
**Evaluation Report
for
BSCS Keys to Science Institutes
Colorado Springs, CO**

***Scientific Inquiry: Research and Practice*
July 15-20, 2007
Evolution across the Sciences
July 29-August 3, 2007**

BSCS Evaluation Report (ER 2008-01 January)

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Background

The BSCS Keys to Science Institute, offered two programs in Colorado Springs during the summer of 2007, both of which were advertised as “content-deepening experiences,” and “high quality professional development programs that go beyond traditional summer Institutes.” They were:

- *Scientific Inquiry: Research and Practice* – This program took place from July 16 - 20, 2007 with 25 participants from 7 states. In addition, an online forum is continuing to engage the participants in a professional development program from 1 June, 2007 until 30 May, 2008.
- *Evolution across the Sciences* – This program was held from 29 July to 3 August, 2007 with 11 participants. The class is continuing with an online professional development community from 1 June, 2007 until 30 May, 2008.

Description of the Institutes

The Keys Institute provides week-long intensive programs at the BSCS office in Colorado Springs as well as year-long, online program offering more than 100 hours of professional development. The online programs incorporate an asynchronous structure that provides continuing professional development experiences and support during the school year without requiring out-of-classroom time. These combined experiences were designed to establish rich learning environments that can help create and develop a professional learning community among Keys participants. The purpose of the professional learning community is to further participants’ understandings, abilities and support for inquiry-based science. Syllabi for each of the Institutes are provided in Appendix A.

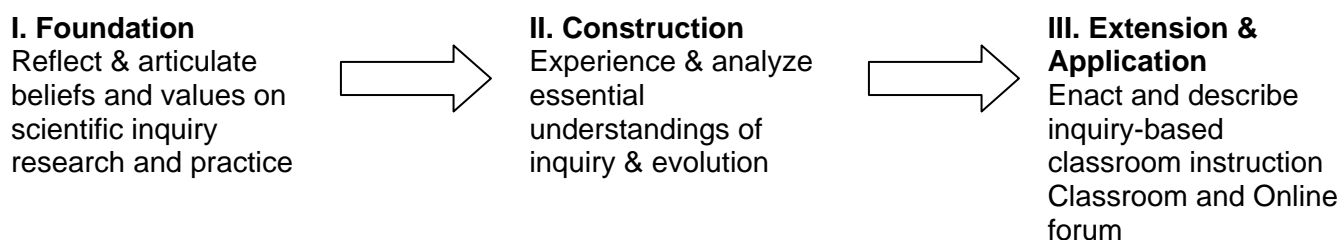
Evaluation Plan

The goals of this evaluation report are to: 1) illuminate the most effective aspects of the Institute programs for successful professional development, 2) define the impact of the Keys to Science Institute programs on participants’ classroom practice, and 3) describe the effects of engagement in the online forum in terms of participant-driven learning.

The report is organized into sections for the two separate institutes according to a 3-part framework, followed by a general summary, and conclusions. Also included are recommendations for both programs offered by the BSCS Keys to Science Institute in 2007. The framework is described below:

- 1) As a foundation, participants reflected upon and articulated their beliefs and values concerning scientific inquiry through an online forum during the 6-week period preceding the workshop in Colorado Springs. Their responses are reported and analyzed first.
- 2) Next, understandings and abilities were developed through active engagement in activities provided during the summer program. These activities focused on essential understandings about inquiry and evolution. Participants were challenged to experience and analyze the activities and relate them to future classroom practice. Their responses and subsequent analysis of learning experiences are discussed through triangulation of results from daily reflections, cumulative session ratings, retrospective pretest and posttest results, and open-ended comments.
- 3) Finally, learning that took place through the summer Institute is extended through participants' and facilitators' interactive discussions on the online forum following the program. Using this format, the impact of the programs and of the online forum is examined in multiple contexts.

The following graphic illustrates the structure for each program's report.



Scientific Inquiry: Research and Practice

Foundation: Reflecting upon and articulating beliefs and values

Educators in the *Inquiry* program were registered on the online forum on 31 May 2007. The facilitator of the online forum set out the following assignment for participants:

Respond to each of the five reflection questions posted with the forum by July 10th. A separate discussion thread has been setup for each.

Respond to each under the topic thread posted. In addition to posting your response to each question, post at least one reflection to two other

participants' responses, and at least one response to another participant's reflection. You should have your reflections posted by July 15th.

All 25 participants responded to the 5 questions that challenged them to reflect upon and articulate their personal beliefs regarding science and science education. The questions are listed in Table 1 with the number of replies posted by the institute members:

Table 1 – Online Forum Questions

Question	Responses
1. What in your view is science? What makes science (or a scientific discipline such as physics, biology, etc.) different from other disciplines of inquiry (e.g., religion, philosophy)?	38 posts
2. Does the development of scientific knowledge require experiments?	38 posts
3. Is there a difference between a scientific theory and a scientific law?	30 posts
4. This past school year, did the students in your classes formulate, communicate, and justify evidence based explanations?	45 posts
5. What does scientific inquiry look like in the classroom? Describe an example of Inquiry in the classroom and specify what makes that scientific inquiry?	36 posts

In addition, two questions were initiated by participants or facilitators in response to others' views:

- “In response to question #3, many people are using either the word 'prove', 'proved', or 'proven'. What does one mean by stating, "I have proven...." or "...has been proved."? Can something be proven scientifically?” (7 responses)
- “Would anyone like to comment on how they define and use the term "fact" in science? How does this compare to how your students use it?” (3 responses)
- Finally, a facilitator-developed poll received 11 responses – “How often is the concept of a model used in your class explicitly?”

The 5 questions served to activate the participants' prior knowledge and beliefs about science and science teaching, as well as establish a formative baseline assessment for the facilitators. Not surprisingly, the responses indicated that the group held diverse views of science and scientific inquiry. Although most science educators recognize inquiry as an important aspect

of science, there are still many misconceptions and varying views of inquiry in the field Luft, Bell, Gess-Newsome (2008). The views of science could be categorized into two primary perspectives: ideas demonstrating combinations of a 'realist' perspective of science, i.e. science as true, unchangeable and independent of the knower, and an 'instrumentalist' perspective of science as tentative, subjective, empirical and testable. A few examples illustrate 1) Realist perspective: “Science is usually considered as accumulated, established and systematized knowledge that is formulated with reference to the discovery of general truths, which are classified and made available in work, life, or the search for truth. In a more distinctive sense, science embraces those branches of knowledge of which the subject-matter is either ultimate principles, or facts as explained by principles or laws.” 2) Combination of realist/instrumentalist views: “Science is a unique method of acquiring, processing, evaluating, & learning. Unlike other disciplines, it uses subjective facts instead of objective thoughts & feelings to determine what is truth.” “Science has a specific process to validate findings. The facts that are discovered are not considered "ultimate truths" but can be molded and shaped as new information is discovered.”

The views of Inquiry initially presented in the forum showed varying and naive perceptions of inquiry in science. Inquiry was portrayed as one of four perspectives: 1. Inquiry as experimentation, 2. Inquiry as the “scientific method”, 3. Inquiry as open-ended activities driven by student interest, or 4. Inquiry as asking questions, mostly student generated questions. A few participants held more sophisticated understandings of Inquiry, describing multiple representations of it in the classroom. Knowledge of Inquiry as portrayed in the National Science Education Standards was very limited.

Through the exchange of ideas and resources and the give-and-take of online discussion, the participants began to form a sense of community. This was noted during the first day in Colorado Springs when participants commented on the discussion and began to associate faces with the usernames and discussions.

Construction: Experiencing and analyzing the ‘big ideas’ of inquiry

The syllabus states: The following questions will guide our work and reflection:

- What is scientific inquiry?
- Why is it essential to science teaching and learning?
- How do we engage learners in meaningful scientific inquiry that promotes deep conceptual understandings?
- How do we know what students have learned about science and inquiry?
- What should scientific inquiry look like in the secondary classroom?

