BSCS National Academy for Curriculum Leadership
Washington State, Cohort 2

Final Evaluation Report

May 20, 2011

BSCS Evaluation Report (ER 2011-04)

Biological Sciences Curriculum Study
5415 Mark Dabling Blvd.
Colorado Springs, CO 80918
719.531.5550

II. OVERVIEW OF THE NACL PROGRAM

The BSCS National Academy for Curriculum Leadership (NACL) is a three-year professional development program for secondary science leadership teams. The design of the NACL Program is based on the core belief that when inquiry-oriented, standards-based instructional materials are implemented in conjunction with an ongoing professional development program designed to transform teachers' thinking and promote collaboration, the combination can contribute to building both a professional learning community in schools and improving student achievement.

The NACL is designed to support leadership teams comprised of:

- **A key administrator:** science supervisor, district curriculum coordinator, building principal, assistant principal, or science department chairperson with budget authority
- **A coach:** teacher or supporter selected from among the team members to facilitate and guide the team as it works together to become more reflective about adult learning and the change process
- **At least two science teachers:** involved in the implementation of new instructional materials

Optional Team Members:

- **Additional Teachers:** especially teachers representing other high schools in the district or teachers from content areas that will soon be selecting new instructional materials.
- **A district or community supporter:** recruited to support the team's efforts; could be a school board member, a consultant, retired teacher, pre-service teacher educator, or member of the business community

The Three-Year NACL Program

Annually, the NACL features *one leadership institute* for team coaches and key administrators, *two whole-group events*—one in the summer or fall and one in the spring, and *on-site technical assistance*. NACL leadership teams take back to their schools and districts new knowledge, skills, and tools useful in designing and supporting a comprehensive professional development program needed to build a *self-sustaining* learning community within their own school and district as they focus on implementing inquiry-based instructional materials and improving student learning.

The program for which this report is developed was a partnership between the BSCS and Washington State Leadership and Assistance for Science Education Reform (LASER). The NACL meetings studied took place between August 2008 and April 2010. All meetings were held in Richland, WA. This report documents the research questions, design, analysis, and conclusions about the NACL scale-up initiative based on the NACL developed through two national development cohorts of leadership teams supported by a grant from the National Science Foundation. The scale-up effort involved the testing of a regional model of the NACL in Washington State and involved teams from Washington, one team from Anchorage, AK, and a team of Regional LASER Alliance Directors along with a faculty of Washington-based experienced PD providers who supported teams, provided technical assistance, and co-facilitated sessions.

Mission

The mission of the BSCS National Academy for Curriculum Leadership is to assist schools and districts in building the capacity to design, implement, and sustain an effective secondary science education program using inquiry-based instructional materials that address the *National Science Education Standards.*

Outcomes

As a result of participating in the NACL program, Leadership Teams will

- Develop and implement a school or district plan focused on changing the learning and teaching of science through the implementation of inquiry-based instructional materials. Teams will accomplish this by
  - applying tools and strategies for effective analysis and selection of inquiry-based instructional materials;
  - designing and initiating a strategic plan for ongoing professional development that incorporates a variety of models, links professional development to teacher change, school change and student learning, and includes an evaluation component; and
  - sustaining the impact of curriculum implementation on students, teachers, and other members of a school community.
- Use facilitation skills and reflective dialogue to help plan, build collegiality, mediate conflicts, and monitor group processes;
- Develop an understanding of the research on teachers' professional communities, curriculum implementation using inquiry-based instructional materials, transformative professional development, and organizational change in schools; and
- Establish a professional learning community among a school's science teachers that demonstrates shared norms and values, a collective focus on student learning, collaboration, deprivatized practice, and reflective dialogue.

Guiding Principles

- The *National Science Education Standards* provide a **vision** of effective science education. In order to realize this vision, school- and district-based Leadership Teams need an increasingly wide range of knowledge and skills, which comes from research, reflective practice, and the expertise of other practitioners.
- A **professional learning community** is the cornerstone of sustainable curriculum implementation and focuses on a collective sense of responsibility for the learning of both students and adults in a school community.
- **Curriculum** can transform the professional practice and thinking of teachers. The implementation of standards-based, inquiry-oriented instructional materials, combined with sustainable professional development opportunities, can have a significant impact on teaching science and student learning.

- **Leadership** for curriculum reform is a shared process that includes understanding adult learning, accommodating the challenges of change, building relationships, and facilitating groups. Curriculum leadership involves building the ongoing capacity for reflective dialogues to construct common understandings and beliefs about curriculum reform.
- The content and pedagogy of **professional development** must be designed through reflective practice to transform teachers' knowledge and beliefs about learning and teaching.

Table 1. NACL Staff

BSCS	Jody Bintz, Director of BSCS National Academy for Curriculum Leadership Meridith Bruozas Elizabeth Edmondson
Pacific Northwest National Laboratory (PNNL)	Jeff Estes Kathy Feaster Alley Tracie Taylor Ann Wright-Mockler Peggy Willcutts, Lead Faculty
Faculty	Anne Kennedy, Vancouver, WA, Lead Faculty John Henry, Port Angeles, WA Pat Ehrman, Seattle, WA Bonnie Lock, La Center, WA Mike Brown, Yakima, WA Year 1- Mary McClellan, Issaquah, WA Year 1- Royace Aikin, Richland, WA
Consultant	Year 1 - Jim Short, American Museum of Natural History

Major Funding

- Battelle

Support

- Pacific Northwest National Laboratory, Operated by Battelle for the U.S. Department of Energy
- Pacific Science Center
- Agilent Technologies Foundation (Year 1)

Participants

At the Fall and Spring meetings, each team included one coach and one key administrator. The coaches and key administrators functioned as liaisons between the BSCS professional development staff and the team, and also attended the Summer Leadership Institutes to prepare for their work with their teams throughout the following year. Fourteen teams began the NACL Academy in year 1. Thirteen teams continued in year 2 and eleven teams completed the three year Academy program (Table 2). Of the eleven teams completing the program, nine were composed of Washington state teachers and administrators. One team was from Alaska and one team was composed of Washington State LASER Directors. The LASER Alliance Regional Directors attended only the Academy meetings.

Table 2. Teams participating in Year 3 of the NACL

Anchorage, AK
Everett
Highland
Issaquah
Mabton
Richland
South Kitsap
Tumwater
Walla Walla
Wapato
Laser Alliance Directors

Table 3. Participants in the nine Washington NACL meetings

		Dates	Participants	Teams
Year 1	Leadership Institute	August 5-9, 2007	26	13
	Fall Academy Meeting	November 11-16, 2007	78	14
	Spring Academy Meeting	March 2-4, 2008	76	14
Year 2	Leadership Institute	August 10-14, 2008	23	12
	Fall Academy Meeting	November 16-21, 2008	70	13
	Spring Academy Meeting	March 1-3, 2009	74	13
Year 3	Leadership Institute	August 9-13, 2009	18	10
	Fall Academy Meeting	November 15-20, 2009	68	11
	Spring Academy Meeting	February 28-March 2, 2010	68	11

III. OVERVIEW OF RESEARCH DESIGN

Research Questions

The research study for Cohort 2 of the Washington NACL was conceptualized by developing a set of questions to focus the collection and analysis of data. Four overarching questions were developed to examine the extent to which the outcomes (identified above) of the NACL were met. These questions are:

- *Inquiry-based Instructional Materials*: To what extent does the NACL impact the participants understanding, beliefs and choices with regard to the selection and implementation of reform-based curriculum?

- *Professional Development/Support:* To what extent does the Professional Development strand of the Academy impact NACL teams and their colleagues' ability to develop and enact a sustainable PD program?

- *Leadership:* To what extent does the NACL impact the participating teams' understanding of leadership, leadership skills, and ability to enact change in their school/district?

- *Systems Impact:* To what extent does participation in the NACL impact the system (school/district)?

After the development of these questions, instruments to collect the necessary answers to the questions were identified and/or developed. The overarching research questions drove the development of meeting evaluations and identification of supplemental data to be collected throughout the three-year Academy.

Thomas Guskey's (2000) levels of evaluating professional development provided a framework for the research questions and guided the selection of appropriate measurement instruments to be included within the meeting evaluations. The three levels that were attended to for this analysis were:

- **Level 2** data on what the participants' prior understanding and beliefs are about the major themes to be addressed in the Academy meeting.
- **Level 3** data on organizational support and change requirements needed to support the new innovations with an organization climate questionnaire.
- **Level 4** data on participant use of the knowledge and skills that they gained from participation in the NACL.

Instrumentation, Data Collection, and Analysis

Data collection tools included surveys, classroom observations, interviews, and artifacts (district documents, team reports, professional development plans). Surveys included traditional pre-test, retrospective pretest and posttest questions as appropriate. Data collection instruments were given to all attendees on the first evening of each meeting of the NACL. Participants were asked to complete the appropriate pages of the surveys at the end of each day of NACL activities. Participants were offered paper copies of the surveys in year 1 and paper or Surveymonkey online surveys in subsequent years.

For the Guskey (2000) Level 2 and 3 items, participants were asked to rate their understandings of the content addressed during NACL sessions as well as their beliefs and values through both a traditional pretest/posttest design and a retrospective pretest and posttest. The pretest/posttest examination of data allowed for the comparison of participants' ideas prior to the Academy to those at the end of the three year Academy. The retrospective pretest asked participants to rate their understandings and agreement by "thinking back" to before their participation in the NACL. The posttest asked participants to rate their understanding or agreement "right now" (after the NACL event). They also responded to questions about the frequency with which they use pertinent elements of the NACL program as well as their assessment of how likely they would be to use newly acquired skills and knowledge when they returned home. Participants were also asked to comment on a number of open-ended questions regarding their use of knowledge, skills, tools, and processes included in the NACL program.
Data analysis involved both quantitative and qualitative methods. For questions involving rating scales, the means and standard deviations were calculated. A statistical comparison of retrospective pretest and posttest data was conducted via a t-test and effect size (Cohen's d). Effect size is a measure of practical significance and is expressed as the difference in standard deviations from one test time point to another. Cohen

characterized a small effect size as less than .30, a moderate effect as .30–.80, and any effect size over .80 as large (Cohen, 1988).Artifacts were analyzed using qualitative methods to identify themes and unique aspects of participants.

For Guskey (2000) Level 4, the Reform Teaching Observational Protocol (RTOP) (Sawada, et al 2002 & Piburn, et al 2000) was used to annually assess science teachers' practice over the course of the program. From the first-year participants, we obtained a sample of twenty teachers. These teachers were observed each of the three years during the NACL. The items on RTOP measure constructs that are similar to the goals for science teaching and learning, instructional materials, and assessment promoted by the BSCS National Academy for Curriculum Leadership. The instrument uses criterion-referenced items scored from 0 (not observed) – 4 (very descriptive) for each item. There are twenty-five items with a total possible score of 100 in five subcategories.

I. Lesson Design and Implementation
II. Content – Propositional Knowledge
III. Content – Procedural Knowledge
IV. Classroom Culture – Communicative Interactions
V. Classroom Culture – Student/Teacher Relationships

The higher the total score on the instrument, the more reform-oriented the classroom. The RTOP instrument has been normalized for four different groups. For middle school classrooms, a score of 50 or above indicates the presence of some level of reform teaching. For high school classrooms, a score of 41.8 or above indicates the presence of some level of reform teaching (Piburn,et al 2000). A matched pair statistical comparison of the means for Year 1 to Year 2, Year 2 to Year 3, and Year 1 to Year 3 was conducted. The use of matched pairs allows for comparisons within a specific teacher between adjacent years.

IV. RESULTS

This section presents the results across the nine evaluation questionnaires and synthesis of other documents. The results are organized, into four major outcome categories that address impacts on the NACL participants. The categories are:

1. Inquiry-based Instruction and Reform-based Instructional Materials
2. Professional Development
3. Leadership
4. Systems

Each section details appropriate findings related to the impact on participants' beliefs and learning, use of tools and resources and measureable impact at the home site.

Instructional Materials and Inquiry-based Instruction

One guiding principle of the NACL is that **curriculum** can transform the professional practice and thinking of teachers. The implementation of standards-based, inquiry-oriented instructional materials, combined with sustainable professional development opportunities, can have a significant impact on teaching science and student learning. In addition, the *National Science Education Standards* provide a **vision** of effective science education. In order to realize this vision, school- and district-based Leadership Teams need an increasingly wide range of knowledge and skills, which comes from research, reflective practice, and the expertise of other practitioners.

Findings Related to Research Question 1

To what extent does the NACL impact the participants and their district colleagues' vision for science teaching and learning? Does the NACL influence their understanding, beliefs and choices with regards to the selection and implementation of reform-based curriculum?

Participant Beliefs and Learning

One strand in the NACL program is supporting participants in the development of a shared understanding of science as inquiry as described in the *National Science Education Standards (NSES)* (NRC, 1996). This shared understanding contributes to the development of a vision of effective science teaching and learning. During their learning experiences participants' beliefs about learning and teaching are surfaced and they are provided scaffolded opportunities to compare their beliefs to those of other team members and other participants in the cohort as well as to relevant research and literature.

Participants' beliefs about science as inquiry as described in the *NSES* changed over the course of the NACL Program. The following agreement (attitudes) about the role of inquiry in the classroom had statistically significant increases from Year 1 to Year 3 of the NACL (Table 4).

- Students can learn science subject matter (e.g., photosynthesis, plate tectonics) through inquiry.
- Inquiry-based teaching strategies should be the primary way that science is taught
- Inquiry can involve students conducting an investigation based on a question supplied by the *teacher*.
- I am comfortable using inquiry-based teaching strategies.
- Inquiry can involve students in experiences that fall along a continuum from more teacher/materials directed to more student-directed.

The question about participants' comfort level using inquiry-based teaching strategies yielded the largest effect size (d=1.08) among these statistically significant results.

Table 4. Understanding and Beliefs about Inquiry-based Instructional Strategies

How would you describe your **agreement** with the following:	**Initial Year 1 Mean/Std dev**	**Final Year 3 Mean/Std dev**	**t-test, df, p value**	**Cohen's d Effect Size**
1. Students can learn science subject matter (e.g., photosynthesis, plate tectonics) through inquiry.	4.36 .70	4.68 .48	t=2.55 df=24 p<.05	0.53
2. Inquiry-based teaching strategies should be the primary way that science is taught	3.88 .93	4.56 .71	t=3.30 df=24 p<.01	0.82
3. Inquiry can involve students conducting an investigation based on a question supplied by the *teacher*.	3.88 .67	4.56 .92	t=2.72 df=24 p<.05	0.84
4. I am comfortable using inquiry-based teaching strategies.	3.88 .93	5.08 1.26	t=4.00 df=24 p<.001	1.08
5. Inquiry can involve students in experiences that fall along a continuum from more teacher-materials-directed to more student-directed.	4.13 .68	4.88 1.04	t=3.89 df=23 p<.001	0.85

Two questions from this section of the survey were not statistically or practically significant (Table 5). These two questions were about participants' beliefs related to difficulty covering required content when using inquiry-based teaching strategies and describing inquiry-based learning experiences as "hands-on." Based on our intended outcomes, the decrease in the two means—albeit slight and not statistically significant—and negative effect sizes provide some indication that participants' beliefs shifted in the desired direction and therefore are more consistent with the understandings about science as inquiry described in the *National Science Education Standards*—not all inquiry learning experiences involve hands-on activities.

