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What Teachers Report About Their Inquiry Practices

Bobby Jeanpierre
University of Central Florida

Based on an analysis of teachers' responses to a rated closed-ended survey on their inquiry practices, which was crosschecked with open-ended qualitative responses, they were using several different science research skills during instruction; however, teachers reported use of inquiry research skills likely occurred during guided inquiry projects with little evidence to support that they used full inquiry as suggested in the National Science Education Standards *(*NSES*) (NRC, 1996).*

Introduction

We have learned much about "good" science instruction, but more inquiry-based research reflecting the perspectives of teachers in the field is still needed. Keys and Bryan (2001) report, "As yet, we have little knowledge of teachers' views about the goals and purposes of inquiry, the processes by which they carry it out, or their motivation for undertaking a more complex and often difficult to manage form of instruction" (p. 636). To address these concerns, a survey of teachers' reported inquiry beliefs and practices combined with in-depth classroom observations, face-to-face interviews, and document analysis are needed to obtain explicit information about how teachers' conceptualization of inquiry aligns with their inquiry practices.

This article reported the results of a survey on K-8 teachers' inquiry beliefs and practices. The survey in this study was part of the National Science Foundation-supported, five-year, in-depth longitudinal case studies aimed at elucidating K-8 classroom teachers' motivations, goals, and purposes for carrying out inquiry in diverse, low SES schools. In the longitudinal case studies, diverse low SES schools were defined as culturally diverse schools, which had 50% or more of their students receiving free and reduced lunches. The teacher respondents in this study completed a K-8 Master's in Mathematics and Science Program, which focused on the development of teachers as reflective practitioners. The survey provided insights into what teachers believed about their own inquiry practices and how their practices aligned with *full inquiry* as described in the *National Science Education Standards* (*NSES*) (NRC, 1996).

Relevant Literature and History

Inquiry and the National Science Education Standards (NRC, 2000) stated that inquiry teaching and learning in school programs is less than a century old. As early as 1909, John Dewey, and Joseph Schwab more than fifty years later (1962), promoted the idea of inquiry in school settings. Dewey (1910) advocated that children experience science and not be passive recipients of ready-made knowledge. He contended that knowledge is "not information, but a mode of intelligent practice and a habitual disposition of mind" (p. 124). Schawb (1962), in "The Teaching of Science as Enquiry," echoed Dewey's sentiments on the importance of inquiry-based teaching and learning. He stated, "[I]n the very near future a substantial segment of our public will become cognizant of science as a product of fluid enquiry, understand that it is a mode of investigation which rests on conceptual innovation, proceeds through uncertainty and failure, and eventuates in knowledge which is contingent, dubitable, and hard to come by" (p. 5). Inquiry-based practices have been heralded as essential to students' development of what Dewey (1910) calls "habits of mind," a way of thinking that promotes scientific reasoning skills.

Today, the *NSES* (NRC, 1996) reemphasizes the need for teachers to implement more "inquiry-based" science teaching and learning opportunities. In fact, in the *NSES*, inquiry is viewed as the key strategy to effective science teaching: "Inquiry into authentic questions generated from student experiences is the central strategy for teaching science" (p. 31). The *NSES* purports that when children inquire into the natural world, they "(1) ask questions about the natural world, (2) plan investigations and collect relevant data, (3) organize and analyze collected data, (4) think critically and logically about relationships between evidence and explanations, (5) use observational evidence and current scientific knowledge to construct and evaluate alternative explanations, and (6) communicate investigations and explanations to others" (pp. 122, 145).