The facilitators built a full schedule (Appendix A) of research-based activities representing a balance of active engagement with reflection and discussion, and of participants’ roles as ‘learner/scientist’ and ‘teacher.’ This enabled the group to experience activities, strategies and ideas from many perspectives, adding depth and breadth to their personal beliefs, understandings, and skills.

The organizing concept for the week was the Five Essential Features of Classroom Inquiry developed by the National Research Council National Research Council (2000). By dissecting the concept of inquiry and modeling its essential elements and different forms, including developing testable questions and evidence-based explanations, the instructors guided participants in experiencing and then closely analyzing the process to build understanding and abilities. Additional skills and knowledge, such as constructing a conceptual flow graphic, learning the tenets of ‘how people learn,’ assessing student conceptions, and organizing instruction to implement inquiry, contributed to the participants’ growing facility with Inquiry teaching and learning.

Written reflections.

Extensive data were collected to assess the effectiveness and impact of the *Inquiry* program. Written daily reflections in response to five statements create a picture of teachers as learners, initially experiencing cognitive dissonance, and fatigue, but gradually developing confidence and mastery of ideas, and then thinking ahead to application of the

skills and knowledge gained through the institute to their personal classroom situations. The daily reflection logs asked participants to reflect on 5 areas; things about the day that were notable, key ideas that they learned, the structures or strategies that the facilitators used, barriers to learning, and questions that they have at the end of the day. Reactions and representative comments for the five days are summarized under each of the statements below.

1. Things I noticed that were notable

Most comments on the first day mentioned collaboration as notable; cognitive dissonance about Inquiry was evident, but participants had strong positive feelings about their “experience as learners.” Later, the strategies of inquiry were mentioned as participants switched from the role of learner to that of teacher. Synthesizing the two roles, the educators noted

“the concept of Inquiry being clarified as result of open inquiry activity; 5Es and conceptual flow.”

Next, reflections became introspective:

“I need to get better at communicating expectations of tasks to students. Inquiry is respectful of learner.”

“I had my AHA moment today. My frustration with the state lesson plans has been because they didn't have the explanation, review and revision of explanation components. Up until now, I couldn't anticipate why I was so frustrated. Now I can articulate my frustrations & fix them.”

2. The key ideas that I learned today were

The majority of responses were centered on the elements of inquiry, with increasing

“clarification; more comfort with definitions, processes.”

By the fourth day, a respondent reported,

“Understanding components and strategies of inquiry – accepting them and seeing value – making connections.”

Finally, a participant could state s/he learned,

“How to implement inquiry in classroom & school.”

3. These are the structures or strategies that the facilitators used that helped me to learn

It is evident from the great number and variety of responses that the facilitators demonstrated many inquiry-based instructional strategies. Most frequently mentioned are: cooperative learning, collaboration and active participation;

“processes of inquiry – designing investigation, sharing work, revising explanations,” “modeling strategies - forcing me to work through the process,”

“Questioning, discussion, feedback much like what would go on in a high school science class (or should). Collaboration is KEY!! Time given to generate thoughts and share with partners.”

4. Barriers to my learning that I encountered today (include personal barriers)

In the first days of the institute, participants found the new material and strategies to be overwhelming, as seen in this comment:

“I could not make connections to my process style of teaching. I need to see where things would fit.”

Frustration and fatigue were reported as the full schedule continued through the week.

“I’m tired & need some time to mull ideas & ‘cognitively wrestle’ w/ what I need to adjust in my classroom to help students learn.”

By the next to last day, a participant reported,

“None really. My learning barriers are diminishing as the week progresses.”

5. Questions that I have after today’s work

Initial efforts to make connections and clarify terms were transformed to concerns for implementation. More ‘how’ questions were asked as participants wrestled with extending program concepts to personal classroom instructional strategies, e.g.

“I still am questioning how students with severe reading and/or behavioral problems will be able to handle Inquiry and come to the understanding our state tests require. How much will I need to share with other teachers in my building?”

“How will I integrate the 5E’s into the learning goal pages my department has created? How will I use the whole conceptual flow model with the same learning goal/unit organizer pages?”

By the final day, one reported,

“Feeling pretty good, but know questions will arise as I begin planning to incorporate my learning into this years plans.”

Session Ratings and Retrospective Pretest/ Posttest (RPT-PT)

Participants were asked to rate each of the program sessions. The percentages, means and standard deviations of responses in each of 5 Likert-type rating categories for 13 sessions in the Inquiry Institute are detailed in Table 2. The three sessions with the highest ratings were Essential Features of Inquiry, Testable Questions, and Evidence-Based Explanations. Interestingly, these match the areas of greatest growth from pretest to posttest scores in the Retrospective Pretest and Posttest (Table 3). The retrospective pretest/post test was administered to *Inquiry* Institute participants on the final day. This

instrument allows respondents to rate their level of understanding of 9 topics introduced during the session, and of 7 abilities related to inquiry instructional strategies. The graphs below represent the growth in understandings and of abilities, all of which are statistically significant at the $p < .001$ level.

Table 2. Session Ratings

% of responses in each category – Highest rated sessions in bold

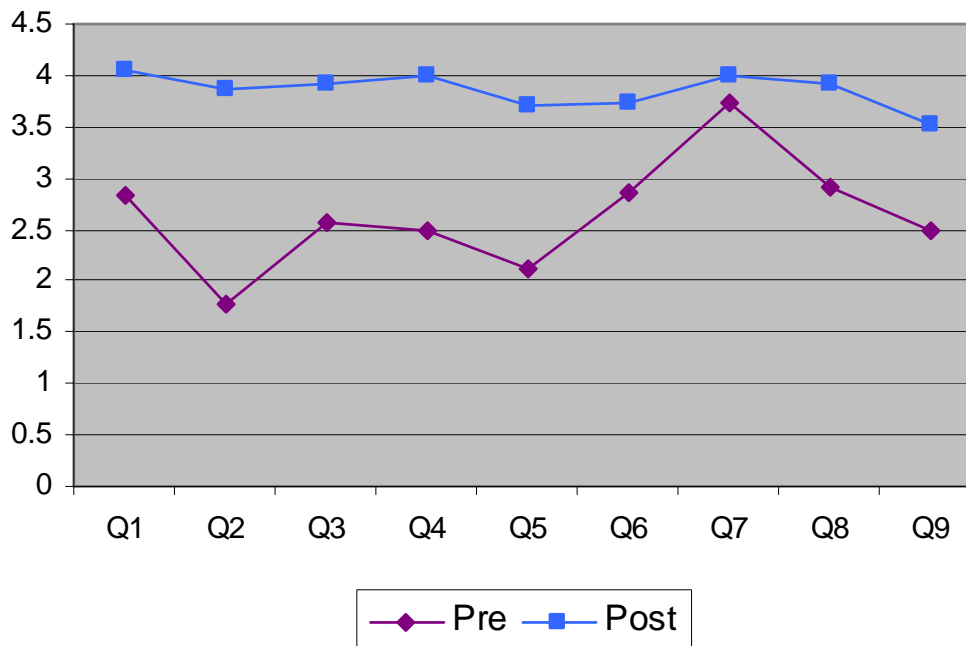
SESSION:	Not at all Useful	Not Very Useful	Some-what Useful	Useful	Very Useful	Mean	Std. Dev.
1. Essential Features of Inquiry	0	0	4.3	26.1	69.6	4.65	.57
2. Testable Questions	0	0	0	34.8	65.2	4.65	.49
3. 5E's vs. 5EF	4.3	0	13.0	47.8	34.8	4.09	.95
4. Evidence Based Explanations	0	4.3	0	4.3	91.3	4.83	.65
5. Concepts	0	0	30.4	34.8	34.8	4.04	.83
6. Tri-Lakes Activity	0	0	17.4	47.8	34.8	4.17	.72
7. Learner Directed Inquiry	0	0	9.1	45.5	45.5	4.36	.66
8. Online Forum	4.3	17.4	47.8	26.1	4.3	3.09	.90
9. Lesson X&Y	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10. How People Learn	0	10.0	20.0	60.0	10.0	3.70	.80
11. PLC's & Student Work	0	10.0	35.0	55.0	0	3.45	.69
12. Garden of the Gods Experience	0	0	4.3	69.6	26.1	4.22	.52
13. Debriefing the Lessons	0	0	17.4	30.4	52.2	4.35	.76
14. Student Conceptions and IM	0	0	4.5	54.5	40.9	4.36	.58