Table 5. Beliefs about inquiry-based teaching methods (5 point scale)

How would you describe your **agreement** with the following:	**Initial Year 1 Mean/Std dev**	**Final Year 3 Mean/Std dev**	**t-test, df, p value**	**Cohen's d Effect Size**
1. It is difficult to cover the required content of my science course when inquiry-based teaching methods are used	3.32 1.28	3.00 1.83	t=-1.05 df=24 p=ns	-0.20
2. Inquiry learning experiences should be hands-on activities.	3.68 .80	3.36 1.63	t=-.902 df=24 p=ns	-0.13

Participants' understanding of science as inquiry and inquiry-based instruction increased significantly with large effect sizes (ranging from d = .74 to 1.90) from Year 1 of the NACL to Year 3 (Table 6):

- Teaching strategies that can be used to support student inquiry as described in the *National Science Education Standards.*
- The Five Essential Features of Classroom Inquiry described in *Inquiry and the National Science Education Standards* (NRC, 2000)
- How to help students develop the skills and abilities to "do" science
- How to help students learn science subject matter (e.g., plate tectonics, photosynthesis) through inquiry-based teaching strategies

Table 6. Understanding and Beliefs about Inquiry-based Instructional Strategies (5 point scale)

How would you describe your level of **understanding** of the following:	**Initial Year 1 Mean/Std dev**	**Final Year 3 Mean/Std dev**	**t-test, df, p value**	**Cohen's d Effect Size**
1. Teaching strategies that can be used to support student inquiry as described in the *National Science Education Standards*	3.23 .91	4.38 .64	t=8.72 df=25 p<.001	1.46
2. The Five Essential Features of Classroom Inquiry described in *Inquiry and the National Science Education Standards*	2.81 .85	4.27 .68	t=8.67 df=25 p<.001	1.90
3. How to help students develop the skills and abilities to "do" science	3.73 .78	4.27 .68	t=3.61 df= 25 p<.001	0.74
4. How to help students learn science subject matter (e.g., plate tectonics, photosynthesis) through inquiry-based teaching strategies	3.65 .89	4.35 .69	t=3.49 df=25 p<.01	0.88

The Analyzing Instructional Materials (AIM) Process and Tools served as the primary vehicle for surfacing participants' beliefs about reform-based instructional materials. AIM is designed in two parts: the Paperscreen Process and Tools to support the selection of instructional materials and the Implementation Process and Tools to support the pilot, field-test, or implementation of instructional materials in the classroom. Through the use of the AIM Paperscreen, teams work together to gather evidence from instructional materials, visually represent the evidence through the development of a conceptual flow graphic (CFG), and analyze the evidence using criteria of high quality instructional materials drawn from relevant research and literature.

Participants' beliefs about instructional materials changed over the course of the three year program. Results for questions about the usefulness and value of instructional materials are statistically and practically significant with p<.05 and moderate effect sizes (Table 7).

- Instructional materials can be useful in supporting inquiry learning and teaching.
- If instructional materials are well designed and based upon research, they should guide the organization and sequencing of science instruction.
- The role of high quality instructional materials is to support both what is taught and how it is taught.

One question yielded a negative effect size (although not statistically significant). This question asked participants to consider their level of agreement with the following: Any set of instructional materials should be used primarily as a resource from which teachers can pull out student activities. The slight shift in mean is an indication of a shift in beliefs away from a "hunter and gatherer" mentality.

- Any set of instructional materials should be used primarily as a resource from which teachers can pull out student activities.

Table 7. Beliefs about Inquiry-based Instructional Materials (5 point scale)

How would you describe your **agreement** with the following:	**Fall Year 1 Mean/Std dev**	**Spring Year 3 Mean/Std dev**	**t-test, df, p value**	**Effect Size**
1. Instructional materials can be useful in supporting inquiry learning and teaching.	4.50 .51	4.77 .43	t=2.27 df=25 p<.05	0.57
2. If instructional materials are well designed and based upon research, they should guide the organization and sequencing of science instruction.	4.19 .80	4.69 1.12	t=2.39 df=25 p<.05	0.51
3. The role of high quality instructional materials is to support both what is taught and how it is taught.	4.46 .51	4.88 .99	t=2.10 df=25 p<.05	0.53
4. Any set of instructional materials should be used primarily as a resource from which teachers can pull out student activities.	3.50 1.11	3.27 1.78	t=-0.63 df=25 p= ns	-0.16

Over the course of their experience, participants developed a greater appreciation for AIM as an evidence-based process that contributes to making the selection of instructional materials as an opportunity for professional learning. However, a key aspect of AIM is the collaborative use of the process and tools. While participants reported AIM as one of the most valuable aspect of the NACL in open-ended responses in each meeting in which the AIM Process and Tools was highlighted (BSCS, 2008a; BSCS 2008b, and BSCS 2009), the retrospective pre and posttest results related to this aspect of AIM were not significant.

Table 8. Beliefs about the AIM Process and Tools (5 point scale)

How would you describe your **agreement** with the following:	**Initial Year 1 Mean/Std dev**	**Final Year 3 Mean/Std dev**	**t-test, df, p value**	**Cohen's d Effect Size**
1. The selection of instructional materials should be based on compelling evidence gathered from the materials.	4.23 .77	4.77 .43	t=0.90 df=25 p<.01	0.87
2. Selecting instructional materials should be viewed as professional development.	4.00 1.08	4.76 1.09	t=1.23 df=24 p<.01	0.70
3. **Selecting instructional materials should be a collaborative process.**	4.77 .51	4.96 .92	t=0.61 df=25 p= ns	0.26
4. Creating a conceptual flow diagram can develop a shared understanding of how concepts are developed in instructional materials.	4.04 .75	4.54 .66	t=0.87 df=23 p<.05	0.71

Use of Tools

Throughout the NACL participants had several opportunities to deepen their understanding of inquiry-based strategies with a focus placed on the development of scientific explanations. At the end of Year 3, participants were asked to identify whether they had used inquiry-based teaching strategies or plan to use them in the future (Table 9). The majority of the participants (>90%) indicated using inquiry strategies more than once in their classroom or work. More than 60% of the participants indicated having used the "explanation tool" adapted from the work of Sutherland, McNeill, Krajcik, and Colson (2006) to scaffold students' construction of scientific explanations. This represents the majority of the classroom teacher population participating in NACL. It should be noted that participants may well have used the strategy more than once as well as included the strategy in their plans. The Likert scale did not allow for multiple responses.

Table 9. Percent, Means, and Standard Deviation for the Likelihood of Use of the following tools/strategies

What is the level of use at your home site?	Not used 1	Our plan has us using in the future 2	Used Once 3	Used More than Once 4	Mean	Std. Dev.
1. Use inquiry-based teaching strategies in your classroom or work in the district.	0	4.3	2.2	93.5	3.89	.43
2. Use the explanation tool to support students' construction of scientific explanations.	17.4	10.9	6.5	65.2	3.2	1.20
3. Use the explanation tool to introduce colleagues to the use of scientific explanations with students.	22.2	13.3	17.8	46.7	2.89	1.23

At the end of Year 3, participants were asked to indicate the overall usefulness of their new knowledge and skills about Inquiry. Greater than 90% of the participants felt that this new knowledge and skills were useful or very useful (mean is 4.63 out of 5) (Table 9).

Table 10. Percent, Means, and Standard Deviation for the overall usefulness of knowledge and skills gained from the NACL

How would you rate the degree to which the knowledge and skills gained from the NACL are useful to your work, your school(s) and/or district?	Not useful at all 1	2	Somewhat Useful 3	4	Very Useful 5	Mean	Std. Dev.
Inquiry	0	0	8.2	20.4	71.4	4.63	.64

NACL teams also used the AIM Process and Tools back home. Fifty percent of the participants indicated having used the AIM Process and Tools at least once to support collaborative curriculum implementation (Table 11). Twenty-seven percent of the participants indicated that their professional development plans included the use of the AIM Process and Tools. According to their professional development plans, eights of ten school-based teams included instructional materials selection and/or implementation in their professional plans. All eight of these teams indicated that AIM or some aspect of AIM would play a role in the enactment of their PD Plans including the selection and/or implementation of instructional materials.

The AIM Process and Tools can be also be used to support the identification and evaluation of assessments of and for student learning. The use of the AIM Process and Tools for assessment was introduced during Year 2. The final year of data showed little change in participants' understanding of how to use the AIM Process and Tools for identification and evaluation of assessments. Over thirty percent of the participants indicated having used the AIM Process and Tools for the identification and evaluation of assessments. Another 34 percent of the group plan to use

the AIM process to evaluate the quality of assessments in the future (see Table 11). It should be noted that participants may well have used the strategy more than once as well as included the strategy in their plans. The Likert scale did not allow for multiple responses.

Table 11. Percent, Means, and Standard Deviation for the Likelihood of Use of the following tools/strategies

What is the level of use at your home site?	Not used 1	Our plan has us using in the future 2	Used Once 3	Used More than Once 4	Mean	Std. Dev.
1. Use the AIM Implementation Process and Tools to support collaborative curriculum implementation.	19.1	27.7	23.4	29.8	2.64	1.11
2. Use AIM Implementation Process and Tools to evaluate assessment of and for student learning.	23.4	34	12.8	29.8	2.49	1.16

Impact

After the last meeting of the NACL, participants responded to questions about the usefulness of various components of the NACL in their work back in their school or district. They reported finding great value in the knowledge and skills gained through the program related to selecting instructional materials with a mean response of 4.29 (between "Useful" and "Very Useful" on a 5 point Likert scale (Table 12).

Table 12. Percent, Means, and Standard Deviation for the overall usefulness of knowledge and skills gained from the NACL

How would you rate the degree to which the knowledge and skills gained from the NACL are useful to your work, your school(s) and/or district?	Not useful at all 1	2	Somewhat Useful 3	4	Very Useful 5	Mean	Std. Dev.
Selecting Instructional Materials	0	8.3	6.3	33.3	52.1	4.29	.92

One overall measure of the impact of the NACL program is the number of teams that selected and implemented reform-based instructional materials during their participation.

Selection & Implementation of Instructional Materials (Year 3 data)

- 4 districts selected and implemented reform-based instructional materials as part of their participation in the program
- 1 district implemented reform-based materials during their participation in the program.
- 3 districts implemented reform-based instructional materials as part of their participation in the combination DOE-ACTS program and Academy program.
- 3 districts agreed to participate in a BSCS Research Study focused on studying the impact of the implementation of *BSCS Science: An Inquiry Approach (BSCS, 2006)*. At the time of the study, 1 team dropped their participation.
- 1 district plans to select reform-based instructional materials in the near future.1 team piloted units from various programs and selected a more traditional textbook

Table 13. Instructional Materials Selection by Team

TEAM	Reform-based materials adopted prior to NACL	Reform-based materials selected and/or implemented during or just after the NACL
Team 1	Elementary and Middle School Kit Program	No new materials were selected; Team began implementing *SEPUP* as a result of DOE ACTS
Team 2	*BSCS Biology: A Human Approach* *Active Coordinated Science* (It's About Time)	Selected Key Curriculum Press: *Living by Chemistry* (AIM year 1 of cohort 2)
Team 3	Some Middle School kits	No materials selected; BSCS Research Study 2009-2011 (Control Group) *BSCS An Inquiry Approach*
Team 4	*FOSS* Middle School kits, *NSRC STC* Middle School, *SEPUP*	No new materials were selected; Team began implementing *SEPUP* as a result of DOE ACTS
Team 5	none	Materials selected spring of 2010 for 2010-2011 *It's About Time: Project-Based Inquiry Science* and *BSCS Science: An Inquiry Approach* Levels I and II
Team 6	*FOSS* Middle School kits, *NSRC STC* Middle School	No new materials selected; Team began implementing *SEPUP* as a result of DOE ACTS; District announced after Christmas 2009 that they would be going through an adoption process 2010-2011
Team 7	none	Implemented *BSCS Science: An Inquiry Approach Level I* in 2008-2009 and *BSCS Science: An Inquiry Approach Level II* in 2009-2010
Team 8	none	Piloted various Middle School units (year 1 and year 2)*Chemistry- Prentice Hall* (adopted end of year 1)
Team 9	*BSCS Biology: A Human Approach*	BSCS Research Study 2009-2011 (Treatment Group) implemented *BSCS Science: An Inquiry Approach Level I* 2009-2010 and *Level II* 2010-2011
Team 10	none	Planned to participate in BSCS Research Study- implemented *BSCS Science: An Inquiry Approach Level I* in 2011-2012 however, they did not complete the process

Another indication of the impact of the NACL is changes in district policies guiding the curriculum adoption process. Of the districts participating in the NACL, key administrators from five of the nine districts reported that the AIM Process and Tools had become part of their district policy for selecting instructional materials.

While the acts of selecting and implementing reform-based instructional materials is an expected and important step in the work of the NACL team, the purpose is to improve classroom instruction. Twenty randomly selected teacher participants were observed in their classrooms each year. Of these 20 teachers, up to 18 were able to participate each year. Both middle school and high school classrooms were observed using the Reformed Teaching Observation Protocol (RTOP) developed and normed by the Arizona Collaborative for Excellence in the Preparation of Teachers at Arizona State University (Piburn, et al. 2000).

At the middle school, RTOP scores greater than 50 out of a possible 100 indicate some level of reform-based teaching practices in the classroom. At the high school, RTOP scores greater than 41.8 out of a possible 100 indicate some level of reform-based teaching practices in the classroom. In the final year of the NACL, the RTOP scores for four of seven middle school teachers observed were greater than 50. At the high school level, 7 of ten teachers' RTOP scores were greater than 41.8 (Table 14).

Table 14. Top RTOP Scores for Middle and High School for Years 1 through 3

	Middle School Scores >50		High School Scores >41.8	
Year 1	60% of teachers observed	3 of 5	50% of teachers observed	6 of 12
Year 2	66.7% of teachers observed	4 of 6	41.7% of teachers observed	5 of 12
Year 3	57.1% of teachers observed	4 of 7	70% of teachers observed	7 of 10

RTOP scores can be broken down into five categories:

I. Lesson Design and Implementation,
II. Content - Propositional Knowledge,
III. Content - Procedural Knowledge,
IV. Classroom Culture - Communicative Interactions, and
V. Classroom Culture - Student/Teacher Relationships.

The total possible score for each category is 20. Figure 1 shows the mean of scores for each of the categories for years 1 to 3 in Table 15 below. An increase in the mean for a category indicates a move toward more reform oriented classroom practice.