Although there is substantial information on inquiry teaching and learning in the *NSES* (NRC, 1996), and even an inquiry supplement to the *NSES*, Cuevas, Lee, Hart, and Deakor (2005) argued that "there is a lack of a clear agreed-upon conception of what science inquiry involves" (p. 338). Anderson (1983), some twenty years earlier, provided meta-analyses of the research literature on inquiry and concluded that it lacked a precise definition. Hence, this argument continues and has merit. Yet, science educators and scientists alike would agree that there are specific habits and processes that are pertinent in the inquiry process which models the work of scientists. The *NSES* (NRC, 1996) defined inquiry as follows:

> *Scientific inquiry refers to the diverse ways in which scientists study the natural world and propose explanations based on the evidence derived from their work. Inquiry also refers to the activities of students in which they develop knowledge and understanding of scientific ideas, as well as an understanding of how scientists study the natural world. (p. 23)*

With the importance that the *NSES* places on students experiencing inquiry learning in schools, it is important to further examine what teachers' beliefs are and their inquiry practices.

Methodology

The survey of teachers' inquiry beliefs and practices was constructed based on a distillation of the research literature, which referenced inquiry-based research skills teachers should promote in their classrooms. Central to the development of the survey items was the explication of inquiry process skills as presented in the *NSES* (NRC, 1996). According to the *NSES*, when children or scientists inquire into the natural world, they (1) ask questions about the natural world, (2) plan investigations and collect relevant data, (3) organize and analyze collected data, (4) think critically and logically about relationships between evidence and explanations, (5) use observational evidence and current scientific knowledge to construct and evaluate alternative explanations, and (6) communicate investigations and explanations to others (pp. 122, 145).

Additionally, several authentic inquiry practices were explicated. An example of an authentic research skill included in the survey was students researching expert research reports as a part of their classroom inquiry. Chinn and Malhotra (2002) argued that "reading expert research reports play almost no role at all in simple forms of school science. At most, students conduct their own research and make some reports to each other" (p. 186).

The survey format was modeled after Burry-Stock's (1995) *ESTEEM (Excellent Science Teaching Educational Evaluation Model)* survey instrument. The Likert-scale ratings for this instrument were 5 (*almost always*), 4 (*often*), 3 (*sometimes*), 2 (*seldom*), and 1 (*almost never*). The *ESTEEM* instrument focused on constructivist teaching practices. Constructivism as used in the *ESTEEM* instrument is a method of teaching. For example, do teachers take into account what students know and do they attend to how socialization occurs between learners. It can be argued that teachers who practice the use of *full inquiry* in their classrooms likely use constructivist methods, too. Alkove and McCarty (1992) argued that "constructivist teachers believe learning in school should be student-centered as opposed to teacher-centered" (p. 20). *Full inquiry*, as described in the *NSES* (NRC, 1996), is student-centered inquiry and is focused on students making meaning of their experiences.

Two researchers worked collaboratively to draft the list of skills and practices used in the inquiry survey (Appendix A). The survey consisted of several components: (1) teacher background information (i.e., name, year graduated the master's program) and school information (i.e., school district, grade level, subjects taught, number of students, classroom space allocation, materials to conduct inquiry and/or problem solving), (2) rated closed-ended inquiry process skills and authentic inquiry skills, and (3) open-ended qualitative responses about specific inquiry projects and practices (i.e., identify project, length of time, where did the inquiry occur, the results of the inquiry, and how students' work was assessed.

The survey was then piloted during spring 2005 with a group of teachers (n = 12) in the K-8 Master's in Mathematics and Science Program. The two researchers reviewed teachers' input and used it to revise the original instrument. From the first pilot of the survey instrument, teachers' comments focused on how long (wordy) several items were; they also thought that several items were unclear. Next, the two science educators incorporated teachers' suggestions, revised the survey instrument, and then piloted it with a smaller subsample of the K-8 Master's in Mathematics and Science Program teachers (n = 5). After review of the suggestions from the second pilot group, we completed the development of the instrument used in this study.