Table 3. Understanding Retrospective Pretest and Posttest Scores

Participants were asked to rank their level of understanding from 1-5 (1=no understanding, 5=complete understanding) for each of the statements below based on what their perceived understanding before (retrospective pretest) the workshop and after (posttest) the workshop. The mean scores for the entire group for each of nine understandings are listed. The significance level indicates a statistically significant difference between retrospective pretest and posttest for all items, indicating that the learning goals of the summer institute were accomplished. (N=23)

UNDERSTANDINGS OF:	Retrospective Pretest Mean	Posttest Mean	t-value	Significance Level
1. About Science as Inquiry	2.83	4.04	6.137	.000
2. The five essential features of scientific inquiry in the classroom.	1.78	3.87	7.091	.000
3. Construction and evaluation of testable scientific questions.	2.57	3.91	6.292	.000
4. Construction and evaluation of evidence-based explanations.	2.48	4.00	5.726	.000
5. How to scaffold students' construction of evidence-based explanations.	2.13	3.70	7.240	.000
6. Instructional Design and how it can influence teaching and learning?	2.87	3.74	3.943	.000
7. That deeper understanding of how instructional materials and their design can contribute to rigorous learning.	3.74	4.00	5.988	.000
8. How to organize instruction to promote conceptual understanding.	2.91	3.91	4.592	.000
9. Strategies to examine and reflect upon student work to assess student understanding and instructional practices.	2.48	3.52	5.700	.000

Figure 1. Understanding: Retrospective Pretest and Posttest Scores



Item 2, “the 5 essential features of scientific inquiry in the classroom,” demonstrated the greatest increase in understanding from pretest to posttest. As the organizing concept of the program, it was supported by the next two items of greatest growth, item 5 “how to scaffold students’ construction of evidence-based explanations,” and item 4 “construction and evaluation of testable scientific questions.” These results demonstrate the strength of instruction and the success of participants’ engagement and subsequent construction of conceptual understandings of inquiry.

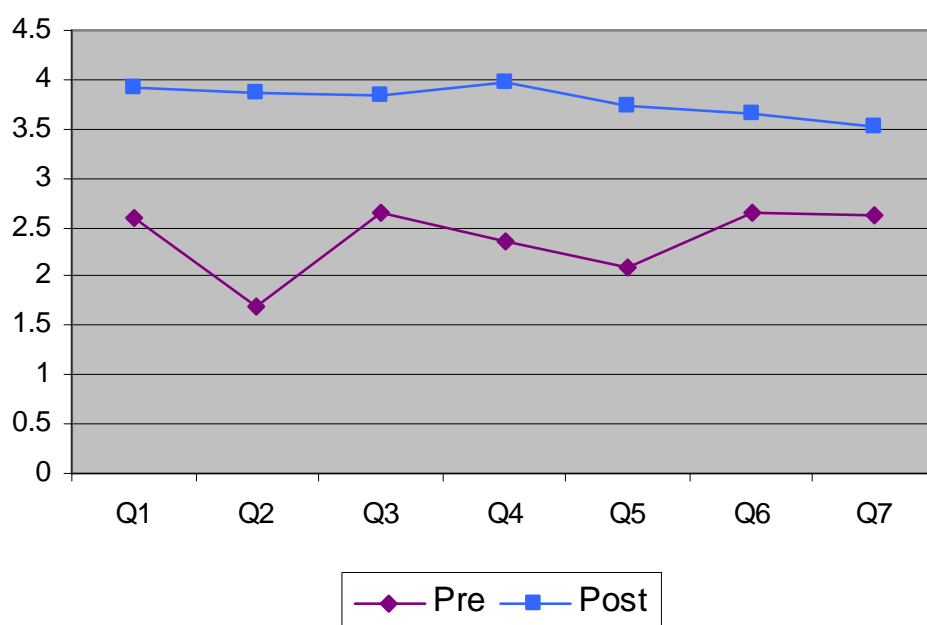
The comparison of retrospective pretest and posttest institute scores for abilities reveals identical results to the understanding scores. Participants rated their ability growth highest for using the 5 Essential Features of Scientific Inquiry in the classroom (item 2), followed by scaffolding students’ construction of evidence-based explanations (item 5), and construction of evidence-based explanations (item 1). For each understanding and abilities scale, the items with low levels of growth are “strategies to examine and reflect upon student work to assess student understanding and instructional practices” and “how to organize instruction to promote conceptual understanding.” These are practical skills that were not directly addressed in depth during the program and which, it is assumed, will be expanded through application in personal classroom experiences and participation in online forum discussions during the following school year.

Participants were also asked to rate their level of ability 1-5 (1=no agreement, 5=complete agreement) on seven skills addressed at the workshop. As with the understanding statements; participants rated their abilities at the present time in contrast to their perceived abilities BEFORE the program. Table 4 shows the mean score for each measure (pre & post) along with the significance level from a t-test comparing the means. All t-tests showed significant differences between pre and post tests. (N=23)

Table 4. Abilities Retrospective Pretest and Posttest Scores

ABILITIES	Retrospective Pre Test Mean	Posttest Mean	t-value	Significance Level
1. To do Science as Inquiry	2.59	3.91	10.887	.000
2. To use the five essential features of scientific inquiry in the classroom.	1.70	3.87	12.500	.000
3. To construct and evaluate testable scientific questions.	2.65	3.83	8.657	.000
4. To construct and evaluate evidence-based explanations.	2.35	3.96	8.656	.000
5. To scaffold students’ construction of evidence-based explanations.	2.09	3.74	12.241	.000
6. To organize instruction to promote conceptual understanding.	2.65	3.65	6.494	.000
7. To examine and reflect upon student work to assess student understanding and instructional practices.	2.61	3.52	5.972	.000

Figure 2. Abilities: Retrospective Pretest and Posttest Scores



Extension and Application: Enacting and describing classroom instruction

Participants left the program well prepared to extend inquiry instruction in their classrooms. As a support for their efforts and as a vehicle for sharing experiences and deepening pedagogical content knowledge, the online forum is continuing throughout the school year. The program facilitators intend for these online conversations to become participant-driven so that the group members will enrich the summer Institute knowledge and skills and extend them to effective classroom instruction.

To date eight topics have been added to the forum, five initiated by the instructors. Of the original 25 institute participants, however, only 6 have been involved in the forum discussions.

Two questions encourage teachers' reports on connecting program knowledge and skills to classroom practice and have received the most replies: "How are you using student work to reflect on your teaching?" (11), and "How are you integrating more Inquiry this year?" (7). One teacher-initiated topic, "Claim, Evidence & Reasoning Rubric" has 9 replies. Two topics, "reference list" and "For your math colleagues" are contributions from Institute program facilitators.