Table 15. RTOP Mean, Standard Deviation and Range by Category for Years 1 through 3

	Year 1 N= 17		Year 2 N= 18		Year 3 N= 17	
	Mean/Std Dev	**Range**	**Mean/Std Dev**	**Range**	**Mean/Std Dev**	**Range**
I. Lesson Design and Implementation	8.13/ 4.39	3 to 18	8.72/ 4.88	3 to 16	11.12/ 4.94	4 to 18
II. Content - Propositional Knowledge	12.53/ 4.47	5 to 20	12.61/ 4.33	5 to 19	13.29/ 4.83	4 to 20
III. Content - Procedural Knowledge	6.8/ 3.75	0 to 15	8.11/ 4.76	2 to 19	10.35/ 5.45	1 to 17
IV. Classroom Culture - Communicative Interactions	8.00/ 4.29	2 to 15	7.72/ 4.13	3 to 17	11.77/ 4.27	5 to 17
V. Classroom Culture - Student/Teacher Relationships	9.33/ 3.77	3 to 17	9.33/ 5.04	3 to 20	12.88/ 4.04	6 to 19
Overall	46.47/ 18.33	19 to 74	47.76/ 20.88	20 to 90	57.88/ 21.5	27 to 86

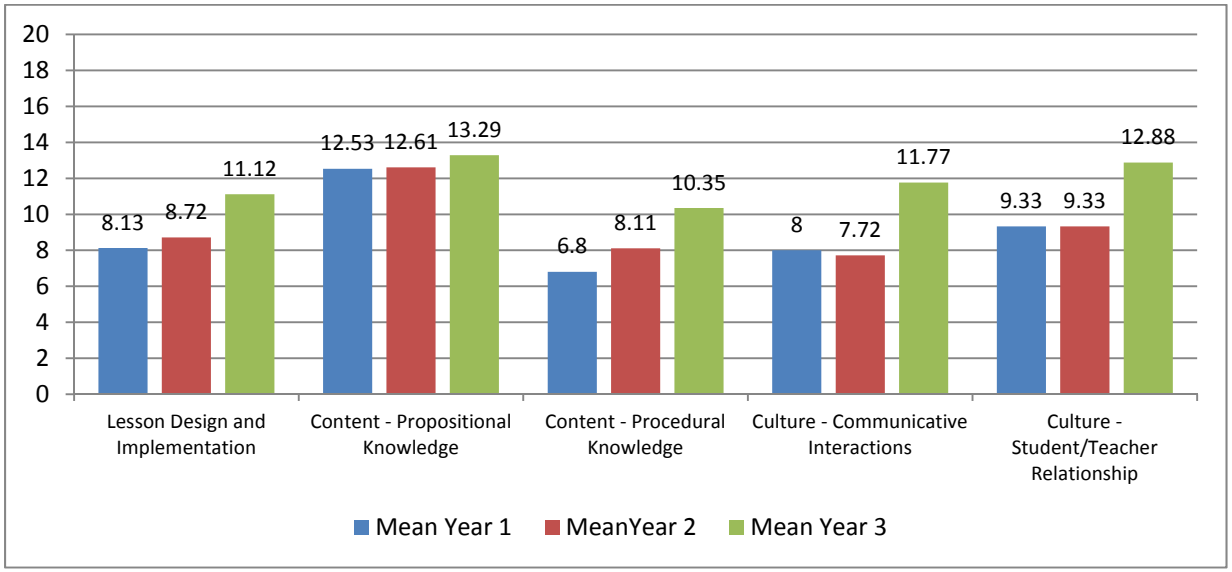

Figure 1. RTOP Scores by Year and Category

A matched pairs t-test was performed for Year 1 and Year 2, Year 2 and Year 3, and Year 1 and Year 3 for each of the RTOP categorical areas. The analysis revealed no statistically significant difference in teacher practice over the three years (Table 16). However, the effect sizes ranged from no effect to a high effect as seen in Table 16. Most notably, Year 1 to Year 3 effect sizes were high for changes in both of the classroom culture components (d = .88 and .91) and small in component II. Content – Propositional Knowledge. The small sample size is one factor that greatly influences the t-test results for statistical significance. The existence of any statistically significant results is encouraging given the small sample size.

Table 16. Matched Pairs t-test and Effect Size for Combinations of Years

	Year 1-2 N= 14		**Year 2-3 N= 15**		**Year 1-3 N= 12**	
	t-test	Cohen's d Effect Size	t-test	Cohen's d Effect Size	t-test	Cohen's d Effect Size
I. Lesson Design and Implementation	t= 0.695, df=13, p= ns	0.27	t= 1.35, df=14, p= ns	0.49	t= 1.27, df=11, p= ns	0.64
II. Content - Propositional Knowledge	t= 0.63, df=13, p= ns	0.02	t= 0.72, df=14, p= ns	0.15	t= 0.64, df=11, p= ns	0.16
III. Content - Procedural Knowledge	t= 0.58, df=13, p= ns	0.31	t= 1.47, df=14, p= ns	0.44	t= 0.94, df=11, p= ns	0.76
IV. Classroom Culture - Communicative Interactions	t=- 0.84, df=13, p= ns	-0.07	t= 2.27, df=14, p <.05	0.96	t= 1.08, df=11, p= ns	0.88
V. Classroom Culture - Student/Teacher Relationships	t= 0.44, df=13, p= ns	0.00	t= 2.26, df=14, p<.05	0.78	t= 1.26, df=11, p= ns	0.91
Overall	t= 0.38, df=13, p= ns	0.06	t= 1.77, df=14, p= ns	0.48	t= 0.91, df=11, p= ns	0.56

The lowest ratings in each category from the Year 3 classroom observations are listed in Table 16. The results from these items indicate most classrooms have a more teacher-centered focus. The classroom experiences provided little opportunity for students to ask and pursue their own questions, engage in thought-provoking activities, wrestle with the material in order to construct personal meaning, or to challenge the ideas presented by one another. While some reform strategies are evident in the classrooms observed, the overall instrument ratings indicate that classrooms are largely teacher-centered.

Table 17. Lowest Scoring Item(s) Per Category

Category	
I.	Item #5: The focus and direction of the lesson was often determined by ideas originating with students. (Rating of 1.76 out of 5)
II.	Item #10: Connections with other content disciplines and/or real world phenomena were explored and valued. (Rating of 2.24 out of 5)
III.	Item #12: Students made predictions, estimations and/or hypotheses and devised means for testing them. (Rating of 1.76 out of 5)
IV.	Item # 19: Student questions and comments often determined the focus and direction of classroom discourse. (Rating of 1.71 out of 5)
V.	Item #22: Students were encouraged to generate conjectures, alternative solution strategies, and ways of interpreting evidence. (Rating of 2.06 out of 5)

Another indication of the impact of the program is changes in district policies regarding classroom observation tools and processes. The coach and key administrator were asked whether the policies for observation of teacher practice by administrators had changed over the course of the NACL (Table 18). Five teams indicated that over the last three years their school or district had changed to use the Observing Evidence of Learning (OEL) (Danielson, 2007) protocol, protocols from the BERC group, the Danielson Framework, or other instruments based on principal choice. None of the teams indicated that observation of teacher practice by administration had changed as a result of the NACL program.

Table 18. Changes in Teacher Observation Protocols

Teams	Did district teacher observations formal/informal change?	If yes, how did they change?
Team 1	no	No standard documents are used.
Team 2	yes	More from the use of the OEL protocol. But, we are successful using OEL because of the foundation built by our NACL experiences and work of the team in their buildings.
Team 3	yes	Informal is changing with a new building administrator.
Team 4	yes	Use of BERC STAR protocol, 1 year into process, generic for all content areas
Team 5	yes	Increased understanding of how people learn. One legged interviews and informal questioning techniques used.
Team 6	no	
Team 7	no info provided	
Team 8	yes	The schools use Charlotte Danielson text (Effective Professional Practice); observation process in building dependent on teams obtaining data and info
Team 9	no info provided	
Team 10	no	

Professional Development

A guiding principle of the NACL is that the content and pedagogy of **professional development** must be designed through reflective practice to transform teachers' knowledge and beliefs about learning and teaching. Professional development is particularly important in support of the implementation of reform-based instructional materials.

Findings Related to Research Question 2

To what extent does the professional development strand of the NACL program impact Leadership Teams and their colleague's ability to develop and enact a sustainable professional development program?

Participant Beliefs and Learning

Two models served as the primary foci for team learning related to professional development. For the purposes of program design and planning, teams learned about and used the Design Framework for Professional Development (Loucks-Horsley, 2003). For the purposes of session design and planning, participants learned and used the Science Immersion Model for Professional Learning (SIMPL) (Baxter, 2007). The Professional Development Design Framework includes emphasis on monitoring and evaluating the impact of professional development. Participants learned about and used NSDC's Standards for Staff Development (NSDC, 2001) and Innovation Configurations (NSDC, 2003), the Concerns-based Adoption Model (CBAM) (Hall and Hord, 2006; Hall, Hord, George, Stiegelbauer, & Dirksen, 2006).), and Guskey's Five Critical Levels of Evaluating Professional Development (Guskey, 2000).

Designing Professional Development

Participants reported significant increases in their understanding of the Professional Development Design Framework including the critical inputs of knowledge and beliefs, context, critical issues, and strategies. Two items from the survey (Tables 19 and 20) yielded statistically significant increases and large effect sizes from Year 1 to Year 3 of the NACL.

Table 19. Participant Beliefs in Professional Development and Design (5 point scale)

How would you describe your **agreement** with the following:	**Initial Year 1 Mean/Std dev**	**Final Year 3 Mean/Std dev**	**t-test, df, p value**	**Cohen's d Effect Size**
Existing knowledge and beliefs about learning, teaching, and the nature of science can influence your district's vision of standards-based science education.	4.13 .55	4.83 1.07	t=1.26 df-22, p<.05	.82

Table 20. Participant Understanding in Professional Development and Design (5 point scale)

How would you describe your level of understanding of the following:	**Initial Year 1 Mean/Std dev**	**Final Year 3 Mean/Std dev**	**t-test, df, p value**	**Cohen's d Effect Size**
The professional development design framework including the inputs of knowledge and beliefs, context, critical issues, and strategies	3.22 .90	4.13 .46	t=1.28 df=22, p<.001	1.27

Year 1 to Year 3 data indicated only moderate levels of impact on their knowledge and/or beliefs about three critical aspects of professional development design (Tables 21 and 22):

- Professional development strategies should be embedded in the everyday work of teachers;
- The activities in a professional development plan need to be coherent and link to the overall goal(s) of the professional development program (practical, but not statistical significance); and
- Using evaluation data is important to inform the design of future professional development activities.

Table 21. Agreement level on Professional Development (5 point scale)

How would you describe your **agreement** with the following:	**Initial Year 1 Mean/Std dev**	**Final Year 3 Mean/Std dev**	**t-test, df, p value**	**Cohen's d Effect Size**
1. Professional development strategies should be embedded in the everyday work of teachers.	4.32 .48	4.55 .60	t=.59 df=21, p= ns	.42
2. Using evaluation data is important to inform the design of future professional development activities.	4.32 .57	4.82 1.05	t=2.43 df=21, p<.05	.70

Table 22. Understanding of Professional Development (5 point scale)

How would you describe your level of understanding of the following:	**Initial Year 1 Mean/Std dev**	**Final Year 3 Mean/Std dev**	**t-test,df, p value**	**Cohen's d Effect Size**
The activities in a professional development plan need to be coherent and link to the overall goal(s) of the professional development program.	3.96 .64	4.26 .54	t=.66 df=22, p= ns	.51

Seventy-four percent of the participants indicated that the knowledge and skills that they learned about professional development were very useful to them, their schools, and/or their districts (Table 23). The remaining participants indicated that this knowledge was at least somewhat useful to them.

Table 23. Percent, Means, and Standard Deviation for the overall usefulness of knowledge and skills gained from the NACL

How would you rate the degree to which the knowledge and skills gained from the NACL are useful to your work, your school(s) and/or district?	**Not useful at all 1**	**2**	**Somewhat Useful 3**	**4**	**Very Useful 5**	**Mean**	**Std. Dev.**
Professional Development	0	0	4.1	22.4	73.5	4.69	.55

Understanding these critical aspects of professional development program design and planning reflect one stage of learning intended to impact participants in the NACL. Another is learning how to use the information in the school or district context. Participants reported moderate to high effect sizes for all four questions related to the frequency with which they were able to "apply" their learning in the school and/or district context. All three of the items yielded statistically significant results—participants reported using information about context (e.g., student learning data) and critical issues (e.g., finding time for PD) as part of the planning process. The other two questions represent ideas that were emphasized during the program as participants developed their conceptual understanding through scaffolded experiences that included opportunities to apply their learning. These questions were related to participants' frequency of connecting PD experiences to a bigger, on-going professional development program for the school or district; and planning based on teachers' existing knowledge bases and belief systems (Table 24).

Table 24. Percent, Means, and Standard Deviation for the frequency with which participants and other PD Designers have engaged in the following design activities at the beginning of Year 2 and end of Year 3. (4 point scale)

Describe the extent to which you and other professional development designers have done the following:	Initial Year 2 Mean/Std dev	Final Year 3 Mean/Std dev	t-test, df, p value	Cohen's d Effect Size
1. Connected professional development experience(s) together as part of some bigger, on-going professional development program for the school or district.	2.11 1.26	2.86 .85	t= 2.55, df= 27, p<.05	.70
2. Considered contextual information in planning the professional development program (e.g., information about students, teachers, parents/community, existing practices, state/local policies).	2.21 1.23	2.96 .51	t= 2.83 df= 27, p<.01	.80
3. Considered existing knowledge bases and belief systems (e.g., about learning, teaching, professional development, change) in planning the professional development program.	2.14 1.21	2.89 .57	t= 2.64, df= 27, p<.05	.79
4. Considered issues critical to the success of any professional development program (e.g., equity, leadership, building professional culture, scaling up) in planning the professional development program.	2.00 1.16	2.79 .69	t= 2.92, df= 27, p<.01	.83

Evaluating Professional Development

Over the course of their experiences during Academy events and work back home, participants reported significant (both statistical and practical) increases in learning and changes in beliefs about professional development design. Results indicated high levels of agreement with the importance of evaluating professional development and using the results to inform program modifications. Participants also reported significant increases in their understanding of the tools used to monitor and evaluate the impact of professional development (Tables 25 & 26)

Table 25. Beliefs about Professional Development Evaluation (5 point scale)

How would you describe your **agreement** with the following:	Initial Year 1 Mean/Std dev	Final Year 3 Mean/Std dev	t-test, df, p value	Cohen's d Effect Size
Evaluating professional development is an important component to professional design.	4.13 .63	4.70 .47	t=4.09 df=22, p<.001	1.03

Table 26. Understandings about Professional Development (5 point scale)

How would you describe your level of understanding of the following:	Initial Year 1 Mean/Std dev	Final Year 3 Mean/Std dev	t-test, df, p value	Cohen's d Effect Size
1. Guskey's five critical levels of professional development evaluation.	2.04 1.26	3.70 .77	t=7.12 df=22, p<.001	1.86
2. The various types of instruments, processes, or tools that can be used to evaluate professional development experiences.	2.61 1.12	4.17 .57	t=6.47 df=22, p<.001	1.76
3. The National Staff Development Council's (NSDC) Standards for Staff Development.	2.13 1.18	3.57 .73	t=6.94 df=22, p<.001	1.48
4. How to use the NSDC Innovation Configuration Maps to support curriculum reform in the district.	2.09 1.12	3.61 .58	t=7.34 df=22, p<.001	1.70

All participants contributed to the design and planning of their districts' science professional development program—at a minimum, the design and planning occurred *during* Academy events. Results (statistically significant; moderate effect size) indicate that participants increased the frequency with which they collaborated in the design of their PD program from seldom to occasionally over the course of the Academy Program (Table 27). In addition, some participants were expected to design and plan professional development sessions with colleagues and conduct sessions for colleagues. Participants reported an increase in the frequency (statistically significant; moderate effect size) with which they planned and conducted professional development sessions with colleagues. Item 3 that addresses conducting sessions was not statistically significant but it did have a moderate effect size.

