an endeavor. Part of the problem is that I am still a novice teacher. Another part of the problem is that my current teaching situation does not encourage such activities. I have too many things to do just to get ready for the next day. How will I ever get better, if I do not have the time to grow? This is very frustrating." Clearly, factors that hindered the development of the various peer-support partnerships within the program were varied and complex. The centrality of technology and STELLA skills to participants' thinking about these relationships, and the fact that technology and STELLA experience were not necessarily correlated with program experience, left partners unsure about the respective roles they were expected to play. Without clear definition, the responsibility for determining how much or little peer partners would actually support one another, and in what ways, was left in the hands of partners themselves. In this context, daily scheduling logistics, technical difficulties, competing responsibilities and individual personalities became major factors in the development of these relationships. One subgroup teacher succinctly characterized the competing costs and benefits of investing time in developing peer-support relationships when he wrote,

> *I remain a fan of the peer collaboration design, but I wonder if it can be counted on as a main mechanism in the MVHS Project. Maybe most teachers' intuition is that the possible benefits of a site visit (new strategies, stylistic tricks, useful perspectives, etc.) are certainly unpredictable and probably modest at best. Meanwhile they face more immediate loud-and-clear challenges, some of them classic to the profession and some of them particular to this year: an awkward calendar which fragmented all but a few teaching weeks in 1998–99; increasing County and State curriculum demands; decreasing student in-class time; an insidiously 'ill' season; distractions of the impending HSA era; tightening regulations regarding the use of substitutes; extraordinary increases in paperwork, such as special ed reporting on 'mainstreamed' students; plus the ordinary spiralling increase of administrative crapola.*

Table I
Models implemented by subgroup participants as of April 1

Teacher	Classes	CoreModels Units
Laura	Environmental Science	Deep Population Carbon Cycle Streams
	Biology I	Deer Population Carbon Cycle Enzymes Cell Growth
	Anatomy and Physiology	Blood Alcohol Glucose
Arthur	ESSO	Diffusion Cell Size Flow Rate Carbon Cycle Enzymes
	Biology I Honors	Diffusion Cell Size Flow Rate Hardy-Weinberg Carbon Cycle Enzyme
	AP Biology	Diffusion Cell Size Flow Rate Hardy-Weinberg Carbon Cycle Enzyme Glucose
Johanna	Biology I TAG (talented and gifted)	Enzyme Deer Population Glucose Blood Alcohol
Albert	Environmental Science	Deer Population Flow Rate Streams Plagues and People
	Biology II	Deer Population Flow Rate Cell Size Partial Diffusion & Osmosis Enzyme Glucose
	Biology AP	Deer Population Flow Rate
	Biology I Honors	Deer Population Flow Rate Cell Size Partial Diffusion & Osmosis Enzyme Plagues and People

Table I (continued)
Models implemented by subgroup participants as of April 1

Teacher	Classes	CoreModels Units
Robert	Tech Prep Anatomy & Physiology	Enzymes Deer Population Blood Alcohol
	College Prep Anatomy & Physiology	Enzymes Deer Population Blood Alcohol Diffusion Bone Hormones (self-designed)
Marty	Earth Science	Streams
	Chemistry	Streams
	Biology	Enzyme Carbon Cycle Diffusion / Osmosis Cell Size Deer Population Glucose (part 1)
Steven		Simple Kinematics Dynamics Applications of Force Tailgating Elevator Momentum Coulomb's Law Universal Gravitation
Jerry	Physics II	Free Fall Simple Kinematics Applications of Force Braking Distance Tailgating Universal Gravitation Spring

Development of Student Learning Frameworks

Student learning in the CoreModels program was not systematically evaluated this year, as was scheduled in the original evaluation plan. There were two main reasons for this. First, the CoreModels team has found that developing adequate assessment questions and scoring rubrics for the various modeling units requires far more collaborative time and effort than had been expected. Therefore, these elements were not in place to be introduced to teachers and presented as an integral part of CoreModels curricula. Second, it has become increasingly clear to the evaluation team and to the CoreModels team that the features of the CoreModels project that are encouraging real adoption of modeling by project participants are also minimizing the degree of uniformity in how these units are being used in various classrooms. Therefore, even with adequate assessments and scoring rubrics in hand, it is clear that making any systematic judgments about the impact of the CoreModels project on student learning based on evaluation of student work generated from the CoreModels units would, at this point, be premature and inappropriate.