The lead facilitator authored the first question on using student work to reflect on teaching. After one reply, he requested examples of student work to enrich the discussions. The exchanges among four teachers then deepened from problems with students making connections and writing extended answers to the use of rubrics for assessing student learning. One respondent included photos of student work on the reasoning section of their

explanations of a cell lab. Another teacher then initiated a separate conversation on the claim, evidence and reasoning rubric. This generated reports and examples of various explanation rubrics developed by the four responders for their schools. Finally, a facilitator-authored discussion requested information on how teachers are integrating more inquiry this year. This generated a rich on-going exchange among 4 teachers and the facilitator.

Summary and Conclusions

Data indicate that the BSCS Keys to Science Institute program, *Scientific Inquiry: Research and Practice*, provided effective professional development for the 25 participants. A comprehensive inquiry-focused agenda engaged the educators in 'content deepening' experiences both as learners and as practitioners in different, yet complimentary contexts. The pre-program online forum served to introduce the participants and involve them in an exchange of beliefs and values to formulate a cohesive perspective on the aspects of scientific inquiry.

Next, guided by the facilitators during the week long program, the educators participated in, and then debriefed, carefully selected activities and lessons that extended and deepened understandings of the Inquiry process and its classroom implementation.

Finally, continued discussion via the online forum has begun to illuminate teachers' challenges and discoveries in applying the understandings and abilities they gleaned during the program.

On the final evaluation, 96% of the participants indicated they are very likely to USE the program content, and 83% are very likely to SHARE the program content with colleagues. When asked to note "what worked best in the program," respondents frequently mentioned "instructors modeling the expectations," "modeling the Essential Features was very effective;" "being able to work through ideas and talk to others was helpful;" "the actual field lessons of Inquiry where we were students was the best instructional practice for me." Final comments also illustrate the positive effect of the Institute program: "The best learning experience I've had in science education;" "My eyes were opened to new ways of teaching;" "Just as team work and collaboration are so important for students and scientists, so are they for educators;" "allowing us to experience and reflect was a tremendous tool."

Evolution Across the Sciences

Foundation: Reflecting upon and articulating beliefs and values

Eleven educators from 5 states, Washington DC, and Singapore met from July 29 through August 3, 2007 at BSCS in Colorado Springs, CO for the Keys to Science Institute program, *Evolution across the Sciences*. This program focused on blending educational theory on inquiry-based instruction with practical hands-on activities and instruction on geologic, stellar and biologic evolution. In the six weeks prior to the program, participants were required to respond to 5 questions posted by the facilitator on the online forum. In

addition, each person was asked to post one reflection to responses made by two other participants and to write a response to another participant's reflection. The questions are listed below with the number of replies submitted by the program members:

Question	Responses
1. What in your view is science? What makes science (or a scientific discipline such as physics, biology, etc.) different from other disciplines of inquiry (e.g., religion, philosophy)?	10 posts
2. Does the development of scientific knowledge require experiments?	10 posts
3. Is there a difference between a scientific theory and a scientific law?	11 posts
4. This past school year, did the students in your classes formulate, communicate, and justify evidence based explanations?	15 posts
5. What does scientific inquiry look like in the classroom? Describe an example of Inquiry in the classroom and specify what makes that scientific inquiry?	10 posts

In addition, a question initiated by a participant received one response: "What is a principle?"

Although not as lengthy as the postings from the *Inquiry* program, the replies from this group displayed the same variations between, and combinations of, a 'realist' perspective of science, i.e. science as true, unchangeable and independent of the knower, and an 'instrumentalist' perspective of science as tentative, subjective, empirical and testable. A response to question 1 reveals this dichotomy: "Science is a process and a set of facts. In order to expand the knowledge and ideas in the scientific community, it must be gathered through a specific set of processes so that the experiments that lead to the knowledge can be replicated. It is important to realize that the knowledge of science is never complete, it is always evolving as it incorporates new information and popular thought." In contrast, this response exhibits a more realist perspective: "Scientists look to understand as opposed to find "meaning." Science examines causes and effects, to understand how things work, often through modeling. We also accept that the answers we have will change as we find out more. Our understandings shift with new perspectives."

The final question on scientific inquiry in the classroom generated more lengthy responses, frequently with examples of lessons, activities and strategies employed by the participants. Although they agreed on a few aspects such as students questioning, seeking answers and sharing ideas, participants revealed relatively shallow conceptions of classroom Inquiry. It is obvious from the responses that understandings of the 'what' and 'how' of Inquiry varied greatly among the group - from discovery of truth, "It means that the teacher presents a topic and the students ask and answer questions about this topic and discover truths," to "students engaged in exploring a concept that is being discussed," to "keep asking why and we keep looking for answers." One respondent summarized, "Give the students a question to answer, and that helps to motivate them. Maybe that is truly inquiry method."

Construction: Experiencing and analyzing the ‘big ideas’ of evolution

The syllabus states: The following questions will guide our work and reflection:

- What do we mean by evolution?
- Why is evolution a foundational concept in science?
- How should evolution be introduced in the science classroom?
- What does evolution look like across the sciences?
- What resources are available to teach evolution through inquiry-based approaches?

Through an engaging “fossil footprints” activity, participants were introduced to the five essential features of inquiry, the BSCS 5E Instructional Model and scientific explanations. These concepts formed the basis for content-based investigations into geologic, stellar and biologic evolution in multiple modes and contexts through the week. A review opened each day, and reflections were collected at the close of each day (Daily reflections for both the *Inquiry* and *Evolution* programs are available in the *Keys 2007 Daily Reflections* supplementary document from www.recenter@bscs.org). The individual and group reflections served to enhance the teachers’ construction of knowledge and related abilities and to guide facilitators’ implementation of the agenda.

Written reflections.

Five prompts, summarized below, served to organize the daily reflections.

- *Things I noticed that were notable*
- *The key ideas that I learned today were*
- *These are the structures or strategies that the facilitators used that helped me to learn*
- *Barriers to my learning that I encountered today (include personal barriers)*
- *Questions that I have after today’s work*

Participants listed a variety of notable aspects on the first day, ranging the facilitators’ instructional strategies such as “working through ‘process’ of inference and claims’ to reflections on the extension of their learning to the classroom: “The need for scientific knowledge is not as important as the process used to get there. Is it important to know what the ‘current truths’ are?” The ‘question, claim, evidence, reasoning’ sequence strongly impacted participants, and provided the framework for their hands-on learning through the week. The following days were devoted to specific disciplines – geologic evolution, cosmic evolution and biologic evolution. Thus, notable features of each day highlighted the content, most of which was new to the biology-focused educators. The breadth and depth of the new content also became apparent in question 4 – barriers to learning. Vocabulary, unfamiliar terms, lack of background knowledge were mentioned frequently as causes for disequilibrium.

As the week progressed, the facilitators employed a variety of inquiry-based instructional strategies noted in the reflections: “emphasis on exploration and importance of prioritizing to develop evidence,” “hands on learning,” “did not just lecture and tell us a bunch of facts,”

“visual aids,” “asking questions to gather data; field experiences,” “give reading and ask related questions. I would like to try this with my students,” “software, technology, logic,” “complete simulations, available for questions.”

Finally, participants’ questions extended from their personal experiences as students to thoughts on their classroom pedagogy. Two types of questions were asked – content, e.g., “How do mountains form?” “What causes ‘things’ to become planets/stars?” and pedagogical, such as, “How do we measure students’ prior knowledge and deal with it effectively?” “How can I develop a unit in evolution?”

The final day’s set of questions noted by participants clearly illustrates the progression and range of thoughts stimulated by the institute:

- What does pengid/homanea (sp?) evolution look like on a dadogram?
- Still questioning whether I am "reading" the trees correctly; Need some practice
- How can I integrate these activities into a 7th grade curriculum?
- Will we address controversy?
- When can I come back?