Table 27. Comparison of Frequency from Fall Year 2 to Spring Year 3 (4 point scale)

How would you rate the **frequency** with which you have done the following:	**Fall Year 2 Mean/Std dev**	**Spring Year 3 Mean/Std dev**	**t-test, df, p value**	**Cohen's d Effect Size**
1. Worked with others to design a professional development program	2.73 1.14	3.33 .71	t=2.53, df= 29, p<.05	.63
2. Planned or helped plan one or more professional development sessions for colleagues in my school, district, or elsewhere	2.86 1.19	3.45 .95	t=2.39, df= 28, p<.05	.55
3. Conducted professional development for colleagues in my school, district, or elsewhere	2.54 1.29	3.04 1.04	t=1.66, df= 27, p= ns	.43

Use of Tools

To inform the design and plan of a professional development program and PD sessions, participants learned about and then used a number of tools during Academy Events and back home. Tools included:

- Tools and processes for PD Program design and planning including the Program Elements Matrix (PEM), PD Design and Plan Tool and Process.
- Data-driven dialogue (Wellman and Lipton, 2004; Love, 2001) tool and process to analyze data about teacher knowledge and beliefs and important context factors to inform the design and then implementation data and impact data to evaluate the quality of *implementation* of the PD Program.
- Tools and processes from the Concerns-based Adoption Model (CBAM) (Hall and Hord, 2006) including Stages of Concern open-ended statements and questionnaire, Levels of Use Branching Interview, and Innovation Configurations (aka Practice Profiles) to assess implementation of the team's innovation.
- The Science Immersion Model for Professional Learning (SIMPL) (Baxter, 2007) tool and process to scaffold the design of PD sessions, particularly curriculum-based PD.

When asked about their use *back home* –

- All but 6% of participants report using *Data Drive Dialogue* to help with professional development design or have included the use of the tool and process in their plan.
- Greater than 75% of the participants have collected and used *Stages of Concerns statements* to inform their future work.
- More than 60% of the participants indicated having used *Level of Use interviews* to inform their professional development plan.

- Fewer than 50% of the participants indicated having used *Innovation Configurations* at least once.
- Thirty percent of the respondents indicated that use of the *Innovation Configurations* was in their professional development plan.
- Fewer than 50% of the participants indicated having used *SIMPL* at least once. About 25% of participants indicate that they've used SIMPL more than once while a slightly higher percentage of participants indicate that they have not used SIMPL.

Table 28. Level of Use for Professional Development Knowledge and Skills

What is the level of use at your home site?	Not used 1	Our plan has us using in the future 2	Used Once 3	Used More than Once 4	Mean	Std. Dev.
1. Use Data Driven Dialogue as a way to make decisions about professional development design.	6.1	22.4	12.2	59.2	3.24	1.01
2. Analyze information about existing knowledge and beliefs to inform your professional development design.	2	22.4	20.4	55.1	3.23	.89
3. Use a variety of strategies as part of your professional development program.	4.1	14.3	6.1	75.5	3.53	.89
4. Use the Science Immersion Model for Professional Learning (SIMPL model) to plan a professional development session.	27.7	34	12.8	25.5	2.36	1.15
5. Use the Science Immersion Model for Professional Learning (SIMPL model) to consider an individuals' role and the impact of a professional development session.	29.8	34	12.8	23.4	2.30	1.14
6. Construct your own tools (e.g., questionnaires) for evaluating your own professional development.	7.8	19.6	27.5	45.1	3.1	.99
7. Collect and use concern statements from colleagues and use them to inform future work and/or professional development.	5.9	15.7	27.5	51	3.24	.93
8. Conduct and use Level of Use Interviews to inform our professional development plan.	18.4	18.4	26.5	36.7	2.82	1.13

Impact

Teams began designing and planning their science professional development program during Year 1 of the Academy Program using the Program Elements Matrix (PEM), developed an initial draft of their plan using the Professional Development Design and Plan Tool in Year 2, then revised their plan based on two rounds of feedback from BSCS and NACL Washington-based Faculty and one round of feedback from another team. The feedback from another team was generated through engaging in a collaborative protocol designed to elicit *critical* feedback. During Year 3, teams also used a tool and process adapted from the criteria and process in *Enhancing Program Quality in Mathematics and Science* (Kaser, 1999) to evaluate the quality of their own professional development plans and modify accordingly.

Revisions to NACL teams' professional development plans included:

1. **Vision and Standards**- Four of the ten teams revised their vision statement to reflect their new understanding of the content learned and their area of focus as a team.
2. **Goals**- Five of the ten teams revised their goals to better reflect their vision and identified area of focus.
3. **Plan**- Nine of the ten teams made revisions to the actions section of the plan which included the addition/enhancement of the following components: interventions and strategies, timeline, resources, responsibilities, and monitor and evaluation components. Three teams did not use the professional development plan tool provided so it is not possible to fully aggregate information from their plans due to the differences in components.
    a. **New Actions:** Seven teams added new activities since their first draft of the professional development plan.
    b. **Monitor/Evaluate the Actions:** One team identified the various levels of evaluation based on Guskey's work (Guskey, 2000) to consider, several teams listed specific NACL tools like Stages of Concern, Levels of Use, and Stages of Concern Questionnaire. Six of the teams listed products of the activities and four teams had no strategies for monitoring the actions listed in their final plans.
    c. **Actions that indicate activity beyond participation in NACL:** Five teams made explicit reference to activities moving past the end of the NACL and two teams included actions that suggest this action.
    d. **Team sustainability:** Five teams mentioned developing activities related to the future of the team. These included having monthly team meetings, revisiting their professional development plan periodically, and maintaining meetings as needed with common professional development.

The planning tool used to scaffold the teams' PD design and plan for their science professional development program included all components of the Professional Development Design Framework. The final plans submitted by eight of ten teams were developed using the tool. Two teams did not submit a plan using this tool. These teams' plans were missing the data analysis and justification component used to inform their plan. All plans included a vision, goals, action steps, and a means of evaluating progress. Plans for eight of ten teams include evidence that the research and literature about learning and teaching, nature of science, professional development, and/or understanding the change process informed their vision statement. Nine of ten teams included in their plan to use of one or more tools from the Concerns-based Adoption Model as a means of monitoring progress toward their goals.

An analysis of the goals and action components of team plans revealed patterns in actions selected by the teams.

- Nine team plans had a focus on instructional strategies and the development or enhancement of professional learning communities.
- Eight teams identified the use of data as a team and with colleagues as part of their action plan.

- Seven teams identified materials selection and/or implementation as a focal area.
- Seven team plans had a focus on formative assessment with summative assessment as a part of at least two of the plans.

Table 29, below provides additional information about each team's plan.

In addition, themes emerged from the professional development strategies that teams incorporated into their plans. A variety of professional development strategies were identified by the teams.

- Seven teams incorporated the use of workshops into their plans.
- Seven teams embedded using student work as a vehicle for professional learning.
- Seven teams identified work focused upon curriculum implementation that was currently going on or would occur in the future.
- Six teams identified working in collaborative structures of some sort within the actions section of the plans.
- Four teams mentioned developing leaders in their plan.
- One team included an action item to revisit and revise their plan.

In the plans of several teams, it was noted that there were no goals and actions that specifically spelled out how the team would be sustained past the NACL. Teams may have made the assumption that they would continue to meet and work together but the lack of specificity in the plan is a weakness that may result in teams that do not follow through.

Table 29. Final Professional Development Plan Analysis- Focus of Goals and Actions

Team	Formative Assessment	PLC	Advocacy (A) NACL Team (N)	Materials Select (S) Implement (I)	Science Notebooks	Using Data	Work with Principals	Instructional Strategies	Technology	Sustain Team	Work with special needs populations
Team 1		X	N		X	X (Team)	X	X		X	X
Team 2	X F/S	X	AN	I	X	X (All)		X	X		X
Team 3	X F/S	X		I (WARES)		X		X			
Team 4	X	X	A	I		X (All)	X	X	X	X	
Team 5		X	A	S				X			
Team 6				Assist with new adoption							
Team 7	X	X		I		x		x			x
Team 8		X				X (Team)		X		X	
Team 9	X	X		I (WARES)		X (Team)		X		X	
Team 10	X	X	AN*			X (All)	X*	X		X (not explicit but team planning meetings indicated a strong commitment)	

*activities to support implementation of K-5 science program, formative assessment column indication of f= formative and s= summative

Table 30. Final Professional Development Plan Analysis -Professional Development Strategies

Team	Workshop	Examining Teaching	Examining Student Learning/Work	Curriculum Implementation	Collaborative Structures	Developing Leaders	Revisiting professional development Plan
Team 1	X		X		X		X
Team 2	X	X	X	X	X (OEL)	X	
Team 3		X	X	X	X		
Team 4	X	X	X	X	X	in vision only	
Team 5	X	X	X	X	X		
Team 6				X			
Team 7	X		X	X			
Team 8	X						
Team 9	X	X	X	X	X	in goals only	

Leadership

A guiding principle of the NACL is that **Leadership** for curriculum reform is a shared process that includes understanding adult learning, accommodating the challenges of change, building relationships, and facilitating groups. Curriculum leadership involves building the ongoing capacity for reflective dialogues to construct common understandings and beliefs about curriculum reform.

One outgrowth of leadership as part of the NACL is the development of a professional learning community (PLC) based on a focus on shared norms and values, a focus on student learning, collaboration, deprivatized practice, and reflective dialogue. Another guiding principle of the NACL is that a **professional learning community** is the cornerstone of sustainable curriculum implementation and focuses on a collective sense of responsibility for the learning of both students and adults in a school community.

One leadership quality and practice is inspiring a shared vision (Kouzes and Posner, 2003; Fullan, 2001; Loucks-Horsley, 2003; Garmston and Wellman, 1999). Another guiding principle of the NACL is that the *National Science Education Standards* provide a **vision** of effective science education. In order to realize this vision, school- and district-based leadership teams need an increasingly wide range of knowledge and skills that come from research, reflective practice, and the expertise of other practitioners.

Findings Related to Research Question 3

To what extent does the NACL impact the participating teams' understanding of leadership, leadership skills, and ability to enact change in their school/district?

Participant Beliefs and Learning

Role as a Leader

Through the NACL, participants learn about leadership at both an individual and team level. Leadership qualities and practices around which data were collected included understanding principles of change and developing highly effective teams. These learning opportunities mean little unless the members of the NACL teams *believe* they are leaders, so these data were also collected. Participants reported feeling more prepared for their role as a curriculum leader by the end of the program (d=.43) (Table 31).

Participants shared some of their thinking in a comments section. In the fall of Year 1, participants shared comments such as:

- "I feel overwhelmed"
- "Our district is not ready for this leadership, or change, or curriculum direction"

In the spring of year 3, participants shared comments such as:

- "Outstanding opportunity to bring clarity, direction and vision"
- "I don't know what I would have done in my new job …w/o the NACL training. …I was underprepared for the management and development of PLCs and Adoptions."
- "This has given me a great set of tools to work with in my district"
- "I loved NACL. I feel so much more confident as a teacher leader. I have the tools to lead a group effectively."

Table 31. Overall Questions: Agreement on a 6-pt Likert

OVERALL QUESTIONS.	Y1 Fall Mean	*Std. Dev.*	Y3 Spring Mean	Standard Deviation	Cohen's d
I feel well prepared for my role as a curriculum leader.	4.91	1.00	5.26	*.58*	.43

In the final survey, participants reported both statistically and practically significant increases in their understanding of the characteristics of effective leaders and how to advocate for their science reform effort (Table 32).

Table 32. Understanding (5 point scale)

How would you describe your level of **understanding** of the following:	Initial Year 1 Mean/Std dev	Final Year 3 Mean/Std dev	t-test, df, p value	Cohen's d Effect Size
1. The characteristics of effective leaders	3.64 .87	4.39 .57	t= 4.70 df=27 p< .001	1.32
2. How to effectively advocate for your science reform effort.	3.07 .99	4.19 .56	t= 5.93 df=26 p< .001	1.39

Change as a Process

One important knowledge base for leaders is understanding change as a process (Fullan, 2001; Hall and Hord, 2006; Loucks-Horsley, 2003; Harvey and Drolet, 2004). One aspect of their study of change was the Concerns-based Adoption Model (CBAM) (Hall & Hord, 2006). CBAM provides a model and set of tools for leading change. The program addresses beliefs and understandings about change during Years 1 and 2 of the NACL, and then the focus shifts to understanding tools for monitoring and supporting change, collecting data, and analyzing results into the future.

Results from surveys taken in years 1 and 2 reveal participants' changes in beliefs about change as a process. Participants developed deeper appreciation (moderate effect size; statistically significant t-tests) for three statements that highlight change as being about the people first, and the innovation second (Table 33):

- Change is a highly personal experience
- People commit to ideas at different rates
- People can be resistant to change because they do not believe the change is worthwhile

Table 33. Beliefs about Change (5 point scale)

How would you describe your level of **agreement** of the following:	Fall 2007 Mean	Standard Deviation	Fall 2008 Mean	Standard Deviation	t-test	Effect Size (Cohen's d)
1. Change is a highly personal experience	4.17	.848	4.62	.622	t= 3.083, df= 28, p<.01	0.60
2. People commit to ideas at different rates	4.21	.902	4.69	.541	t= 3.136, df= 28, p<.01	0.65
3. People can be resistant to change because they do not believe the change is worthwhile	4.28	.922	4.66	.553	t= 2.087, df= 28, p<.05	0.50

Participants' understandings about change as a process also showed growth from year 1 to year 2 of the NACL program with statistically significant t-tests and moderately large effect sizes.

Table 34. Means, t-test, and Effect Size results for understanding of change and the CBAM model for participants with matched data (5 point scale)

How would you describe your level of **understanding** of the following:	Fall 2007 Mean	Standard Deviation	Fall 2008 Mean	Standard Deviation	t-test	Effect Size (Cohen's d)
1. Change is a process requiring developmental growth in feelings and skills	3.76	.912	4.31	.660	t= 4.04, df= 28, p<.001	0.69
2. Since people commit to ideas at different rates, there are several different "adopter" types in a change process	3.59	.946	4.28	.751	t= 4.17, df= 28, p<.001	0.81

During Year 3 teams were given the choice to attend several sessions, one of which addressed issues of change and dealing with conflict and resistance. Sixteen team members participated in the session and completed the survey. Results indicate that participants' beliefs and understandings changed significantly over the course of the event (Tables 35 and 36).

Table 35. Retrospective Pre-Post Means, t-test, and Effect Size Results for Beliefs and Values (5 point scale)

Beliefs and Values	Before the Meeting Mean Std. Dev	After the Meeting Mean Std. Dev	t- test	Cohen's d Effect Size
1. Resistance is an expected part of the change process	3.71 .985	4.71 .470	t= 3.89 df= 16 p<.001	1.29
2. Conflict *can* be used constructively	3.29 1.160	4.47 .514	t= 5.10 df= 16 p<.0001	1.32

Table 36. Retrospective Pre-Post Means, t-test, and Effect Size Results for Understanding of Fall Academy Meeting Ideas (5 point scale)

Understanding	Before the Meeting Mean Std. Dev	After the Meeting Mean Std. Dev	t- test	Cohen's d Effect Size
1. Sources and antidotes for resistance	2.41 .507	3.94 .556	t= 10.10 df= 16, p<.0001	2.86
2. How to anticipate and recognize signs of resistance	2.76 .664	4.00 .612	t= 6.77 df= 16, p<.0001	1.95
3. How to develop strategies for dealing with resistance or reluctance	2.47 .874	4.12 .697	t= 9.68 df= 16, p<.0001	2.09
4. Different kinds of conflict (e.g., values, interpersonal, cognitive)	2.12 .857	4.06 .659	t= 9.68 df= 16, p<.0001	2.53
5. Tips for managing yourself during conflict.	2.65 .786	3.88 .600	t= 6.77 df= 16, p<.0001	1.95
6. How to engage conflict constructively	2.53 .800	4.00 .707	t= 6.43 df= 16, p<.0001	1.94
7. How to see a problem from another person's perspective	3.06 .748	4.18 .636	t= 6.62 df= 16, p<.0001	1.61

A major focus of the Year 3 NACL program was the Concerns-based Adoption Model (CBAM). Participants learned about and appreciate CBAM tools including the Levels of Use branching interview and Innovation Configurations (Practice Profiles). Innovation configurations from a variety of sources were studied during the sessions including some developed by BSCS and others from the National Staff Development Council (NSDC). Participants report increased confidence in using the NSDC innovation configurations. Survey results also show statistically significant t-tests and large effect sizes for participants' understanding of various components of the Concerns-based Adoption Model showed the greatest change with effect sizes ranging from 1.46 to 2.46.