The project team has, however, done extensive work this year to articulate and improve the learning goals for the various units, and to create assessment questions appropriate to those goals. Activities they have undertaken this year include reviewing and then revising or replacing student questions in various curriculum units; leading discussions with project participants about their goals for student learning; reviewing the Maryland Core Learning Goals for Science (CHECK) and the Project 2061 Goals for Science Learning for systems thinking; and convening a roundtable of teachers active in the evaluation study, for a review and discussion of student learning.

These various activities can be characterized as occurring on two different levels. One level of work has involved encouraging project participants to articulate and reflect upon their own goals for student learning and to begin examining how and whether the CoreModels curriculum units are consistent with those goals. The implications of these goals for the design of assessments has been a relatively minor part of these discussions, only because in the context of the initial conversations it becomes an excessively ambitious problem to take on. On the second level, the CoreModels team is conducting its own series of discussions and reflections which are focused less on bridging teachers' existing student learning goals and the curriculum units, and more on bridging the curriculum units and the two sets of learning standards that have served as important points of reference for the project team: the Maryland Core Learning Goals and the Project 2061 Science Learning goals.

To date, these two streams of conversation have not been well integrated. To some extent this independence reflects an unwillingness on the part of the CoreModels team to be excessively prescriptive to the project participants about how to make use of modeling in their classrooms. In some senses this unwillingness is well placed, and reflects a respect for teachers' professionalism and independence that is fundamental to the success of this project. However, it is also true that the CoreModels team does implicitly expect teachers to move forward from a more basic to a more sophisticated understanding of the role modeling can play in their classroom. Therefore, the project team needs to find ways to push teachers forward, toward certain goals for student learning that the project team finds most important and most valuable.

Growth in Understanding

Although we have not conducted a systematic analysis of student learning in the context of this program, student learning has been a very prominent concern among project participants. Participants at every level of the project have grappled with such questions as "Why should I have my students build or investigate a model of this phenomenon?" and "Why should I use modeling when I teach this subject?" And as the project has developed, we have observed growth in participants' understanding of their own answers to these questions. Specifically, as project participants have gained experience with modeling in the classroom, they have articulated different ideas about what modeling brings to their students. We describe some of their thinking below, using first-person statements that are typical of different descriptions we heard from many project participants:

1. **Modeling is another way to cover the same material I was covering before.** It makes the activity more visual, and that is an easier way into the concepts for some students who have trouble understanding my verbal explanation. Since I am covering the same material as I cover without modeling, I don't expect that I will change my assessments, though I am curious about whether my students' performance will improve on my existing assessments.
2. **Modeling deepens my students' engagement with the content I want them to learn.** It makes it possible for them to include more variables in the system, to test out rival hypotheses, and to ask more "what if" questions. I would like to add more "what if" questions to my assessments to see whether they are retaining what they learn from the modelling exercise about how particular systems change when inputs to that system change.

3. **Modeling changes my role as a teacher because it puts my students in charge of defining and exploring the systems they are studying.** When they are building models, my students are conducting their own inquiries into the subject area, and rather than leading them through a body of information I am helping them discover things on their own. This experience is making me want to use modeling in more content areas – I'm looking at my whole curriculum and asking, "What else can we model?" I would like to include elements in my assessments that ask students to show that in addition to knowing what I think is important about this topic, that they understand the relationship between the model they built, the mathematical equations we talked about, and the general content knowledge and science principles they learned through my lectures, hands-on labs, etc.
4. **Modeling brings a new framework to the study of all complex systems.** In addition to the specific content they are learning, my students are building up their knowledge of system dynamics as they model different phenomena. Over time, they are conducting a systematic inquiry into the dynamics of complex systems in general. Therefore, I think that I would learn a lot about their thinking if I could find a way to assess their knowledge of systems thinking concepts in general, in addition to their understanding of specific models.