Session ratings

SESSION:	Not at all Useful	Not Very Useful	Somew hat Useful	Useful	Very Useful	Mean	Std. Dev.
1. Observations & Inferences- Fossil Footprints	0	10.0	0	40.0	50.0	4.30	.95
2. Scientific Explanations – Cubes/Ice Man	0	0	0	30.0	70.0	4.70	.48
3. 5 Essential Features of Inquiry	0	0	30.0	10.0	60.0	4.30	.95
4. 5E’s vs. 5EF	0	10.0	30.0	40.0	20.0	3.70	.95
5. Considering a ‘Mile High” transformation	0	9.1	18.2	27.3	45.5	4.09	1.04
6. Geological Evolution field experience	0	9.1	0	27.3	63.6	4.45	.93
7. Draft & evaluate geologic explanations	0	0	0	27.3	72.7	4.73	.47
8. Evolution of a star	0	9.1	18.2	63.6	9.1	3.73	.79
9. Evidence of stellar evolution	0	9.1	18.2	45.5	27.3	3.91	.94
10. Explanations of stellar evolution	0	9.1	27.3	45.5	18.2	3.73	.91
11. Communicating & evaluating explanations of stellar evolution.	0	27.3	27.3	27.3	18.2	3.36	1.12
12. Natural Selection & flora variation	0	9.1	0	45.5	45.5	4.27	.91
13. Natural Selection- Darwin’s Snails	0	10.0	10.0	10.0	70.0	4.40	1.08
14. Teaching about evolution & natural selection - student conceptions	0	0	18.2	36.4	45.5	4.27	.79
15. Other mechanisms of evolution	0	9.1	9.1	45.5	36.4	4.09	.94

16. Experiments with processes of evolution	0	9.1	18.2	36.4	36.4	4.00	1.00
17. Diversity & the Tree of Life	0	9.1	18.2	27.3	45.5	4.09	1.04
18. Climbing the Tree of Life & Evolving around the World	0	20.0	0	40.0	40.0	4.00	1.16
19. Genetic basis of speciation	0	11.1	11.1	55.6	22.2	3.89	.93
20. Simulations – dogs, HIV	10.0	0	40.0	40.0	10.0	3.40	1.08
21. Why teach biological evolution?	0	0	27.3	18.2	54.5	4.27	.91
22. Evolution & the classroom	0	0	9.1	45.5	45.5	4.36	.67
23. Daily Reflections	0	9.1	18.2	54.5	18.2	3.82	.87
24. Dinner & Discussions	9.1	0	9.1	63.6	18.2	3.82	1.08

Participants were asked to rate 23 program sessions on a Likert scale from 1, not at all useful, to 5, very useful. Those with the highest mean score were: Draft and evaluate geologic explanations; Scientific explanations – cubes/iceman; Geological evolution field experience; Natural selection – Darwin’s snails. Those rated lowest were: Communicating and evaluating explanations of stellar evolution; Simulations – dogs, HIV; 5E’s vs 5EF (essential features).

Table 2. Session Ratings

Session Ratings - % of responses in each category; highest ratings in bold

The significance of these ratings is elaborated by participants’ open-ended comments from the evaluation form. When asked to “write what you thought worked best in the program and what could use some improvement,” respondents listed the field trip and hands on learning activities as valuable. It appears that the combination of the geologic field trip, the inquiry-based instructional strategies, and the debriefing with the claim-evidence-reasoning technique presented a holistic experience for the teachers both as learners and as educators.

As mentioned in the daily reflections, the content was new to most of the participants, and they experienced first hand the disequilibrium in a learning situation with new vocabulary and unique, intriguing concepts. By “probing and not giving explanations” (daily reflections day 2) the instructors demonstrated constructivist questioning strategies, facilitating participants’ development of understanding and promoting ownership of the concepts. Thus, in contrast to the *Inquiry* program where activities elucidating the process of inquiry were rated most highly, the participants of the *Evolution* program learned the effectiveness of the inquiry process through direct experience in content-specific activities. This also explains why instruction relating the 5E Instructional Model and the 5 Essential Features of Inquiry was not rated as meaningful in isolation as it was when combined with learning experiences. Further, computer simulations, although educational, were not as valuable for teachers seeking development of their inquiry-based instruction.

It is important to note that four sessions related to stellar evolution were included on the rating sheet. Of these, the sessions on evolution of a star and evidence and explanations of stellar evolution were rated relatively high. Only “communication and evaluation session of stellar evolution” was rated low, perhaps because it was a small part of the stellar evolution experience and closely related to the previous explanation session.

Extension and Application: Enacting and describing classroom instruction

The online forum extends the summer Keys to Science Institute program experiences and is designed to chronicle participants’ application of their learning about evolution and scientific inquiry in the classroom. To date, all five of the topics have been initiated by four different teachers. However, only 14 replies have been posted despite a total of 134 views. One teacher’s postings have dominated the discussions because, as a result of her experience with the Keys to Science Institute, she has become an activist in regard to her school’s origins/evolution policy. A lively discussion has developed among Institute instructors and participants. Involvement in this real world situation has inspired the educators. As one discussant wrote,

“What you are doing is very impressive. I am teaching and living in a different political climate than you. But as we all know, a political climate can change in an electoral heartbeat. You have motivated me to investigate what, if any, specific district policies exist here regarding evolution. I will keep you posted.”

Thus the educational experiences of the *Evolution* program have extended beyond the classroom, with participants sharing ideas and resources to confront and influence educational policy. However, as far as applying the knowledge gained through the Institute program, only two teachers have discussed their classroom inquiry instruction at this point. It is assumed that the stimulation of one teacher’s efforts will persist, and that the group will continue to share and support each others classroom efforts in addition to monitoring policy issues.

Summary and Conclusions

The *Evolution across the Sciences* program differed from the *Inquiry* program in a number of ways. The smaller *Evolution* group was exposed to more focused subject matter, namely the process of evolution. Although both groups focused on the essential features of the inquiry process, the ways in which participants interacted with the topics varied. *Inquiry* program members expressed their expanded understanding of the elements of Inquiry through direct experience and support in challenging inquiry-focused activities, lessons, and daily discussion and reflection. The *Evolution* program used content-specific geologic, stellar and biologic activities as vehicles to emphasize inquiry-based strategies, but balanced the debriefing and meta-analysis around evolution and inquiry. By experiencing disequilibrium as learners in new content areas, the *Evolution* program participants also constructed realistic understandings of inquiry instructional strategies. On the final evaluation, 73% of the *Evolution* program participants indicated it is ‘very likely’ they would USE the program content, and 73% said they are very likely to SHARE the program content.

Participant recommendations for improvement included providing background knowledge prior to the activities, devoting more time to classroom application, and adding more field activities. Suggested topics for future professional development included lab formats, good questioning in the classroom, use of internet and resources in addition to specific topics of genetics, more geology and astronomy, and ecology and environmental science. Finally, these evaluation comments highlight the positive effect of the program:

“I am going away with a wealth of info and a source of continued collegial sharing.”

“Changed the way I think about teaching evolution.”

There was a lot of information that clarified some of my misconceptions and expanded my knowledge on evolution.” All reports indicate that this program met its goal as a ‘content deepening experience’ that developed theoretical and practical understandings of teaching evolution through inquiry-based instructional strategies.

I. BSCS Keys to Science Institutes 2007 General Summary and Evaluation

Findings

Both the *Scientific Inquiry: Research and Practice* program and the *Evolution across the Sciences* program engaged teachers in authentic, hands-on ‘content-deepening’ learning experiences about the process of scientific inquiry and skills of inquiry teaching in three arenas.

1. A pre-program online forum introduced the participants to each other as they reflected upon and articulated their beliefs and values related to the scientific process and inquiry-based science instruction.
2. Through effective instructor modeling, alternation between student and teacher roles during the summer Institute programs exposed participants to the challenges of learning and teaching through constructivist pedagogy. Debriefing and analyzing their learning, guided by the program facilitators, enabled participants to construct deeper understandings and skills related to their classroom instruction.
3. Finally, continuation and extension of Keys for Science Institute topics through the online forum discussions provides on-going, participant-driven professional development.