Table 37 Pre- Post- Means, t-test, and Effect Size Results for Beliefs and Values (4 point scale)

How would you describe your level of **agreement** with the following:	**Before the Y3 Fall Meeting Mean/Std. Dev**	**After the Y3 Fall Meeting Mean/Std. Dev**	**t- test**	**Cohen's d Effect Size**
I am confident that I can use the NSDC Innovation Configuration Maps to monitor and improve the quality of professional development in our school, district, or region.	2.31 1.221	3.76 .830	t= 8.990 df= 44 p<.0001	.90

Table 38. Pre-Post Means, t-test, and Effect Size Results for Understandings (5 point scale)

How would you describe your level of **understanding** of the following:	**Initial Fall Year 1 Mean/Std dev**	**Fall Year 3 Mean/Std dev**	**t-test, df, p value**	**Cohen's d Effect Size**
The Concerns-Based Adoption Model suggests that there are three types of information that can illustrate one's progress in adopting an innovation: his or her Stage of Concern, Level of Use, and classroom practice (Practice Profile)	2.17 1.037	3.86 .743	t= 6.935, df= 28, p<.001	1.87
How to classify concern statements using the Stages of Concern framework	1.79 .902	3.93 .842	t= 10.864, df= 28 p<.001	2.46
How to design interventions that address specific Stages of Concern	1.82 1.02	3.07 .663	t= 6.355, df= 27, p<.001	1.46
How to use the branching interview to determine someone's Level of Use of the innovation.	1.68 .89	4.16 .83	t= 10.57, df= 18, p<.001	2.88

Highly Effective Teams

Participants studied the characteristics of highly effective teams (Harvey and Drolet, 2004), developed norms and guidelines to support collaborative work (Harvey and Drolet, 2004; Garmston and Wellman, 1999), and reflected on their development as a team throughout the NACL (Harvey and Drolet, 2004; Garmston and Wellman, 1999; Myers-Briggs, 1998). A shared vision is an important characteristic of highly effective teams and NACL Leadership Teams are expected to inspire a shared vision back home. In the Year 3 final survey, over 90% of participants reported the vision is shared by their team members with a mean response of 3.88 on a 4 point Likert-type scale. However, 53.8% of participants are unsure the degree to which their vision is shared by the larger community (Table 39).

Table 39. Percent, Means, and Standard Deviation for the statements about Professional Development Plan Vision after this final meeting

	Not sure 1	Not agreed upon by the group 2	Somewhat agreed upon 3	Completely agreed upon 4	Mean	Std. Dev.
1. Among your team	2.4	0	4.9	92.7	3.88	.51
2. Among teachers in school or district targeted by the PD	12.8	15.4	66.7	5.1	2.64	.78
3. District Administrators	17.5	2.5	65	15	2.78	.92
4. Community at Large	53.8	7.7	35.9	2.6	1.87	1.01

Participants reported significant changes in their beliefs related to two characteristics of highly effective teams including the role of shared norms and a vision for their work. They also reported significant changes in their understandings of four characteristics of effective teams. Effect sizes for these questions ranged from moderate to large.

Table 40. Beliefs about Leadership and Teams (5 point scale)

How would you describe your **agreement** with the following	**Initial Year 1 Mean/Std dev**	**Final Year 3 Mean/Std dev**	**t-test, df, p value**	**Cohen's d Effect Size**
1. Highly effective teams establish and revisit frequently norms or guidelines for how they are going to work together (e.g., talking and listening to each other).	4.07 1.02	4.82 .98	t= 2.88 df=27, p< .01	.75
2. Highly effective teams develop together a shared vision of their work.	4.32 .91	4.93 .90	t= 2.50 df=27, p< .05	.67

Table 41. Understandings about Leadership and Teams (5 point scale)

How would you describe your level of **understanding** of the following:	**Initial Year 1 Mean/Std dev**	**Final Year 3 Mean/Std dev**	**t-test, df, p value**	**Cohen's d Effect Size**
1. Research suggests that members of an effective team understand their individual roles and the roles of others on the team.	3.75 .93	4.43 .50	t= 4.65 df=27, p< .001	.91
2. Research suggests that highly effective teams use specific norms or behaviors to work collaboratively.	3.74 1.09	4.67 .48	t= 4.49 df=26, p< .001	1.10
3. Highly effective teams identify time for dialogue and discussion to work collaboratively and increase the quality of decisions.	3.81 1.08	4.44 .58	t= 3.90 df=26, p< .001	.73
4. Highly effective teams utilize strategies to deal with conflict.	3.75 1.00	4.39 .63	t= 3.73 df=27, p< .001	.77

Professional Learning Community

Participants studied the characteristics of a professional learning community (PLC) and were instructed in the skills and strategies and the processes and tools that help in the development of a learning community (Garmston and Wellman, 1999; Hall and Hord, 2006; Loucks-Horsley: et.al., 1987; Louis, Kruse, and Associates 1995). Characteristics included shared norms and values, focus on student learning, collaboration, deprivatized practice, and reflective dialogue. Participants reported an appreciation of the positive role of PLCs in sustaining their science reform efforts. They also reported confidence in their NACL team's ability to contribute to the development of an effective learning community (Table 42).

Table 42. Percent, Means, and Standard Deviation for the statements of Beliefs and Values

How would you describe your agreement with the following:	No agreement 1	Very low level of agreement 2	Moderate level of agreement 3	High level of agreement 4	Very high level of agreement 5	Mean	Std. Dev.
The development of an effective professional learning community can help us sustain our science reform efforts.	0	0	0	23.3	76.7	4.77	.43
I am confident that our NACL team can contribute to the development of an effective professional learning community.	0	0	0	34.9	65.1	4.65	.48

Results indicate that participants' understandings of the characteristics of PLCs increased significantly (Table 43). In the final survey, participants were asked to report their understanding of what leaders do to create and sustain PLCs. All participants indicated at least a moderate level of understanding and 80.5% of participants reported a high or very high level of understanding (Table 43).

Table 43. Understanding of PLCs (5 point scale)

How would you describe your level of **understanding** of the following:	Initial Year 1 Mean/Std dev	Final Year 3 Mean/Std dev	t-test, df, p value	Cohen's d Effect Size
The characteristics of a professional learning community.	3.63 1.07	4.21 .42	t= 2.48 df=18, p<.05	.71

Table 44. Percent, Means, and Standard Deviation for statements of understanding after this final meeting

How would you describe your level of understanding of the following:	No Understanding 1	Very low level understanding 2	Moderate level of understanding 3	High level of understanding 4	Very high level of understanding 5	Mean	Std. Dev.
What leaders do to develop and sustain professional learning communities.	0	0	19.6	56.6	23.9	4.04	.67

Use of Tools

Throughout the NACL program, participants learn to use tools to enhance their leadership practices. These practices include advocacy, monitoring and supporting change, and developing as a team and a learning community. Tools include scaffolds to develop advocacy statements, CBAM tools to monitor and support change, and frameworks and protocols to support development of the characteristics of a highly effective team and professional learning community.

Role as a Leader

Participants reported little increase in the frequency of leadership activities. The frequency of advocating for reform-based change decreased. None of the results were statistically significant and effect sizes were small.

Table 45. Frequency of leadership activities (5 point scale)

How would you rate the **frequency** with which you have done the following?	Initial Year 1 Mean/Std dev	Final Year 3 Mean/Std dev	t-test, df, p value	Cohen's d Effect Size
1. Taken a leadership role in a reform effort	3.64 1.19	3.86 1.01	t= .67 df=27, p= ns	.20
2. Spoken with various stakeholders about the need for education reform	3.64 1.16	3.57 1.17	t= -.41 df=27, p= ns	-.06
3. Successfully convinced colleagues of a need for education reform	3.15 1.26	3.41 1.15	t= .73 df=26, p= ns	.22

Data was also collected about the leadership activities of NACL team members. Twelve participants reported taking on additional leadership roles in the area of professional development. For seven of the twelve, the leadership role was a completely new experience. These leaders indicated that they had facilitated sessions ranging in length from one to 10 hours. The areas of focus included inquiry, grading practices, science notebooking, and department meetings. For four of the twelve individuals, concepts that they learned at the NACL provided the content for the professional development sessions in their district (BSCS, 2010).

Change as a Process

Participants learned about various CBAM tools over the course of the NACL. Participant ratings indicated that they were between "somewhat likely" and "very likely" to use these tools (Table 46). An indication of their intentions to use the tools was revealed through an analysis of the team PD Plans. Nine of 10 school-based teams specifically referenced CBAM tools such as Stages of Concern open-ended statements, Levels of Use branching interview, and/or innovation configurations (practice profiles) as part of their strategy for monitoring and supporting their PD initiative.

Table 46. Likelihood of Use at Your Home Site

Likelihood of Use	Very Unlikely 1	Somewhat Unlikely 2	Somewhat Likely 3	Very Likely 4	Mean	Std. Dev.
1. Use Innovation Configurations to describe and clarify our science reform effort.	0	6.7	46.7	46.7	3.40	.618
2. Use Innovation Configurations about teaching (e.g., implementing research-based instructional materials or inquiry-based teaching) to monitor and support the effectiveness of our science reform efforts.	0	4.4	44.4	51.1	3.47	.588
3. Collect Stages of Concern data through the use of open-ended statements.	0	0	20	80	3.80	.405
4. Use open-ended Stages of Concern responses to inform our planning of professional development	0	0	17.8	82.2	3.82	.387
5. Collect Levels of Use data using the Branching Interview.	0	8.9	42.2	48.9	3.40	.654
6. Use Levels of Use data to inform our planning of professional development	0	2.2	28.9	68.9	3.67	.522

Gathering the data is only one step in the process. Leaders also need to know what to do to intervene. Participants in the breakout session designed to specifically address issues of change and resistance during the Year 3 Fall Academy Meeting reported increases in their readiness to deal with resistance and conflict. Results were statistically and practically significant (Table 47).

Table 47. Statistics for Likelihood of Use at Your Home Site (4 point scale)

Likelihood of Use	Before the Meeting Mean Std. Dev	After the Meeting Mean Std. Dev	t- test	Cohen's d Effect Size
1. Plan advocacy efforts based on the sources and signs of resistance	2.35 .786	3.53 .514	t= 6.667 df= 16, p<.001	1.77
2. Go to "balcony" when facing resistance or in the midst of conflict	2.06 .748	3.59 .507	t= 8.790 df= 16, p<.001	2.39
3. Plan professional development with the antidotes to resistance in mind	2.24 .970	3.65 .493	t= 5.470 df= 16, p<.001	1.83
4. Actively work to enhance my five states of mind	1.88 .806	3.31 .602	t= 6.446 df= 15, p<.001	2.01
5. Actively work to build others' efficacy, flexibility, craftsmanship, consciousness, and interdependence	2.00 .816	3.38 .719	t= 6.822 df= 15, p<.001	1.79

Participants' comments provide additional insights into their thinking.

- *It has helped by providing a means to be more intentional with intervention strategies, i.e. we will be better able to anticipate and recognize types of conflict and appropriately address them.*
- *Where do I start?? Before the meeting I knew that conflict is inevitable in any change process. Conflict scared me immensely!! Having the tools to deal with the conflict…not quite so scary!*
- *My planning of PD with resistance in mind would depend on the needs of the group.*

Impact

Highly Effective Teams

Team members were asked to complete the Team Characteristics Inventory from Harvey and Drolet (2004). With responses to items on the inventory, team members indicate the degree to which their team exhibits characteristics of effective teams. Twenty-five participants responded to the Harvey Team Inventory (Harvey and Drolet, 2004) in a retrospective pretest (RPT) to posttest format. The inventory includes 17 items with four subcategories. Respondents rate their agreement with each prompt on a Likert-style scale ranging from 1 = "not at all" to 5 = "very much."

The Harvey Inventory includes four subcategories:

1. Purpose
   Highly effective teams share a common identity, beliefs, and tasks. Teams with a sense of efficacy and success act as a cohesive unit.
2. Composition
   Highly effective teams have a clear definition of team membership, recognize individual contributions, and balance roles. Balanced roles means that every member is involved—sometimes doing the tasks for which they are best suited and sometimes not.
3. Interaction
   Highly effective teams exhibit mutual trust, enjoy a sense of relationship, and share a common base of information. The relationships among team members are characterized by flexibility and responsiveness, toleration of errors, and a high level of communication. As part of a productive team, members have a healthy level of stress and are able to work through conflict in an open and direct way.
4. Structure and Context
   Highly effective teams have a clear understanding of the structure of the group and they pay attention to group maintenance and take time to reflect on what they are doing or learning and how well they are working together as a team. Effective teams recognize the outside forces that inevitably impact their work and work together to mitigate these forces to the extent possible.

This self-report data clearly shows participants believe that their respective teams have become more highly effective over the course of their participation in the NACL. The largest changes were in the Purpose and Interaction subscales, but all subscales had statistically significant gains and large effect sizes from RPT to post. An examination of individual characteristics revealed more specific challenges. The greatest areas of weakness for the teams are Open Conflict and Balanced Roles (BSCS, 2010). Table 48 details the participant responses to each of the subcategories of the Harvey Team Inventory.

Table 48. Harvey Inventory Subcategories RPT to Post

	Retrospective Pretest Mean	Post Mean	t-test	Cohen's d Effect Size
Purpose	7.68	12.08	t = 8.92, df = 24, p<.001	2.03
Composition	7.76	11.84	t = 6.59, df = 24, p<.001	1.72
Interaction	22.48	31.16	t = 6.82, df = 24, p<.001	2.11
Structure and Context	8.72	12.32	t = 6.97, df = 24, p<.001	1.66

Professional Learning Community

The results of participants' report of the frequency with which they engaged in activities consistent with those of a professional learning community were not statistically significant. The effect sizes for questions 1 and 5 were negative indicating the means of participants' responses decreased during the Academy Program related to collaboratively addressing student learning needs and participating in collaborative professional development experiences such as lesson study. However, none of these differences were statistically significant and the effect sizes were small on all items except for the item "Used established discussion protocols to structure conversations with colleagues" which had a moderate effect size and a t-test approaching significant.