These ideas reflect a progression over time from a focus on content to a focus on systems dynamics, and a movement from viewing models as isolated activities to viewing them as representing an interconnection between independent student inquiry and engagement with systems dynamics concepts. The different levels in this progression are reflected in many of the issues discussed in the findings related to the subgroup, described above. Their relevance to future research around student learning in the CoreModels project and their implications for program implementation issues will be discussed in the Student Learning section of the discussion below.

Discussion

Plans for Year 3 Evaluation

This section of the report reviews our plans for the Year 3 evaluation.

Surveys

We will conduct three different surveys this year:

- **In the fall, we will survey the new program participants, using the same instrument we used in the fall of 1998.** This will provide us with a uniform body of information on all program participants.
- **Also in the fall, we will administer a very brief survey to continuing program participants.** This instrument will focus only on teachers' plans for program participation this year and their expectations of the benefits and hurdles associated with participation.
- **In the spring, we will administer a final survey to all program participants.** This survey will be similar to the Spring, 1999 survey, but will be modified somewhat to allow us to capture some summary information from participants about their overall experience of the program and its impact on their teaching practices and beliefs.

Case studies of a subgroup of teachers

Two priorities guided our selection of a subgroup for Year 3. First, we wanted to continue to follow some of the teachers we had worked with during Year 2, in order to collect a two-year picture of their experience with CoreModels, while also following the experiences of some new participants in chemistry, earth science, and environmental science. Second, we wanted to mirror in our case studies the movement of the overall program toward a broader definition of "peer collaboration" to include not only Supporting Teacher/Participating Teacher partnerships but also individual teachers supporting groups of teachers in their schools, and other possible arrangements of several teachers working together, within or across disciplines.

Based on these priorities, we plan to work with the following individuals during Year 3 of the CoreModels program:

- **One Supporting Teacher/Participating Teacher pair in biology that was part of the subgroup last year.**

- **A Supporting Teacher and Participating Teacher in biology who were a pair in the subgroup last year, but who may not continue to collaborate with one another this year.** These teachers are both collaborating with other teachers in their schools and/or districts.
- **A group of environmental science teachers in a Northern Region school.**
- **A chemistry teacher in the Western Region who will be collaborating with other teachers, in other disciplines, in his school.**

We will speak with teachers in the subgroup on a regular basis, documenting their collaborations with one another and their use of CoreModels materials. Through these conversations we will encourage them to reflect about their goals for using modeling in the classroom and about their understanding of what they are learning from their experience in CoreModels.

Student learning

The CoreModels project as a whole is making steady progress on developing conceptual and technical frameworks for the assessment of student work in modeling. However, for a host of reasons, our original plan of basing our student learning findings on teacher assessments of their own students' work, using uniform assessment criteria, is not well matched to the realities of teachers' current assessment practices or to the diversity of implementations of CoreModels materials. Therefore, we have proposed conducting a different study that will capture some useful and interesting evidence of the impact CoreModels is having on student learning. This new study constitutes a new piece of the evaluation plan (under the heading of Student Learning) but should not be considered a replacement or a devaluation of the ongoing work on developing quality assessment criteria across the program. We expect that work to continue during Year 3 and will support the program in those efforts.

In order to collect some evidence of student learning that can be analyzed uniformly across a number of classrooms, we plan to invite a sample of CoreModels teachers to give their CoreModels students a pencil-and-paper exercise that involves reflecting on and describing an existing STELLA model that is not domain-specific. The exact makeup of the sample for this study will need to be determined in collaboration with the project leaders. This exercise will not involve building a model. Instead, it will give students information about a phenomenon or situation and describe a model of that situation (providing graphs, etc., as appropriate) and then ask students to answer some questions about that model.