It is notable that 100% of participants of both programs answered YES to the questions: “Was the Keys to Science Institute program a good use of your time?” and, “Would you recommend this program to your colleagues?” As one educator noted,

“Invaluable ideas, resources, contacts – and FUN learning.”

Most effective elements of the Keys to Science Institute programs

Comments from both programs highlighted the skilled, knowledgeable instructors who developed challenging agendas, modeled strategies, facilitated learning, and provided time for reflection and collaboration. Most effective elements of the Institute programs noted by the participants included collaborative learning and group reflections, active hands-on learning activities, dual roles for participants, and unique field experiences guided by outstanding facilitators.

Impact and extension

The final goals of this evaluation are to define the impact of the Keys to Science Institute programs on participants' classroom practice and to describe the effects of engagement in the online forum in terms of participant-driven learning. Information on these goals is developing through participants' gradual but continuing communication through the online forum. Exchanging ideas and stimulating each other to apply ideas and techniques from the programs during a busy school year is a challenge, but participants' motivation developed by the Institute's facilitators appears to be strong.

Recommendations

Future content

Participants enthusiastically rated both programs highly and stated their desire for colleagues to attend future BSCS Keys for Science Summer Institute program. When asked to suggest topics for future professional development experiences beyond the existing topics, two types of recommendations were offered. First mentioned were content-specific topics such as molecular genetics, environmental science/ecology, earth science, biotechnology, genetics, geology, physics, oceanography, chemistry, meteorology, more astronomy, Big Ideas in biology, evolution, energy transfer, and diversity of life.

The second category of suggestions dealt with instructional practice – requests for instruction on lab formats, good questioning, use of internet and resources, effective science lesson planning, practice in analyzing the conceptual progression, integrating inquiry across the disciplines, K-12 articulation, and using inquiry K-12.

Online forum.

Based on participant responses to the online forums, it is recommended that expectations and methods be developed to encourage continued, more frequent interaction with this effective means of participant-driven professional development in the months following the summer programs. This would serve to strengthen the impact of the Institute programs on classroom practice as teachers reflect upon and analyze their inquiry-based pedagogy and then share the information with their colleagues through the forum.

**Appendix A
Program Syllabi**

A.1 Scientific Inquiry: Research and Practice
July 16 – 20, 2007

BSCS Scientific Inquiry: Research & Practice Foundations – 2 Credit Hours
BSCS Scientific Inquiry: Research & Practice Elaborations – 2 Credit Hours (online)

Overview of the Program:

BSCS Scientific Inquiry: Research & Practice: This program encompasses two sequential courses that are designed for secondary science teachers to deepen their understandings and abilities of scientific inquiry. Elements of both theory and practice are included in this program to assist you in assuming an active role in developing the knowledge and skill necessary to facilitate learning about and through scientific inquiry. The scope of the first course begins to lay the foundation, while the second course provides opportunities for application and reflection on one's practice.

Today, educators acknowledge that teaching and learning is a complex activity; however, when studying and trying to improve the learning and teaching of science, we usually concentrate on one aspect or another rather than the entire complex phenomenon. In the late 1960's, Joseph Schwab suggested four points of view when studying science teaching and learning-- the milieu (the school, the community, and the society); the content (the nature of science); the teacher (you and how you teach); and the student (how a student learns and what motivates them to learn). As we work to improve science learning and teaching, there is more and more evidence that what a teacher chooses to teach (the curriculum) and how he or she decides to teach it (instruction) flows from his or her beliefs about the nature of science and how students learn. In this program we will focus our efforts on the content specifically around scientific inquiry as defined by the National Science Education Standards and consider how students learn.

This syllabus is written as a framework from which to learn and work through this program. We will discuss the syllabus and program requirements in detail during our time together in Colorado Springs, so that you have time to read and reflect on the outline below.

The following questions will guide our work and reflection:

- What is scientific inquiry?
- Why is it essential to science teaching and learning?
- How do we engage learners in meaningful scientific inquiry that promotes deep conceptual understandings?
- How do we know what students have learned about science and inquiry?
- What should scientific inquiry look like in the secondary classroom?

Organization of the Program:

The program begins with an online activity and discussion that participants will engage in between June 1 and July 8, 2007. This introductory discussion will initiate the online community and provide a platform from which to jump into the summer program.

The first program, *BSCS Scientific Inquiry: Research & Practice Foundations*, consists of the intensive five-day summer course (July 16-20, 2007) and associated assignments.

This course will provide an engaging experience into scientific inquiry and examines what inquiry looks like in secondary classrooms. Participants will explore scientific inquiry first-hand as they develop scientific explanations and consider how inquiry-based learning promotes understanding of the nature of science. Participants will elaborate on the role of inquiry in student learning and develop foundational understandings to engage their students. We will examine examples from biology, chemistry, Earth science, and physics.

The second course requires completion of the first and is being delivered online. It consists of regular communication between program participants and BSCS faculty in order to share experiences, deepen understanding about current applicable educational and cognitive research, and serve as an online professional learning community to support effective change in the local educational setting. Participants in *BSCS Scientific Inquiry: Research & Practice Elaborations* will complete monthly assignments to examine student work, reflect on teaching practices, consider conceptual cohesiveness of their lesson plans, and other relevant topics that emerge from our discussions.

BSCS Scientific Inquiry: Research & Practice Foundations – 2 Credit Hours

Program Goals:

Participants will develop:

- a common understanding of science as Inquiry (understandings about and abilities to do) as described in the *National Science Education Standards*
- An understanding of the essential features of Inquiry in the support of rigorous teaching and learning.
- skills and understandings to construct and evaluate testable scientific questions.
- skills for constructing and evaluating evidence-based explanations.
- understandings how to scaffold students' and teachers' construction of evidence-based explanations.
- a common understanding of what we mean by *Instructional Design* and how it can help in thinking about teaching.
- deeper understanding of how instructional materials and their design can contribute to rigorous learning.
- understandings about important concepts in science and how to organize instruction to promote conceptual understanding of those concepts.
- strategies to examine and reflect upon student work to assess student understanding and instructional practices.

Expectations:

Attendance is required during all of the scheduled times during the week in Colorado Springs, unless prior arrangements have been made with the instructors. We expect that you will: attend and actively participate in all sessions; critically read and reflect on all reading assignments; demonstrate your reflection through your writings and discussions; collaborate with your colleagues; be prompt and professional with all assignments; put forth more than the minimal effort when completing assignments; ask for help when needed; and offer help to others when you can.

Assignments/Products Due:

Reading & Reflection #1 (online assignment, due by July 10, 2007)

Respond to the five reflection questions posted on the Inquiry Forum for reflection #1 as stated below. Post at least one response to two other participants' postings, and at least one response to another participant's response. Your posting and responses should be written following the etiquette for posting described on the Inquiry Forum Site.

Paper#1 – Enacting Inquiry in my Classroom (Assignment due by September 1, 2007)

Write a plan for how you intend to introduce inquiry into your science classroom this school year. The paper should include intended learning goals for your students, a description of how you intended to alter your practices to introduce Inquiry (not only what will you do, but what is different about what you will be doing from past practices), and describe how you will assess your new practices. Within each section, you should describe your reason(s) with appropriate citations if based on research or practices of others, for the practices and goals you have chosen to use. Include reference information for instructional materials that you intend to use.