Table 49. Frequency of PLC Activities (5 Point Scale)

How would you rate the **frequency** with which you have done the following?	Initial Year 1 Mean/Std dev	Final Year 3 Mean/Std dev	t-test, df, p value	Cohen's d Effect Size
1. Come together with colleagues to collaboratively address students' learning needs	3.75 1.02	3.55 .95	t= -.94 df=19 p= ns	-.20
2. Shared your classroom practice with colleagues	3.84 .89	4.05 .97	t= 1.00 df=19 p= ns	.23
3. Used established discussion protocols to structure conversations with colleagues	3.00 1.08	3.45 .83	t= 1.92 df=19 p= ns	.47
4. Examined student work with colleagues	2.68 1.11	2.95 1.08	t= .96 df=19 p= ns	.25
5. Participated in collaborative professional development experiences such as lesson study	2.89 1.05	2.79 1.03	t= -.34 df=19 p= ns	-.10

Systems

To develop an effective science education program, support at the school and district level is essential to ensure implementation of the innovation. To ascertain the participants' perception of changes in the system over the three year NACL program, Thomas Guskey's (2000) level 3 tool, *Organization Support*, was used to collect data on organizational support and change requirements needed to support the new innovations.

Overall Findings Related to Question 4.

- ***To what extent does participation in the NACL impact the system (school/district)?***

All of the Organization Setting statements yielded statistically significant results when examined in a retrospective pretest to posttest method ($p<.001$) (Table 50). The statements were found to improve over the three years. All statements had moderate or large effect sizes. All of the statements had final means of 3.88 or higher which indicates that overall most at least agreed a little with the statements. Statement 8 was rated the lowest with a mean below 4 (4 = agree a little). Statement 8 relates to follow up support for professional development activities within the district. Professional development activities continue to be single events with little follow-up support for new learning within most of the districts.

Table 50. Mean, t-test, and Effect Size results for organizational setting at home district

Thinking about the organizational setting at your home district, what is your level of **agreement** with the following statements?	Retrospective Pre-NACL (Fall 2007) Mean	Standard Deviation	Spring 2010 Mean	Standard Deviation	t-test	Effect Size (Cohen's d)
1. Our professional development programs and activities are aligned with our district mission, goals, and objectives.	3.43	1.35	4.91	.83	t= 7.141; df= 43; p<.001	1.32
2. Funding for professional development is a line item in our district budget.	3.75	1.3	4.41	1.3	t= 3.905; df= 43; p<.001	.51
3. The administration, faculty, and/or other staff members of our school work together to plan professional development activities.	3.2	1.23	4.61	1.15	t= 8.004; df= 43; p<.001	1.18
4. Leaders in our district advocate, encourage, and support professional development through incentives and resources.	3.64	1.08	4.43	1.09	t= 4.746; df= 43; p<.001	.73
5. The administration and faculty of our school have studied the change process to assist in planning and implementing effective professional development programs and activities.	2.74	1.29	4.14	1.08	t= 7.904; df= 42; p<.001	1.18

Thinking about the organizational setting at your home district, what is your level of **agreement** with the following statements?	Retrospective Pre-NACL (Fall 2007) Mean	Standard Deviation	Spring 2010 Mean	Standard Deviation	t-test	Effect Size (Cohen's d)
6. A norm of experimentation exists in our school that permits educators to try new instructional practices without fear of criticism should initial efforts fail.	3.89	1.08	5.05	.89	t= 7.790; df= 43; p<.001	1.17
7. District-level personnel help guide our professional development planning efforts and assist in implementation.	3.43	1.21	4.43	1.28	t= 5.813; df= 43; p<.001	.80
8. Provisions for follow-up support are included in all of our district professional development plans.	2.81	1.3	3.88	1.03	t= 6.257; df= 42; p<.001	.91
9. A norm of continuous improvement exists in our district that recognizes that learning about best practices in our profession is never finished.	3.91	1.18	5.02	.93	t= 6.566; df= 43; p<.001	1.04
10. We have ready access to expertise when implementation problems or difficulties in our district are encountered.	3.27	1.11	4.77	1.01	t= 9.726; df= 43; p<.001	1.41
11. The resources required to implement new practices are considered during planning and built into our district budget.	3.35	1.25	4.21	1.19	t= 4.335; df= 42; p<.001	.70
12. District-level professional development programs and activities are thoughtfully planned and complement our school-level efforts.	3.00	1.14	4.48	1.09	t= 8.229; df= 43; p<.001	1.33

Source: Guskey, T. R. (2000). *Evaluating professional development*. Thousand Oaks, CA: Corwin Press.

Participants were also asked to identify the items they believed had changed the most significantly over the three years (Table 51). All items were identified by at least one participant as having changed significantly, except for #2 and #8, over the three year NACL.

Statement #2 relates to funding by the district and Statement #8 relates to follow up support for Professional Development activities within the district. While participants did not comment on these two items, the rating for statement #2 did change significantly but had the lowest effect size (d=.51) of any of the 12 statements.

The rating for statement #8 also changed significantly and had an effect size in the large range (d=.91). The lack of comments on those two statements indicates that the participants did not view those particular items as having changed as much as other statements. These are two areas that can impact the success of the Professional Development Program plans developed by the teams. These areas need to be monitored and support provided if teams are to be successful in sustaining their reform efforts (The complete comments can be found in Table 52). Themes that emerged from the participants' comments are described in Table 51.

Table 51. Themes

Theme	Number of Comments by Respondent	Examples
Meaningful professional development: Participants described factors that could or have contributed to improvements in the quality of the professional development offered in their districts.	3 (1, 4, 12)	• We know more what to ask for for meaningful PD • PD with a purpose – we have quality, focused PD this is used with the intent of long-range success.
Change Participants referred to change in two basic ways: change in their own thinking or the influence of understanding change as a process on others.	5 (2, 11, 13, 16, 18)	• Even though not all the faculty are familiar with the change process, our administration is and that has helped us work together to change the direction of our school and district. • More than anything, my thinking has changed not because the district has changes, but because I have become more aware of PD and therefore make a more informed decision on this through NACL.
Plan Participants referred to the value of the planning process, the importance of aligning science professional development the district plan, and the role of the plan in helping to focus efforts.	6 (2, 4, 10, 13, 16, 19)	• Worked to align district science initiative with building "SIP" plans • It seems like we have never had an actual plan for PD. To actually get a group together and think about what are needs and goals are is a huge step for our district. As we have been developing our plan it hasn't been aligned to our overall goals. This last session has really helped us figure out our priorities and the professional development that will help us achieve what we want. • Through the NACL program we have learned about the change process and what it takes to successfully advocate for and integrate our science PD plan with the goals of the district.
Leadership Participants described leadership at three levels: others, us (team), and me.	13 (1, 2, 3, 4, 7, 8, 11, 12, 15, 17, 21, 22)	• District level leadership has allowed and promoted a continuous learning cycle and strongly supports teacher leadership • It [NACL] has also made our own leaders start to rise to the top to share their expertise and to recruit other staff members with knowledge and skills to share via PD courses and activities.

Theme	Number of Comments by Respondent	Examples
		• At the school level, our NACL team has been more involved in implementing schoolwide and department level professional development and are being viewed as teacher leaders within the building. • Getting the word out - I feel that I am regarded in my district and building as a leader and a resource for reform.
Work together and support Participants described the role of the team, the importance of support from their district, and the value of a network of support.	9 (1, 3, 5, 6, 7, 10, 12, 14, 22)	• We will keep work toward that goal [we want to do what is best for students] • Collective responsibility • There has been such a development of a network of support over the last 3 years. We now have a plethora of support!
Other important ideas	**Number of Comments by Respondent**	**Example(s)**
Sustainability	1 (13)	• The mindset of PD has shifted away from one day wonder workshops to a more sustained effort.
Students	2 (5, 19)	• Our District-level PD programs are now very well connected to our school-improvement efforts which means we are getting more time and funding to develop as teachers and help students to learn to a higher standard.
No progress	1 (20)	• I'm afraid we haven't moved very much on anything (from my perspective). We have always had very savvy staff and are usually up to date with many practices. Currently professional development has been introduced but we have not made a shift towards the district level.

Table 52. Identification of statement that changed the most significantly over the three years

#3. We know more of what to ask for meaningful PD; #4 District is more supportive of teachers going to PD. Feeling is they will be more receptive (at least we have better chance of selling it) to plans we will develop.
#7. The personnel at the district office have helped in the last two years in that "guiding role" as a result of her participation in NACL; #12. As a result of NACL, the PD has been grounded in the research, with appropriate strategies and tools used to implement and evaluate them compared to prior to the academy.
#5. I never heard about change models prior to NACL - now since NACL I know that this team has been trained; #12. We now have a Director of Curriculum & Instruction who is supportive of our thoughtful planning and will help us implement our PD plan.
PD with a purpose - we have quality, focused PD that is used with the intent of long-range success! Getting the word out - I feel that I am regarded in my district and building as a leader and a resource for reform.
#6 - We want to do what is best for students; #9 - and we will keep working toward that goal
Collective responsibility; cycle of continuous improvement; critical mass; leveraging the talents of others; data collection and analysis
#4 and #5 - District level leadership has allowed and promoted a continuous learning cycle and strongly supports teacher leadership; #11 and #12 - District level alignment of resources promotes PLC work and continuous improvement cycle.
#3 - I have become more aware of, and become a part of, the planning that goes on to identify the need for planning and presenting PD. My participation is a result of being an NACL member. #7 - As a result of our NACL planning, the district is now working WITH us to plan and implement PD.
All have changed drastically with education and new leadership.
#10 – we have built on NACL in developing the coach's positions; #11 - Time to meet and workshops were supportive; #12 - worked to align district science initiative with building "SIP" plans
#5-Even though not all of the faculty are familiar with the change process our administration (Jon Wilcox) is and that has helped us work together to change the direction of our school and district. #7-This was high to begin with but I am grateful that our district secondary curriculum person attended one of the 2008 NACLs. Our district understands and supports the work. It is quite gratifying.
#3- in the past I thought PD was one size fits all and out of our control. Now I realize that our needs matter and the district support is there to improve what we do in the classroom; #10-There has been such a development of a network of support over the last 3 years. We now have a plethora of support!
#1-Through the NACL program we have learned about the change process and what it takes to successfully advocate for an integrate our science PD plan with the goals of the district; #9- By attending NACL for 3 years we have changed a lot of people's opinion of the length of a PD program. The mindset of PD has shifted away from one day wonder workshops to a more sustained effort.
I now feel our district has an Effective Implementation Tool. Our direction of our Science Department has moved toward inquiry. We are working together for a common goal, not building by building.
Just the exposure to NACL expertise made us feel like we can get input/feedback/suggestions when needed. I've asked at least one of the faculty to borrow some materials used at the conference to help prepare for our own offerings and she was glad to share. It has also made our own leaders start to rise to the top to share their expertise and to recruit other staff members with knowledge and skills to share via PD courses and activities.
#1: It seems like we have never had an actual plan for PD. To actually get a group together and think about what are needs and goals are is

a huge step for our district. As we have been developing our plan it hasn't been aligned to our overall goals. This last session has really helped us figure out our priorities and the professional development that will help us achieve what we want. #9: A lot of these things I think have changed because our own awareness has changed. The norm of continuous improvement is always there, but our awareness and ambition has increased as a part of this process. We now feel empowered to contribute to that positive change we want to see. #10: We have acquired so many mentors and resources because of NACL. We know we are not alone and we have so many contacts to help us achieve our goals.
NACL has allowed us to create a teacher driven team that can bring forward Science related issues. The success of the team is yet to be determined!
More than anything my thinking has changed not because the district has changed, but because I have become more aware of PD and therefore make a more informed decision on this through NACL.
Our plan is much more focused than it was 3 years ago, but we already had a PD plan in place from our first cohort. Our District-level PD programs are now very well connected to our school-improvement efforts which means we are getting more time and funding to develop as teachers and help students to learn to a higher standard.
I'm afraid we haven't moved very much on anything (from my perspective). We have always had very savvy staff and are usually up to date with many practices. Currently professional development has been introduced but we have not made a shift towards the district level.
At the school level, our NACL team has been more involved in implementing schoolwide and department level professional development and are being viewed as teacher leaders within the building.
Monetary support for programs has decreased substantially over the past 3 years. We are barely squeaking along. We now have an administrator focusing on science. This has been very helpful.

Discussion of Results

Instructional Materials and Inquiry-based Instruction

The NACL is designed to support teams in leading the selection and implementation of reform-based instructional materials in their home district and this focus is clearly communicated in the application for participation. Also as expected, participants came to the first full Academy Meeting (Fall 2007) with a variety of beliefs about the nature and value of such materials. Results from two questions are of particular interest.

> Fall 2007
> In response to the question: If instructional materials are well designed and based upon research, they should guide the organization and sequencing of science instruction, the mean response was 4.19 (4 = quite a bit of agreement) and in response to the question: Any set of instructional materials should be used primarily as a resource from which teachers can pull out student activities, the mean response was 3.50 (3 = moderate agreement). At the same time, 45.5% of participants reported that they used a wide variety of instructional materials as resources from which I pick and choose to design an instructional sequence.

In the final analysis, participants' beliefs about the role of instructional materials to guide the organization and sequencing of science instruction changed significantly with a moderate effect size ($t(25) = 2.39$, $p<.05$, Cohen's $d = .51$). The item "Any set of instructional materials should be used primarily as a resource from which teachers can pull out student activities" had a reduction in agreement from year 1 to year 3, indicating that the "any materials will do" mentality decreased during participation in the NACL. While not statistically significant, this finding indicates that participants' beliefs about the importance of *high quality* instructional materials to guide instruction may have changed as the mean for this question decreased slightly from 3.50 to 3.27 from year 1 to year 3. Participants were not asked to identify the scenario that best described their use of instructional materials in the final survey.

One characteristic of reform-based instructional materials is the thoughtful way that developers integrate support for inquiry-based teaching and inquiry-based learning experiences into the fabric of the materials (Schroeder, 2007). In an analysis of research into science teaching and learning, Colburn (2008) concluded: "Most studies I examined supported the collective conclusion that inquiry-based instruction was equal or superior to other instructional models for students producing higher scores on content achievement tests." If we want to produce a scientifically-literate population, then we cannot deny students an inquiry-based science education, firmly grounded in the nature of science and conceptual understanding. To help NACL teams develop a shared vision of science as inquiry, guided by the *National Science Education Standards*, participants' were immersed in inquiry-based learning experiences during the NACL experience, designed to help them understand the abilities necessary to do scientific inquiry, understandings about scientific inquiry, the nature of science and the five essential features of classroom inquiry and their variations (NRC, 2000). Participants constructed their understanding of relevant teaching strategies emphasized in national documents (National Science Education *Standards* (NRC, 1996), *Inquiry and the National Science Educations Standards* (NRC, 2000), Taking Science to School (NRC, 2007), and Ready, Set, Science, Shouse & Schweingruber, 2008) and how to scaffold similar experiences in their own classrooms and with their colleagues.

One learning goal for the NACL was to help participants develop an understanding of science as inquiry and how it is described in the *National Science Education Standards* (NRC, 1996) and *Inquiry and the National Science Education Standards* (NRC, 2000). This includes the

differentiation between abilities to do inquiry and understandings about inquiry. One indication of their understanding of this is the slight decrease in the mean of the responses and negative, albeit small effect size revealed in their agreement with the statement that inquiry-based activities must be hands-on at the beginning of the NACL Program when compared to their level of agreement at the conclusion of the Program. The negative effect size provides some indication that participants' beliefs shifted in the desired direction and are more consistent with the understandings about science as inquiry described in the *National Science Education Standards* that not all inquiry learning experiences involve hands-on activities

.