We will collect this material and evaluate it with an emphasis on looking for evidence of students' ability to use the skills CoreModels associates with modeling and systems thinking (as articulated in the Maryland Core Learning Goals and in the 2061 Goals). Further, our analysis will explore possible associations between various characteristics of the sample, styles of program implementation, and student scores on the exercise. This will allow us to go beyond reporting summary scores for the entire sample to provide some evidence about what kinds of classrooms may be having the most success with CoreModels materials.

Key Year 2 Findings

Key findings will be reported with reference to our three topics for evaluation: efficacy of program components, changes in teacher practice, and student learning. The majority of findings will be discussed under the first of these headings, as this issue was the primary focus of the Year 2 evaluation. In the Year 3 summary evaluation report we will focus on overall programmatic findings, emphasizing findings related to the second and third evaluation goals.

Efficacy of Program Components

Does the CoreModels program provide a functioning and effective programmatic *structure* for professional development?

- **The four key leaders of the CoreModels program have successfully implemented the program of work they outlined for Year 2.** Their accomplishments include writing and disseminating 30 curriculum units (over both years) that feature modeling and systems thinking; supervising and coaching 30 Participating Teachers and 8 Supporting Teachers across the state; holding 11 workshops; and recruiting new program participants for Year 3. Additionally, the project team has, with the support of various program participants, presented widely about the CoreModels programs, both to practitioners and to district- and state-level administrators.
- **Program participants are enthusiastic about the program leadership and about the workshops that they lead.** "Relationships with project leaders" was one of the highest-rated benefits of the program in the fall survey. This was especially true for the Supporting Teachers. "Attending workshops" was rated equally highly as a benefit of program participation by both Supporting and Participating Teachers.
- **Judged by its original intentions, the peer-coaching model was not entirely successful this year.** Supporting Teachers reported visiting the classrooms of their "peer-support partners" on average just 1.2 times this year, with 3 being the highest number of visits reported; Partici-

pating Teachers reported visiting the class of their "peer-support partner" on average just 0.4 times, with 2 being the highest number of visits reported. Teachers consistently reported that it was too difficult to engage in these visits because the distance they needed to travel was too great and because it was difficult to get permission to leave the building. However, other evidence suggests that program participants remain interested in particular aspects of peer collaboration, particularly working together on developing curriculum and assessments and learning about other teachers' teaching strategies through observation and discussion. Further, teachers continue to rate peer collaboration as an important component of the program, even when their participation in that component was minimal.

Teachers' responses to the idea of collaboration, observation and coaching among peers were complex. Teachers found that it was largely up to them to define the goals and structure of their peer-support relationship. Further, the project team was unwilling to impose specific goals and expectations on the peer-support process. Consequently, those teachers who were unable or unwilling to go through the process of defining personally relevant goals for that relationship had a "way out" of a process that would have been not only logistically challenging for them but professionally and emotionally challenging as well. The teachers' ambivalence about the relative benefits and risks involved in this process were, in effect, reinforced by the open-endedness of the goals associated with these relationships.

The project leaders have already responded to this tension in part by taking on more classroom visiting responsibilities themselves. They also recognize that many teachers (both Supporting and Participating) are developing other, less structured collaborative relationships, often within their schools, and are encouraging teachers to establish those relationships more formally.

- **The curriculum development component of the program continues to be a major time and effort commitment for the project leaders. However, the flexible implementation these units has been key to teacher participation in this program.** The project leaders have wisely cut down on the number of units they are providing to the new teachers joining the program in Year 3 (who are environmental science, earth science, and chemistry teachers). Participants' reported use of the existing 24 units suggests that a certain units have become important introductory units that teachers feel comfortable experimenting with in their classrooms. However, as teachers become more comfortable with the materials they are likely to begin either building a new modeling dimension into existing curriculum units or heavily retooling a CoreModels unit. In other words, the sample units seem to be serving primarily as a series of stepping-stones for teachers who are just beginning to make use of modeling in their classrooms.