Class Assignments:

You will complete a variety of tasks during the program. All tasks will be used to assess your understandings throughout the program. All tasks should be done completely and professionally

Program Schedule:

June 1- July 10: Online posting available to complete Online Assignment #1

July 10: Online Assignment #1 due

July 16: Day 1- Monday

8:30	Welcome, Introduction & pre-survey
8:50	Scientific Inquiry – Inquiry Cards
9:15	Scientific Inquiry – Inquiry Cubes
10:00	Break
10:10	Five Essential Features of Classroom Inquiry & reflections from online discussions
11:10	Introduction to Testable Questions
11:30	Lunch
12:30	Developing Testable Questions- Buoyancy & Density Immersion Unit from SCALE
3:30	Debrief Lesson
3:50	Daily reflection
4:10	Break
5:00	Dinner & Discussion- View “A Private Universe”
7:00	Adjourn

July 17:	Day 2- Tuesday
8:30	Review Day 1 and discuss BSCS 5 E's vs. 5 Essential Features
9:00	Evidence-based Explanations
10:00	Break
10:10	Learning for Conceptual Understanding; Concept v. Fact
10:30	Constructing a Conceptual Flow Graphic
11:30	Lunch
12:30	Engaging in another inquiry activity- Tri-Lakes Activity from BSCS Biology: A Human Approach
4:20	Daily Reflections
4:30	Adjourn
July 18:	Day 3- Wednesday
8:30	Review Day 2 and Debrief Tri-Lakes
9:00	Evaluating Scientific Explanations
9:45	Learner Directed Inquiry Investigations
10:15	Break
10:25	Continue Learner Directed Inquiry
11:30	Lunch
12:30	Continue Learner Directed Inquiry
3:45	Debrief Inquiry Investigations
4:20	Daily Reflection
4:30	Adjourn
July 19:	Day 4 - Thursday
8:30	Review day 3
8:45	Review online expectations and assignments
9:30	Lesson X & Y
10:30	Break
10:40	How People Learn & How Students Learn Science
11:30	Lunch & Group Photos
12:30	Professional Learning Communities
1:30	A protocol to examine student work and Scientific Explanations
2:30	Experiencing an Earth Science Inquiry- Garden of the Gods field trip
5:30	Break
6:00	Dinner & Discussion, View Minds of Their Own
8:00	Adjourn
July 20:	Day 5- Friday
8:30	Review day 4, Debrief the Earth Science Investigation & Revisit Inquiry Cards
9:15	Thinking about student conceptions
10:00	Break
10:20	Organizing Instruction to implement inquiry

11:30	Working Lunch: Wrap up – Questions & Answers, reflecting on visions of Scientific Inquiry, Post-survey
1:00	Adjourn

September 1: Paper #1 due.

BSCS Scientific Inquiry: Research & Practice Elaborations – 2 Credit Hours (online)

Participants will develop:

- a deeper understanding of science as inquiry (understandings about and abilities to do) as described in the *National Science Education Standards*
- an understanding of how the essential features of inquiry can be implemented in their classroom.
- recognition of the barriers to implementing inquiry in their classroom
- deeper understandings how to scaffold students' and teachers' construction of evidence-based explanations.
- deeper understanding of how instructional materials and their design can contribute to rigorous learning.
- strategies to examine and reflect upon student work to assess student understanding and instructional practices.
- understandings and skills to engage in an online professional learning community to enhance their practices.

Expectations:

Weekly login is required each week between August 30, 2007 and May 1, 2008, excluding Thanksgiving week, Christmas week, and other dates that will be mutually agreed upon by the group (e.g., state testing week). We expect that you will: actively participate in the discussions; critically read and reflect on all reading assignments; demonstrate your reflection through your postings; share additional readings and ideas with the group; respond thoughtfully to other postings from your colleagues; be prompt and professional with all assignments; put forth more than the minimal effort when completing assignments; ask for help when needed; and offer help to others when you can.

Assignments/Products Due:

Weekly postings

Each week you will be required to login in to review any upcoming assignments, read postings by your colleagues, and either add a response to at least one other posting or to begin a thread based on a question or issue that you are struggling with related to scientific inquiry.

Monthly assignments

Each month there will be a designated assignment. The assignment will be posted by the program instructor, but will be based on the discussions and an assessment of

understandings and needs of the group. The assignment will require approximately 3 hours to complete. Each assignment will be posted and you will have at least a three-week window to complete the assignment. In addition to the posted assignment, you will be expected to review and respond to other participants' postings on a weekly basis as noted above.

Reading Critique Paper

You will complete one reading critique paper (due April 30, 2008). Read and critique an article from a recent (less than 3-years) science education or other appropriate research journal (such as *Science Education*, *Journal of Research in Teaching Science (JRST)*, and *Harvard Educational Review*). The article should be related to scientific inquiry or another pre-approved by the instructor topic that emerges from our discussions. Use the suggested questions (to be posted on the Forum), as well as questions of your own, for a basis of your critique. Additionally, we would like you to examine the communication skills of the author(s). Think of yourself as a naive reader -- interested in the topic but not an expert. What does the author do to catch your interest? How well does the author define and provide examples of key terms? How well does the author transition -- move from sentence to sentence, paragraph to paragraph, section to section? Does the author deliver what is promised in the introduction? Your critique should be less than five (5) pages: 1-1.5 pages summarizing the article (including the citation); 2-3 pages on your analysis of the substance of the paper; and 1-1.5 pages (single spaced) on your analysis of the style of the article.

Program Schedule:

We will discuss the assignment schedule during our meeting in Colorado Springs and it will be posted on the Inquiry Forum calendar.

**A.2 Evolution across *the Sciences*
July 29-August 3, 2007**

BSCS Evolution across the Sciences Foundations – 2 Credit Hours
BSCS Evolution across the Sciences Elaborations – 1 Credit Hours (online)

Overview of the Programs:

BSCS Evolution across the Sciences: This program encompasses two sequential courses that are designed for secondary science teachers to deepen their understandings about evolution as a foundational pattern across the sciences. Elements of both theory and practice are included in this program to assist you in assuming an active role in developing the knowledge and skill necessary to facilitate learning about evolution from cosmological, geological and biological perspectives. We will also consider how to teach evolution through scientific inquiry. The scope of the first program begins to lay the foundation, while the second program provides opportunities for application and reflection on one's practice.

Today, educators acknowledge that teaching and learning is a complex activity; however, when studying and trying to improve the learning and teaching of science, we usually concentrate on one aspect or another rather than the entire complex phenomenon. In the late 1960's, Joe Schwab suggested four points of view when studying science teaching and learning-- the milieu (the school, the community, and the society); the content (science); the teacher (you and how you teach); and the student (how a student learns and what motivates them to learn). As we work to improve science learning and teaching, there is more and more evidence that a teacher's content understanding influences his or her teaching of the subject matter. In this program we will focus our efforts on the content specifically around evolution considering cosmic evolution, geologic evolution of Earth, and biological evolution (patterns and processes).

This syllabus is written as a framework from which to learn and work through this program. We will discuss the syllabus and program requirements in detail during our time together in Colorado Springs, so that you have time to read and reflect on the outline below.

The following questions will guide our work and reflection:

- What do we mean by evolution?
- Why is evolution a foundational concept in science?
- How should evolution be introduced in the science classroom?
- What does evolution look like across the sciences?
- What resources are available to teach evolution through inquiry-based approaches?

Organization of the Program:

The program begins with an online activity and discussion that participants will engage in between June 1 and July 27, 2007. This introductory discussion will initiate the online community and provide a platform from which to jump into the summer course.

The first course, *BSCS Evolution across the Sciences Foundations*, consists of the intensive six-day summer course (July 29-August 3, 2007) and associated assignments. The course provides an intense, engaging experience into evolution and examines

evolution from the perspectives of biology, astronomy and geology. Participants will consider evolution through inquiry-based experiences including a full-day field experience, and will review instructional materials designed for teaching evolution in the secondary classroom. Participants will also discuss the issues around evolution and teaching science.