Results indicate that participants' beliefs about the value of science as inquiry and their understandings about science as inquiry increased over the course of the Academy Program with significant increases in teachers' reported comfort level with inquiry-based teaching strategies and belief that inquiry should be the primary way in which science is taught. Results also indicate that participants' understandings about science as inquiry and how to teach using inquiry-based teaching strategies increased significantly. Participants reported that they have a better understanding of how to help students develop abilities to do science and how to help students learn subject matter using inquiry-based teaching strategies.

An important aspect of helping students develop their abilities to do science is scaffolding their learning. Over 60% of participants reported having used the "explanation tool" adapted from the work of Sutherland, McNeill, Krajcik, and Colson (2006) to scaffold students' construction of scientific explanations. This represents the majority of the classroom teacher population participating in NACL. One contributing factor to their reported use may have been the connection participants made between expected student responses on their state science assessment and how the tool could help their students improve their performance or learning. For example, one participant commented that students would better understand science through the use of claim, evidence, and reasoning rather than focusing only on some of the components of a conclusion emphasized on the state science assessment (BSCSc, 2008).

Participants' experiences around science as inquiry helped them developed a shared understanding of what inquiry is and what it looks like in instructional materials. This understanding helped them more effectively use the AIM Process and Tools as a means of gathering evidence around research-based criteria of high-quality instructional materials, analyzing it based on well-tested rubrics, and drawing conclusions about the overall strengths and limitations of the program(s) being evaluated.

The use of the AIM Process and Tools is intended to help participants develop a deeper understanding of concept development, conceptual coherence, relevance, science as inquiry, quality assessment practices, and effective teaching approaches and strategies—not only in theory, but more importantly at a practical level as they learn about these characteristics and then gather evidence of their quality in instructional materials. Participants consistently reported finding value in the AIM Process and Tools. They understood the role AIM can play in selecting instructional materials and to a somewhat lesser degree the role AIM can play in supporting the implementation of instructional materials. Participants recognized the AIM Process and Tools as providing a systematic approach to gathering evidence, conducting analyses, and determining actions related to the selection of instructional materials (moderate effect sizes) and how the development of a conceptual flow graphic can help teachers understand how concepts are developed in instructional materials (moderate effect size). Participants also consistently identified the AIM Process and Tools as one of the most valuable aspects of the NACL Program. In addition, seven of nine teams included the selection and/or implementation of instructional materials in their PD Plans. All seven of these teams indicated the use of AIM or the plan to use AIM in the future as part of the process.

The NACL is a leadership development program, so while changes in teacher practice are not the primary focus of the NACL, the work in the area of inquiry-based instructional practices and selection and implementation of reform-based instructional materials would lead one to expect changes in teacher practices. Participants reported that they have used or would continue to use inquiry-based teaching strategies in their classroom and promote the use within their district. However, results from classroom observations using the Reform-based Teaching Observation Protocol were somewhat disappointing. While means and effect sizes generally increased over the course of the three year program, few of the results were statistically significant. However, effect sizes, an indicator of practical significance that is not dependent on the sample size, were moderate to large from Year 1 to Year 3 across four of the five subcategories.

The greatest improvements in reform-based teaching practices were in the two categories related to classroom culture. Practices supportive of communicative interactions and student teacher relationships improved significantly when compared across years 2 and 3 of the program. While not statistically significant, the effect sizes for these same two categories were large when compared across the three years of the NACL Program. The classroom culture practices include teacher questioning and impact on students' thinking, the variety of student modes of communication with one another, proportion of student talk with one another, the degree to which student talk influenced the flow of the lesson, the degree to which students and teacher demonstrated respect, the variety of problem-solving strategies, and the extent to which active participation was expected and valued.

One potential explanation for the significant changes in classroom culture is the continuous and quality modeling of these practices by facilitators of the NACL Program. Participants consistently commented on the quality models of effective teaching practices provided by NACL leaders in their responses to open-ended questions. Their comments included references to effective modeling of what a student-centered science activity looks like and what quality PD looks like. They also commented on the value of seeing how scaffolds such as the use of the Scientific Explanation Tool and Science Immersion Model for Professional Learning (SIMPL) could help them be a better teacher of students and leader of professional development back in their home district.

The results from classroom observations of reform-based teaching practices did not yield statistically significant improvement in lesson design and implementation, propositional knowledge, or procedural knowledge. These improvements were expected since other studies have indicated that teachers using reform-based instructional materials exhibit teaching practices (Carlson, et al, 2011)). The moderate effect sizes for lesson planning and design and procedural knowledge are promising. The RTOP results indicate teachers have ample room for growth in the creation of student-centered classrooms and implementation of reform-based teaching practices with a final mean score of 57.88 out of a possible score of 100.

Highly Effective Teams and Professional Learning Community

The development of the NACL team as a highly effective team is an integral component of the program. The formation and development of the NACL team plays a critical role in the sustainability of their district science reform efforts including the implementation of reform-based instructional materials. A number of tools and strategies were used to help teams develop the characteristics of effective teams described by Harvey and Drolet (2004). These included processes to develop and revisit their vision of effective science teaching and learning and an effective science professional development program, to collect and analyze various types of data about learning including student work and teacher implementation, to develop norms of collaboration and identify shared tasks around which to collaborate, and to reflect on their development as a team. These

reflections were not only about their learning, but also how well they were working together and what they were doing well and what they could improve upon. NACL leaders emphasized how use of these processes contributed to the development of their team and learning community. Overall, the teams indicated positive changes in team development based on these characteristics and commented that their NACL experiences contributed to their development as a highly effective team.

The characteristic that was most challenging for teams was open conflict. Given this challenge, at least one member of most teams attended a session designed to challenge their beliefs about conflict and help them deepen their understanding of conflict and resistance. Based on the results of the retrospective pre and posttest survey, the beliefs and understandings about conflict were significantly influenced. Participants described more about their learning in a comments section. One participant indicated that as a result of the session they would be able "to be more intentional with intervention strategies, i.e. we will be better able to anticipate and recognize types of conflict and appropriately address them." Another said, "Where do I start? Before the meeting I knew that conflict is inevitable in any change process. Conflict scared me immensely! Having the tools to deal with the conflict…not quite so scary!"

One measure of a given team's efficacy is the extent to which they planned for ongoing work together after the conclusion of their participation in the NACL. In their PD plans, five teams explicitly mentioned ongoing activities of the team. These included holding monthly team meetings, revisiting their professional development plan periodically, continuing to meet to plan for professional development and reflect on its impact, and advocating for their reform efforts. In some cases, the teams linked the idea of sustainability to the ongoing work of their teams.

One of the premises around which the NACL is designed is that the formation of a highly effective leadership team can seed the development of a learning community in their school or district. Participants in the NACL reported increases in their understandings of both the characteristics of PLCs and what leaders do to develop and sustain PLCs. However, their ability to develop a professional learning community back home was limited. While results were not statistically significant, two of the questions related to frequency of PLC activities revealed a decrease in the frequency of activities. One possible reason for this could be increasing district budget constraints during the three year program. Another reason could be that participants developed a deeper understanding of what it means to "be" a PLC and therefore set a higher standard for what it means to engage in PLC activities. With this higher standard we could potentially see a decrease in the frequency of activities that they would perceive as high quality.

Even though participants' reports of the frequency of activities were relatively low, all ten district-based teams included the development or enhancement of PLCs as part of their science professional development program. One reason may be linked to expectations. For example, the inclusion of professional learning communities in their plans was certainly emphasized during the NACL program, it may be an expectation of their district, and it may likely be consistent with their own vision of how they want to work together moving forward. Another potential reason is their strong belief that an effective professional learning community can help sustain their science reform efforts. In addition, participants were confident that their NACL team could contribute to the development of an effective professional learning community.

Leadership and Professional Development Design and Plan

Two key roles of curriculum leaders were emphasized as part of the NACL program. One was leading change and the other designing professional development—both focused on the selection and implementation of reform-based instructional materials. Participants reported increased levels of confidence in feeling prepared for their role as a curriculum leader over the course of their participation in the NACL.

Each year participants deepened their understanding of change as a process and learned to use tools to help them monitor the implementation of reform-based instructional materials and make decisions about appropriate interventions. Many of the lessons were consistent with participants' experiences and their beliefs about the change process. Examples of these beliefs include: people tend to think they don't have enough resources to enact the change. Other lessons about change showed significant differences over time. A pattern in participants' beliefs was in the increase in their appreciation for change as about the person first. Participants' reported significant increases (statistical; moderate effect sizes) in their appreciation of change as a *personal experience*-- that people commit to ideas at different rates and people can be resistant to change because they do not believe the change is worthwhile. Note that this final statement relates to the important role of teacher beliefs in planning for professional development and the need for differentiation!

Appreciating and understanding change as a process is only one characteristic of an effective leader. To lead change, participants needed tools to monitor and support the change for which they were advocating—for most teams this was the implementation of reform-based instructional materials. Participants' reported significant increases (statistically; large effect sizes) in their understanding of how to use tools to help them in their work. Tools included those from the Concerns-based Adoption Model (Hall and Hord, 2006; Hall, Hord, George, Stiegel, Bauer, & Dirksen, 2006) and Innovation Configurations from NSDC (2003). Nine of ten teams provided evidence of both the value they placed on these tools and their understanding of their use when they embedded at least one of them in their professional development plans.

One area related to leading change that participants identified as particularly challenging was dealing with conflict and resistance. Conflict was an area in which teams struggled in their own interactions. Dealing with resistance also became a greater concern as they developed a greater understanding of what it takes to actually implement a reform effort that not all *believe* is worthwhile. Following a break-out session during the Year 3 Fall Academy Meeting, participants reported significant (statistically; large) increases in their understanding of conflict, resistance, and how to more effectively work through these challenges.

Participants reported significant increases (statistical; large effect sizes) in their understandings about professional development design. They indicated statistically significant increases in understanding the roles of teacher knowledge and beliefs, context, and critical issues in informing decisions about the overall plan for their science professional development program. They also reported significant increases (statistical; moderate to large effect sizes) in their efforts to actually use this information in their planning process. Their professional development plans provided evidence of their understanding and application of these ideas.

Participants struggled a bit more to appreciate how professional development should be embedded in the everyday work of teachers (statistically significant; moderate effect size). While all teams included multiple professional development strategies in their plans, the "workshop strategy" was among the most frequent activity identified in plans. Eight of ten teams built into their plans professional development strategies that could be considered embedded in the everyday work of teachers. These strategies include examining teaching and examining student work. It's one thing to identify the strategy and another to have the organizational structure to support collaboration. Of these eight, six teams identified collaborative structures to support the use of these strategies. Collaborative structures included time set aside by the district for such activities and the identification of protocols to support productive dialogue. Their professional development plans provided evidence of their understanding and application of these ideas.

Another area in which participants struggled was in understanding how to link their plan to their goals—essentially how to ensure coherence. Participants' pre and post-test report of their understanding was not statistically significant and showed only a moderate effect size. The need for coherence was the most frequent focus of feedback on teams' professional development plans. As part of their feedback, faculty consistently provided observations from their plans identifying disconnects among their vision, analysis of data and critical issues, and actions. Feedback also included questions, suggestions, or examples to help teams improve the coherence of their plans. Faculty supported teams through the planning process providing consultation, facilitation, and coaching. The quality of the plans improved with each round of feedback.

NACL teams began developing a shared vision and professional development plan in Year 1 of the Academy Program. The Year 2 program emphasized designing a program using the Professional Development Design Framework (Loucks-Horsley, et al 2003) and a Professional Development Design and Plan Tool developed by BSCS to scaffold planning opportunities. Each team began the design and planning process using this tool. As part of the design, teams developed a vision of learning and teaching science as well as for effective professional development. The vision statements were expected to be informed by the research base and literature with respect to learning and teaching, the nature of science, professional development, and the change process. The plans of eight of ten teams provided evidence of such consideration.

Teams analyzed data from a variety of sources including student learning data from the state science assessment and data from teachers including implementation data. Data-driven dialogue (Wellman and Lipton, 2004) was the tool and process used to support their analysis of data. Eighty-two percent of participants report having used data-driven dialogue more than once or having included it in their plans for future use. Only about 6% of participants (potentially new team members) indicated that they had never used data-driven dialogue. Conclusions from data analysis and a review of critical issues were used to inform the development of goal statements.

Feedback on the teams' designs and plans was provided by the NACL Faculty at the conclusion of the Year 2 Fall Academy Meeting and again just prior to the Year 3 Spring Academy Meeting. In each instance, teams used the feedback along with new information gained during the meeting to revise their professional development plans. During the Year 3 Spring Academy meeting each team also received feedback from another NACL team. Teams also assessed the quality of their own plans using a tool adapted by BSCS from Enhancing Program Quality in Mathematics and Science (Kaser, et al 1999). Through these feedback and revision cycles, teams improved the quality of their plans based on the criteria including vision, use of data from a variety of sources to inform decision, clarity of goals, the incorporation of multiple PD strategies selected based on important critical issues, and the inclusion of tools and strategies to monitor and support teacher implementation and measure impact of the PD program. While inclusion of these components was important, the coherence and alignment of the components was of utmost importance.

While the quality of the plans improved over the course of their participation, little data was gathered to indicate the degree to which the plans were implemented and no data was gathered to make any conclusions about the impact of the design and plan back home. Future study of the NACL program could focus on assessing the degree to which the plans were implemented and the impact of the interventions on NACL participants and within various levels of the school and district structure. A study of this nature would reveal more about the extent to which the NACL Teams were successful in leading the reform effort within their districts and schools.

Multiple professional development and evaluation strategies are important components of a quality professional development program. As evidence of change, plans were also expected to include advocacy-related activities to increase the likelihood of sustainability. Of course, the

development of PLCs and plans for ongoing work of the NACL team also indicate that teams made efforts to ensure sustainability of their reform effort.

Participants reported a significant (statistical; large effect size) increase in the understanding of how to effectively advocate for their reform effort. They also reported significant (statistical; moderate effect size) increases in their agreement that leaders in their district effectively advocate for professional development. However, results from the question about the frequency with which they had successfully convinced a colleague of the need for reform were not significant (statistical; low effect size). A number of factors could be at play here. Participants may now better understand what they have to do to successfully advocate and realize that prior efforts were lacking on their part. They may now have more information about what it takes to really convince someone of the need for change or they may now recognize that the only way to achieve lasting change is for the person to *want* to change. Plans for professional development include evidence of the value teams place on advocacy. Five of ten teams included at least one advocacy-related activity in their professional development plan.

Systems

The system in which the NACL teams work influences what teams do, how they work together as a team and with others, and what they are or are not able to accomplish. For the purposes of this report, the system is the district. Data was gathered about district policies and changes in policy over the course of the three year NACL Program. Little change in district policy was reported by the coach and/or key administrator. The only area in which district policy was somewhat influenced as a result of the program was in the inclusion of the AIM Process and Tools or some aspect of the process in four of ten districts.

From the perspective of participants, the level of organizational support did change. The perceived improvements in organizational support as defined by Guskey (2000) over the course of the NACL program were all statistically significant ($p<.001$) with moderate and large effect sizes. The items with the largest effect sizes were those associated with coherent and thoughtfully planned district PD (items #1 and #12) and access to expertise to mediate implementation challenges (item #10). The item with the lowest overall initial and final means was related to district planning for follow up support. The item with the lowest effect size was related to funding for PD as a line item in the district budget (item #2).