The curriculum-writing process has consistently been a catalyst for reflective and challenging conversation among the project leadership. Writing new units, and extensive revisions of existing units, is now also playing an important role for a small group of teachers involved in the program. In a sense, this writing and revising process is a mechanism through which these teachers are developing and clarifying their own goals and expectations for modeling and systems thinking within their curriculum. These teachers are acting as an important link connecting other project participants to this process, as they present their materials both formally and informally at meetings and workshops. The curriculum development process, then, is inviting teachers into exploring the intellectual content of the systems thinking approach in a way that does not necessarily occur through their daily teaching practice.

Teacher Practices

What evidence exists of changes in beliefs and practices among teachers participating in the CoreModels project?

- **Project participants are acting on the ideas and materials they are exposed to in the CoreModels workshops.** Specifically, they are using new curricula (the units themselves), teaching new concepts (systems thinking), expanding their use of technology, and in many cases covering new content or covering existing course content in more depth than before. The eight Supporting Teachers used 65 modeling units, and the thirty Participating Teachers used 171 modeling units in their classrooms during the 1998-1999 school year. All of the physics and biology units created for the CoreModels program were used.

- **Supporting Teachers are taking leadership roles within the project and within their schools, are becoming increasingly invested in acting as mentors and collaborators around systems thinking curriculum issues with other teachers and report a growing reflectiveness about student learning, goals for instruction, and appropriate forms of student assessment.** Consistent differences between Supporting Teacher and Participating Teacher responses in the spring survey indicate that Supporting Teachers are further along in a process of changing their beliefs and practices, and that Participating Teachers are at an earlier point in the same process of change. These differences include: more closely meeting goals for acquiring technology skills and for engaging in technology-related meetings within their schools and at conferences; more closely meeting goals for engaging students in systems thinking and collaborative activities; becoming more interdisciplinary in their teaching; and placing a value on peer-support. Year 3 surveys will allow us to test our hypothesis that Participating Teachers who continue to be active in the project will respond to next year's survey in a manner similar to this year's Supporting Teachers.

- **Group discussions in workshop settings have moved away from technical and logistical discussion and toward discussion of teaching practices, student learning goals and resources to support writing original curriculum.** This was true in both large and small, discipline-specific groups and suggests that as a group CoreModels participants are invested in using group meeting times for reflection and discussion rather than for short-term troubleshooting or skill building. The quality of the conversation continues to grow over time, and the project leadership recognizes this as an evolutionary process that will particularly benefit newer teachers coming into the project as they learn from the experiences of others.
- **As a group, CoreModels participants have reached a general consensus that having students engage in the model-building process is the preferable classroom experience, and that exploring prefabricated models is more appropriate to sessions early in the year when students are first using STELLA.** The relative merits of model building and exploration of existing models was a major question for the group during Year 1 which has for the most part been resolved.
- **Although CoreModels is not primarily a technology integration project, participants consistently report that they have increased their skill and confidence in using technology with their students and that they are using technology to support their teaching more frequently.** This finding is particularly important as evidence that, when technology is treated not as a central issue but as a tool integral to a highly focused exploration of specific content, teachers can gain the same technical skills gained in programs dedicated entirely to technology integration. In the CoreModels context, technology skills become a natural outgrowth of engagement with a content-specific set of pedagogical and conceptual issues.

Student Learning

- **The CoreModels project does not currently promote or share a consistent vision of the importance of modeling to student learning.**

  However, this subject is being discussed and developing understanding around what students are learning from modeling activities is a prominent goal across all levels of project participants. However, participants' perspectives on the relationship between learning about content and learning about systems thinking varies widely. These differences arise, in our view, from the fact that modeling plays different roles and takes varying levels of prominence in individual teachers' classrooms. How they have implemented CoreModels materials in the past, and what goals they have for their implementation in the future, influences their current understanding of how modeling can alter and expand how they teach and what their students learn (see the Growth in understanding section under the Findings section above).