The second course requires completion of the first and is being delivered online. It consists of regular communication between program participants and BSCS faculty in order to share experiences, deepen understanding about current applicable educational and cognitive research, and serve as an online professional learning community to support effective change in the local educational setting. Participants in *BSCS Evolution across the Sciences Elaborations* will have access to a moderated online professional learning community consisting of their colleagues from the summer experience, providing support and continued professional development by reflecting on teaching practices, considering conceptual cohesiveness of their lesson plans, and more.

BSCS Evolution across the Sciences Foundations – 2 Credit Hours

Program Goals:

Participants will develop:

- a common understanding of what we mean by evolution and how it is represented across the various scientific disciplines.
- an understanding of why evolution is considered a fundamental idea in science.
- a common understanding of the nature of science including scientific inquiry and scientific theory as described in the *National Science Education Standards*
- a deeper understanding of the processes of biological evolution and resulting patterns.
- a common understanding of scale and perspectives and their importance in understanding evolution
- understanding of pedagogy to teach evolution
- abilities to identify and select appropriate instructional materials to teach evolution.

Expectations:

Attendance is required during all of the scheduled times during the week in Colorado Springs, unless prior arrangements have been made with the instructors. We expect that you will: attend and actively participate in all sessions; critically read and reflect on all reading assignments; demonstrate your reflection through your writings and discussions; collaborate with your colleagues; be prompt and professional with all assignments; put forth more than the minimal effort when completing assignments; ask for help when needed; and offer help to others when you can.

Assignments/Products Due:

Reading & Reflection #1 (online assignment, due by July 15, 2007)

Respond to the five reflection questions posted on the Inquiry Forum for reflection #1 as

stated below. Post at least one response to two other participants' postings, and at least one response to another participant's response. Your posting and responses should be written following the etiquette for posting described on the Evolution Forum Site.

1. What, in your view, is science? What makes science (or a scientific discipline such as physics, biology, etc.) different from other disciplines of inquiry (e.g., religion, philosophy)?
2. Does the development of scientific knowledge require experiments? If yes, explain why. Give an example to defend your position. If no, explain why. Give an example to defend your position.
3. Is there a difference between a scientific theory and a scientific law? Illustrate your answer with an example.
4. This past school year, did the students in your classes formulate, communicate, and justify evidence based explanations?
5. What does scientific inquiry look like in the classroom? Describe an example of inquiry in the classroom and specify what makes that scientific inquiry?

Paper#1 – Teaching Evolution in my Classroom (Assignment due by September 1, 2007)

Write a plan for how you intend to introduce evolution into your science classroom this school year. The paper should include intended learning goals for your students, a description of how you intended to alter your practices to introduce evolution (not only what will you do, but what is different about what you will be doing from past practices), and describe how you will assess your new practices. Within each section, you should describe your reason(s) with appropriate citations if based on research or practices of others, for the practices and goals you have chosen to use. Include reference information for instructional materials that you intend to use.

Class Assignments:

You will complete a variety of tasks during the course. All tasks will be used to assess your understandings throughout the course. All tasks should be done completely and professionally.

Program Schedule:

June 1- July 15: Online posting available to complete Online Assignment #1

July 15: Online Assignment #1 due

July 29:	Day 1- Sunday
12:00	Meet & Greet Lunch
1:00	Introduction, Welcomes and Pre-assessments
1:30	Observations, Inferences & Claims: Fossil Footprints
2:00	Scientific Explanations
2:45	Five Essential Features of Classroom Inquiry
3:15	Five EF's vs. BSCS 5 E Instructional Model
3:30	Reflections on Geologic Evolution – considering a “Mile-high” transformation.
5:00	Dinner & Discussion
7:00	Adjourn
July 30:	Day 2 – Monday
8:30	Considering geologic evolution – field investigation (evidence to explanations: evolution of the Front Range)
3:30	Drafting & evaluating explanations
4:15	Daily reflections
4:30	Adjourn
July 31:	Day 3 - Tuesday
8:30	Review Day 2 and introduce considering cosmic evolution-preconceptions about the cosmos and evolution.
9:15	Evolution of a star – considering the evolutionary path.
10:00	Break
10:15	Evidence of stellar evolution: luminosity, brightness, temperature, and color- making sense of astronomic measurements.
11:30	Lunch
12:30	Developing explanations of stellar evolution.
3:00	Communicating and evaluating explanations of stellar evolution.
4:15	Daily reflections
4:30	Adjourn
August 1:	Day 4- Wednesday
8:30	Review Day 3 and introduce considering biologic evolution – Natural selection inventory.
9:00	Natural selection and variation: examining floral structures, thinking about sources of variation
10:30	Natural selection and variation: computer simulation of Darwin's snails using “Symbiotic” software.
11:30	Lunch
12:30	Teaching about evolution and natural selection – common student conceptions of evolution.
1:30	Other mechanisms of evolution
3:00	Putting it all together—experiments with the processes of evolution

4:15 Daily reflections
4:30 Adjourn

August 2: Day 5 - Thursday

8:30 Review Day 4 and continue considering biologic evolution – diversity and the tree of life.
9:00 The Tree of Life (Flowers & Trees)
10:30 Climbing the Tree of Life & Evolving around the World
11:00 Introduction to speciation
11:30 Lunch
12:30 The genetic basis of speciation
1:30 Domesticating dogs - computer simulation
3:00 Using patterns of evolution: studying HIV
3:30 Why teach biological evolution? Also introduce more instructional resources.
4:15 Daily reflection
4:45 Dinner & Darwin
7:00 Adjourn

August 3: Day 6 - Friday

8:30 Review Day 5.
8:45 Evolution and the science classroom
10:30 Evolution and society
11:30 Working Lunch: Wrap-up, Questions & Answers, Post-survey
1:00 Adjourn

September 1: Paper #1 due.

BSCS Evolution across the Sciences Elaborations – 1 Credit Hours (online)

Participants will further explore:

- evolution as a unifying theme in their science programs.
- strategies to examine and reflect upon student work to assess student understanding and instructional practices.
- understanding and skills to engage in an online professional learning community to enhance their practices.

Expectations:

Weekly login is encouraged between August 30, 2007 and May 1, 2008, excluding Thanksgiving week, Christmas week, and other dates that will be mutually agreed upon by the group (e.g., state testing week). We expect that you will: actively participate in the discussions; critically read and reflect on all reading assignments; demonstrate your reflection through your postings; share additional readings and ideas with the group; respond thoughtfully to other postings from your colleagues; be prompt and professional

with all assignments; put forth more than the minimal effort when completing assignments; ask for help when needed; and offer help to others when you can.

Assignments/Products Due:

Reading Critique Paper

You will complete one reading critique paper (due April 30, 2008). Read and critique an article from a recent (less than 3-years) science education or other appropriate research journal (such as *Science Education*, *Journal of Research in Teaching Science (JRST)*, and *Harvard Educational Review*). The article should be related to evolution or another topic pre-approved by the instructor that emerges from our discussions. Use the suggested questions (to be posted on the Forum), as well as questions of your own, for a basis of your critique. Additionally, we would like you to examine the communication skill of the author(s). Think of yourself as a naive reader -- interested in the topic but not an expert. What does the author do to catch your interest? How well does the author define and provide examples of key terms? How well does the author transition -- move from sentence to sentence, paragraph to paragraph, section to section? Does the author deliver what is promised in the introduction? Your critique should be less than five (5) pages: 1-1.5 pages summarizing the article (including the citation); 2-3 pages on your analysis of the substance of the paper; and 1-1.5 pages (single spaced) on your analysis of the style of the article.

Program Schedule:

We will discuss the assignment schedule during our meeting in Colorado Springs and it will be posted on the Evolution Forum calendar.