Three questions on the organizational setting survey focused on the district's support for implementation, provision for follow-up support as part of the district professional development plan, and the district's provision of resources to support the implementation of new practices. While these items yielded statistically significant results with large or moderate effect sizes, the fact that these items yielded the three of *lowest* effect sizes on the survey raises hope and caution. First, the reported increases in participants' perceptions are important. Given the research that suggests changes in teaching practice requires time and ongoing support (Hall and Hord, 2006; Supovitz and Turner, 2000), improvements in these three areas of ongoing support is critical. However, district support in these areas is essential for the teams to sustain their improvement efforts.

Participants elaborated items from the inventory that represented the greatest changes to organizational setting. Themes that emerged from these comments included insights into participants' thinking about their experiences and the changes they've experienced. Comments about leadership and collaboration indicate that participants developed greater appreciation for working together to affect change and the importance of support from inside and outside the organization. For example, one participant commented: "At the school level, our NACL team has been more involved in implementing school-wide and department level professional development and are being viewed as teacher leaders within the building."

Participants' comments about both professional development and the plan indicate a level of appreciation for the role that effective planning has on the quality of professional development. For example, one participant commented, "…We know more of what to ask for meaningful PD; … District is more supportive of teachers going to PD. Feeling is they will be more receptive (at least we have better chance of selling it) to plans we will develop."

Conclusions about the Impact of the NACL

The NACL significantly impacted the understanding, beliefs, and skills of the participants with respect to:

- science teaching and learning, role of instructional materials, and selection and implementation of reform-based instructional materials,
- professional development design, the development of a professional development plan, and as a team work as a PLC,
- leadership characteristics, development of leadership skills, and ability to enact change, development as a team, and consideration of the change process in the development of the Professional Development Plan.

The NACL had some impact with respect to:

- the use of the AIM process and tools, and classroom instructional practices,
- the use of Data-driven Dialogue to make decisions, and participant adoption of leadership roles.

The NACL did not significantly impact the teams with respect to:

- administrative classroom observation practices, and district policies about instructional material selection and/or implementation,
- enactment of a successful professional development program, and establishment of additional PLCs,
- school and district policy changes as a result of their new leadership skills,
- the integration of the new tools and processes into the school/district as a system.

We are not able to conclude whether the impact was significant with respect to:

- enactment of a professional development program, and planning and delivering professional development opportunities.

Recommendations

Every major strand in the NACL program yielded statistically significant results from the self-report retrospective pre/post survey. Clearly participants recognize that their beliefs about learning and teaching, the nature of science, professional development, and the change process changed over the course of their participating in the NACL. They also believe that they learned a great deal about curriculum leadership in these same areas. Results associated with application or impact back home were less significant. The recommendations below are informed by both the results from this study and the results from previous research and evaluation of the NACL program.

The more targeted inclusion of specific strategies and scaffolding to support inquiry-based teaching and learning proved effective for participant learning. For example, nearly all teacher participants reported using the explanation tool introduced during the NACL. The continual modeling of strategies to support discourse and collaboration also *seemed* to influence their classroom practices.

Improvements in reform-based classroom practices over the course of the NACL Program were disappointing. Consistent with the guiding principles of the NACL, increased efforts should be made to support teams' selection and implementation of high quality instructional materials early in the program. These efforts could include helping teams develop greater capacity to *facilitate* the AIM Process and Tools with colleagues. Currently, the program is designed to help them use the process, not to facilitate the process. The program could be revised to include a session focused on facilitation of the AIM Paperscreen Process and Tools or this could be offered as part of technical assistance for the purpose of helping teams lead AIM back home to select instructional materials.

As part of the NACL program in years 2 and 3, each team received feedback on their designs for professional development and action plans. Evidence suggests that the feedback was valued by participants and used by teams to revise their design and plan for professional development. This feedback helped teams better apply their learning to the design and plan for an effective professional development program. The fact that most teams and the entire NACL faculty were Washington-based contributed to the effectiveness of the feedback as it could be based directly in the context of the state initiatives and resources.

Greater emphasis was placed on helping teams learn to use CBAM tools. For example, more time than in previous cohorts was spent practicing the analysis of Stages of Concern Open-ended Statements and the Levels of Use Branching Interview. Teams were also expected to gather and bring data collected from these (and other) instruments to various Academy Meetings during which the data was analyzed. The analysis of data was followed by a team planning session so they could make decisions about next steps based on their findings.

Efforts were made particularly in Years 2 and 3 to differentiate the program based on needs and followed by session choice on the part of teams. In some cases, sessions were designed to accommodate differences in the size of the district and at other times based on where districts were in the selection and implementation of reform-based instructional materials. At other times, particularly in Year 3, the program was differentiated based on the needs of individuals. These modifications to the program were effective and additional differentiation should be explored. For example, all participants benefit from understanding change as a process and awareness of the tools from the Concerns-based Adoption Model (CBAM). In theory, coaches and key administrators might benefit more from a deep understanding and practice using tools from CBAM, while coaches and teacher leaders might benefit from increasing their capacity to *facilitate* the AIM Process and Tools. Additional efforts should be made to differentiate the program based on individual and team needs.

The AIM Process and Tools includes a component focused on implementation. The program could be revised to include sessions focused on developing the capacity of the team to use the AIM Implementation Process and Tools to support the implementation of reform-based instructional materials. The AIM Process and Tools also includes components to help teams focus on standards alignment and assessment. These components could receive greater emphasis in the program to teams' ongoing efforts.

While some revisions to the overall program were made to better model the nature of curriculum-based professional development, teams could be better supported in planning for "Initial use" training followed by developmentally appropriate professional development focused on the implementation of a new program. This could include specific actions of NACL leaders to connect NACL teams and publishers or connect NACL teams with regional experts in the program selected by their respective districts. Washington has a robust support network of science leaders, many of whom served as NACL Faculty. These leaders were highly valued by teams and frequently referenced in team plans particularly to support the selection and implementation of instructional materials.

Teams may need more concrete tools and strategies to develop awareness, shared understanding, implementation, and reflection on reform-based teaching practices such as those measured by the RTOP. Currently, the program includes innovation configurations describing some of these practices. Teams could be better supported in using them back home. For example, helping team members lead a study group to understand the components and engage in reflective dialogue about the status of teachers' practice. These practices could improve RTOP results described earlier. Technical assistance could be focused on the use of tools and resources back home. While not addressed elsewhere in this report, the NACL is designed to include technical assistance to teams by NACL leaders. For this cohort of teams, the technical assistance was spotty at best. In theory, more robust technical assistance would increase teams' influence on their colleagues. However, the strong network of science leaders across the state—some of whom served as NACL Faculty and others members of the LASER Regional Alliance Director Team—provides great hope that efforts will be sustained.

Additional efforts should also be made bring together other school leaders such as the district superintendent or leaders from intermediate agencies to develop awareness of the goals of the program and to build support for the teams' efforts. For example, such leaders could be brought together along with the coaches and key administrator s for a dinner meeting to discuss needs, ideas, and progress related to Academy goals. Alternatively, statewide meetings could serve as a forum to engage this audience. The regional NACL model and critical partnerships among statewide agencies and leaders provide an impetus for additional networking and advocacy.

Even with a regional model involving teams primarily from one state, each of the teams has its own local context and both challenges and strengths that influence the degree to which they will be able to achieve their goals. All of the teams would benefit from additional mentorship and/or coaching from the NACL Faculty and others in leadership roles. The opportunity for the teams to meet together and share successes and challenges would help support their work and provide much needed inputs of energy to sustain their efforts.

The results of this study answer some questions and generate others. Examples of additional questions include:

- What is the long-term impact on individual participants, teams, and districts?
- To what extent do teams' actions back home influence student learning?
- What factors most influence long-term sustainability of the implementation of reform-based instructional materials at the secondary level?
- To what extent are classroom practices influenced when principals or evaluators better understand reform-based instructional materials and practices?
- What is the impact of a leadership development program on student learning?

These questions and others should be considered in future iterations of the BSCS National Academy for Curriculum Leadership.

References

Baxter, H. L., D. (2007). *The SIMPL approach to science education reform.* University of Wisconsin-Madison.

Biological Sciences Curriculum Study (BSCS) (2006). *BSCS science: An inquiry approach level 1*. Dubuque, IA: Kendall/Hunt Publishing Company.

Biological Sciences Curriculum Study (BSCS) (2008a). *Evaluation Report for the Cohort 2, Year 1 Fall Meeting of the BSCS National Academy for Curriculum Leadership, A Partnership between the BSCS Center for Professional Development and Washington State LASER, November 11-16, 2007* (ER 2008-02). Colorado Springs, CO: Edmondson, E. and Stuhlsatz, M.A.M.

Biological Sciences Curriculum Study (BSCS) (2008b). *Evaluation Report for the Cohort 2, Year 1 Spring Meeting of the BSCS National Academy for Curriculum Leadership, A Partnership between the BSCS Center for Professional Development and Washington State LASER, March 2-4, 2008* (ER 2008-05). Colorado Springs, CO: Edmondson, E. and Stuhlsatz, M.A.M.

Biological Sciences Curriculum Study (BSCS) (2008c). *Evaluation Report for the Cohort 2, Year 2 Leadership Institute of the BSCS National Academy for Curriculum Leadership, A Partnership between the BSCS Center for Professional Development and Washington State LASER, August 10-14, 2008* (ER 2008-16). Colorado Springs, CO: Edmondson, E. and Stuhlsatz, M.A.M.

Biological Sciences Curriculum Study (BSCS) (2009). *Evaluation Report Cohort 2, Year 2 Spring Academy Meeting, BSCS National Academy for Curriculum Leadership, A Partnership between the BSCS Center for Professional Development and Washington State LASER, March 1–3, 2009* (ER 2009-04). Colorado Springs, CO: Edmondson, E. and Stuhlsatz, M.A.M.

Biological Sciences Curriculum Study (BSCS) (2010). *Summary of Additional Data Collected for Cohort 2, Year 3, BSCS National Academy for Curriculum Leadership, A Partnership between the BSCS Center for Professional Development and Washington State LASER, August 2009 – March 2010* (ER 2010-16). Colorado Springs, CO: Edmondson, E.

Carlson, J., Gardner, A.G. Stuhlsatz, M, Taylor, J. A., Wilson, C. D., Gess-Newsome, J., Cardenas, C., & Austin, B. A. (2011). *Impact of Educative Materials and Transformative Professional Development on Teachers PCK, Practice, and Student Achievement.* National Association for Research in Science Teaching (NARST) Annual Meeting, Orlando, FL:.

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences.* (2nd ed.). Mahwah, NJ: Lawrence Erlbaum.

Colburn, A. (2008). *What teacher educators need to know about inquiry-based instruction*. Retrieved February 22, 2008, from http://www.csulb.edu/~acolburn/AETS.htm

Danielson, C. (2007). *Enhancing Professional Practice: A Framework for Teaching* (2nd ed.) Alexandria, VA: Association for Supervision & Curriculum Development (ASCD).

Fullan, M. (2001). *Leading in a culture of change*. San Francisco, CA: Jossey-Bass.

Garmston, R. J., & Wellman, B. M. (1999). *The adaptive school: A sourcebook for developing collaborative groups* (1st ed.). Norwood, MA: Christopher-Gordon..

Guskey, T. R. (2000). *Evaluating professional development.* Thousand Oaks, CA: Corwin Press, Inc.

Hall, G. E., Hord, S. M., George, A. A., Stiegelbauer, S., & Dirksen, D. (2006). *Measuring Implementation in Schools: The Concerns Based Adoption Model.* Austin, TX: Southwest Educational Development Laboratory.

Hall, G. E., and Hord, S. M. (2006). *Implementing change: Patterns, principals, and potholes* (2nd ed.). Boston, MA: Allyn and Bacon.

Harvey, T. R., & Drolet, B. (2004). *Building teams, building people: Expanding the fifth resource* (2nd ed.). Lanham, MD: Technomic Publishing.

It's About Time (2006). *Active Science.* Armonk, NY: It's About Time, Herff Jones Education Division

Kaser, J., Bourexis, P., Raizen, S., & Loucks-Horsley, S. (1999). *Enhancing program quality in mathematics and science.* Thousand Oaks, CA: Corwin Press.

Kouzes, J. M., & Posner, B. Z. (1997). *Leadership Practices Inventory* (2nd ed.). San Francisco, CA: Pfeiffer.

Kouzes, J. M. P., B. Z. (2003). *Leadership Practices Inventory Participant's Workbook* (3rd ed.). San Francisco, CA: Jossey-Bass.

Loucks-Horsley, S., Hewson, P. W., Love, N., & Stiles, K. E. (2003). *Designing professional development for teachers of science and mathematics* (2nd ed.). Thousand Oaks, CA: Corwin Press.

Loucks-Horsley, S., Harding, C. K., Arbuckle, M. A., Murray, L. B., Dubea, C., & Williams, M. K. (1987). *Continuing to learn: A guidebook for teacher development.* Paper presented at the The Regional Laboratory for Educational Improvement of the Northeast and Islands/National Staff Development Council, Andover, MA.

Louis, K. S., & Kruse, S. D. (1995). *Professionalism and community: Perspectives on reforming urban schools*. Thousand Oaks, CA: Corwin Press.

Love, N. (2001). *Using Data/Getting Results: A Practical Guide for School Improvement in Mathematics and Science.* Norwood, MA: Christopher-Gordon Publishers, Inc.

Michaels, S., Shouse, A. W., & Schweingruber, H. A. (2008). *Ready, Set, Science: Putting Research to Work in K-8 Science Classrooms.* Washington, DC: National Academy Press.

Myers-Briggs, I. (1998). *Introduction to type: A guide to understanding your results on the Myers-Briggs Type Indicator.* Mountain View, CA: CPP, Inc.

National Research Council (NRC). (1996). *National Science Education Standards*. Washington, DC: National Academy Press. National Research Council (NRC). (2000). *Inquiry and the national science education standards: A guide for teaching and learning.* Washington, DC: National Academy Press.

National Research Council (NRC). (2007). *Taking science to school: Learning and teaching science in grades K–8.* Washington, DC: National Academy Press.

National Staff Development Council. (2001). *Standards for Staff Development, Revised*. Oxford, OH: NSDC.

National Staff Development Council (2003). *Moving NSDC's Staff Development Standards into Practice: Innovation Configurations*. Oxford, OH.

Piburn, M., Sawada, D., Falconer, K., Turley, J., Benfored, R., & Bloom, I. (2000). *Reformed teaching observation protocol (RTOP)* (No. ACEPT IN-003).

Sawada, D., Piburn, M., Judson, E., Turley, J., Falconer, K., Benford, R. & Bloom, I. (2002). Measuring reform practices in science and mathematics classrooms: The Reformed Teaching Observation Protocol. School Science and Mathematics, 102(6), 245-253.

Schroeder, K.A., Scott, K.M., Tolson, C.M., Huang, T.P., T.-Y., H & Lee, Y.-H. (2007). A meta-analysis of national research: Effects of teaching strategies on student achievement in science in the United States. *Journal for Research in Science Teaching*, 44(10), 1436-1460.

Stacy, A. (2010). *Living By Chemistry: First Edition Textbook.* Emeryville, CA: Key Curriculum Press.

Sutherland, L.M., McNeill, K.L., Krajcik,J. S., & Colson, K. (2006). Supporting middle school students in developing scientific explanations. In Douglas, R., Klentschy, M. P., Worth, K., & Binder, W. (Ed.), *Linking science and Literacy in the K-8 classroom* (pp. 163-181). Arlington: NSTA.

Wellman, B., & Lipton, L. (2004). *Data-driven dialogue: A facilitator's guide to collaborative inquiry.* Sherman, CT: Mira Via.