  When teachers' goals for student learning vary, so will their method of implementation, the amount of time they spend on modeling activities, and the kinds of assessments they will use to gauge what their students learned from a modeling activity. Overall, the CoreModels team is heavily focused on engaging students with the conceptual issues underlying modeling in general – these are the issues stressed in the Project 2061 Goals for Science Learning that have formed the basis for the CoreModels team's work on assessment rubrics. In contrast, most participating teachers who are just beginning to use modeling activities understand them as a different avenue into essentially the same body of content knowledge as they were teaching before. Therefore, their interest lies in conducting the same assessments they were using previously, and their teaching proceeds accordingly. Consequently, they are unlikely to work to enhance students' understanding of the underlying modeling principles they are working with.

  What is important to note here is that though teachers have their own ideas about the relationship between modeling and student learning, those ideas do not belie the potential of the curricula or of the teacher him- or herself to successfully engage students with highly sophisticated notions of systems dynamics. Rather, through the quality of their participation in the CoreModels program teachers are making it clear that they need to go through a process of adaptation and assimilation in which they first make modeling make sense in the context of their existing practices. Only after they have done this, then, do they begin, over time, to adapt their practices to take advantage of the new or enhanced opportunities for inquiry and learning made possible by the modeling tools and curricula.

Recommendations

These recommendations raise issues that are appropriate for long-term consideration and discussion by the CoreModels leadership. They relate to the overall framing of the CoreModels project, and to strategic, long-term planning for the program. In some cases they may imply modifications to the program that are not possible given the remaining time and resources available for the project. However, they should be considered as initial responses to important issues in the program which might be addressed in the near term or considered in more depth for future program development.

- **Use workshop time to engage CoreModels teachers directly with the systems thinking concepts that bridge across multiple content areas.** The CoreModels program strikes a balance between challenging teachers, both intellectually and pedagogically, and respecting their autonomy to implement and experiment with new ideas and new materials in their classrooms at their own pace. The findings of this evaluation suggest that CoreModels participants recognize and appreciate this balance.

  At the same time, this evaluation also indicates that teachers are rapidly developing an increasing interest in finding ways to think about and explore the role that modeling may be playing in shaping and supporting what their students are learning. Therefore, Year Three is an opportune time for the CoreModels leadership to move forward and challenge participants to engage with the conceptual framework underlying the use of systems thinking as a science learning tool for high school students. Many teachers, particularly among the Supporting Teachers, are already deeply engaged with these issues, but the group as a whole will benefit from working together to build a stronger understanding of the common themes being addressed across the many CoreModels units (change over time, the heuristic nature of models, etc.). The findings of this evaluation suggest strongly that program participants are interested in engaging with these ideas and that they will continue to appropriate and interpret group discussions and program goals to fit their own personal needs, circumstances and priorities. Therefore, it would be worthwhile to support a group of teachers who are already focused on these cross-cutting systems thinking concepts to organize and lead sessions on these topics (and their relationship to goals for student learning) during program workshops this year.

- **Strengthen the peer-support component of the program by loosening the definition of the relationships and structuring the process of identifying and setting goals for collaboration.** The peer support component of the program, while inevitably challenging, is important and deserves continued support. The findings of this evaluation suggest that two changes are needed. First, the definition of who can or should support or collaborate with whom needs to be reconceptualized to include in-school, cross-discipline collaborations, work with non-CoreModels teachers, and other relationships that are logistically practical and personally comfortable to participants. To a large extent this is already happening.

  Second, the CoreModels leadership needs to design and institute a process to help project participants define their own needs or interests that could be supported by peer collaboration and set clear goals to be accomplished through that collaboration. Imposing some strong structures on this process seems to be necessary, because our findings suggest that participants continue to place value on peer support in principle, but do not spontaneously identify substantive areas of work that they want to take on with a peer support partner. This is not surprising since collaboration is not traditionally valued or institutionally supported for teachers; therefore the extra "push" provided by setting clear, personal tasks and goals seems to be necessary and may lead more teachers into substantive and worthwhile partnerships with other teachers or groups of teachers.

  Finally, participants also need some combination of clear expectations and incentives to both push and encourage them to make the effort to do substantive work with their collaborators. Collaboration does take significant time and effort and, as this evaluation demonstrates, believing that it is important in principle is not reason enough for teachers to make it happen.

- **Collect and evaluate student work, to gain insight into participants' classroom implementations of the materials and to spur the development of shared criteria and scoring tools.** Engaging with evidence of student work from various CoreModels classrooms will provide an important opportunity for the leadership of this project to make connections between the diverse implementation strategies of the project participants and the development of a core set of criteria for evaluating student learning in this program. In turn, the creation and consequent discussion of these criteria and scoring tools should help to engage the entire group of CoreModels participants in reflection on the over-arching goals of the CoreModels program relative to student learning. Although there were many productive discussions of both implementation and assessment at all levels of the program this year, during Year Three it will be important to bridge these two aspects and to increase the program emphasis on the common themes, related to modeling, that students should be engaging with in their modeling activities.

- **Create new forums for teachers to share and build on one another's curriculum-writing efforts.** Evidence from this evaluation suggests that even teachers who are not currently interested in direct classroom observation and extended discussion of teaching practices with their peers are interested in working with others around the development and modification of curriculum and assessments. In the same way that the CoreModels definition of peer-support is currently being broadened and diversified, it may be appropriate to open up the program's curriculum writing process to engage more teachers and to support teachers not only in writing entirely new units, but in modifying, extending, and elaborating existing units. Several other teacher collaboration projects have invested in using the World Wide Web to document and disseminate similar efforts, such as the Access Excellence website for high school biology teachers (www.accessexcellence.org) and the American Memory Fellows Program, sponsored by the Library of Congress for American history teachers. A similar mechanism for might be appropriate for the CoreModels community. Project leadership should consider what kinds of supports might be made available to guide teachers in making thoughtful and appropriate modifications to existing curriculum. What kinds of templates, models, or resources could be made available to support teachers in this process? Taking on this task might be an appropriate role for a group of teachers particularly interested in the curriculum development component of this program.
- **Encourage discussion about pedagogical strategies and learning expectation across academic tracks.** Despite the stated interest of the CoreModels project in demonstrating how modeling can be a part of science learning for all students, program participants clearly have strong beliefs about how and whether students in different academic programs can benefit from modeling and systems thinking (although these beliefs do vary, sometimes diametrically; see the subgroup section of this report, above). Most frequently, teachers do not feel that students in lower academic tracks can benefit from modeling to the same extent as students taking more advanced science sequences.

Other research projects have demonstrated that students taking lower-level science sequences can benefit from working with the core concepts involved in studying dynamic systems (Dede, 1998; Honey, McMillan, Tsikalas, & Grimaldi, 1995; Honey, McMillan, Tsikalas & Light, 1996; Krajcik, Soloway, Blumenfeld, & Marx, 1998; Soloway, Jackson, Klein, Quintana, Reed, Spitulnik, Stratford, & Studer, 1996). The CoreModels project leadership needs to address this subject directly with the program participants and encourage teachers both to articulate their existing beliefs and to consider alternative views about this subject. This seems to be particularly important this year, when environmental and earth science teachers (who are working more frequently with students in lower academic tracks) are joining the program. It would be dispiriting for them and unfortunate for the project if they felt that other teachers believed that the subject of this program—modeling and systems thinking—was inappropriate for the very students that they work with most intensively.

[1] Throughout this report the phrase "CoreModels staff" or "CoreModels team" will refer to the Project Director and Principal Investigator, Mary Ellen Verona, and the three regional Center Directors, Susan Ragan (Central Maryland), Don Schaffer (Northern Maryland), and Charlotte Trout (Western Maryland).