Twenty-three survey items pertained to what teachers said about their inquiry practices. Eighteen were closed-ended survey items, which were rated from *almost never* (1) to *almost always* (5) for each indicated research skill and or practice. The open-ended survey statements (5 items) asked for specific information about teachers' inquiry practices. For example, survey item 19 stated, "Name an inquiry project." Survey item 20 was used to gather information about the amount of time teachers spent on the inquiry project which was asked about in survey item 19. Survey item 20 stated, "What was the length of the project (#19) in number of class sessions?" The author of this paper looked for congruence between teachers' responses to the closed-ended rated survey items and their reported examples of inquiry practices in the open-ended survey items. Prior to the development of the survey instrument, we examined different research reports on the use of electronic surveys, and we followed their suggestions for increased credibility of electronic samples. To increase credibility of the sample for this study, prenotifications were sent, teachers were targeted, and we used published e-mail addresses (Shammon, Johnson, Searcy, & Lott, 2002).

The survey was then uploaded to a commercially designed template (see Appendix A) and e-mailed to 338 teacher graduates of the K-8 Master's in Mathematics and Science Program, with a two-week response request. Approximately 5% of targeted e-mails were returned as undeliverable. Of the remaining, 319 recipients (42%) visited the site, and 32% completed either all (28%) or parts (4%) of the survey. The most common reason respondents gave for not completing all parts of the survey was that they were no longer a classroom teacher; however, most respondents were still in the K-12 educational setting as either an administrator or in some other leadership role.

Results and Analysis

For closed-ended survey items 1, 2, 3, 7, 8, and 15, teachers consistently reported that they *often* or *almost always* used the indicated practices or inquiry research skills with their students.

Table 1A. Highly Rated Inquiry Survey Items

Survey Item	Percent (*Often* or *Almost Always*)
1. I am a facilitator of students' learning.	92%
2. I welcome students' questions.	99%
3. I encourage students to seek answers to their own questions.	96%
7. I do not depend on the textbook.	88%
8. I focus on students' understanding of science concepts.	87%
15. I have students communicate their research results to their peers.	81%

Hence, teachers' responses to the above-stated survey items indicated that they saw themselves as facilitators of student-centered learning experiences.

In contrast to the above reported data, teachers' responses to survey items that focused on scientific inquiry skills received substantially lower ratings.

Table 1B. Scientific Inquiry

Research Skills	Percent (*Often* or *Almost Always*)
10. I have students develop their own hypotheses.	66%
11. I have students design their own experiments.	41%
12. I have students analyze data based on their own research.	30%
13. I have students interpret data based on their research evidence.	64%

Although teachers were extremely positive (Table 1A) about having classrooms that were student-centered, their responses in Table 1B (i.e., survey items 11 and 12) indicated that a substantial number of them did not rate themselves positively for facilitating inquiry. Collectively, survey items 10, 11, 12, and 13 were designed to illustrate practices carried out during *full inquiry* experiences. Approximately two-thirds of the teachers felt that they provided opportunities for students to develop their own hypotheses and interpretation of data based on their research evidence, yet only 41% of teachers responded *often* or *almost always* to having students design their own experiments, and even fewer teachers (31%) responded *often* or *almost always* to having students analyzing their own research results. Teachers' responses to this set of questions were disconnected and did not portray that they consistently provided students with experiences that aligned with the description of *full inquiry* as presented in the *NSES* (NRC, 1996).

The third set of survey items were related to other instructional practices teachers employed in the reform-based science classroom.

Table 1C. Inquiry Survey

Other Instructional Practices	Percent (*Often* or *Almost Always*)
4. I ask students what they are interested in learning	70%
5. I use students' interests as a guide when constructing my lessons.	64%
6. I use discrepant events to motivate students.	48%
9. I have students working on different research questions during a class period.	40%
17. I provide students with science inquiry experiences which include a balance between developing their research skills and concept understanding.	62%

In Table 1C, discrepant events were not a prevalent instructional strategy used by teachers. Forty-eight percent of teachers responded that they used it *often* or *almost always*. This meant that 52% of them used discrepant events *sometimes* or *less frequently* in their classrooms. Additionally, only 40% of teachers stated that they had students work on different research questions during the same class period.

Teachers' responses to this question aligned to the responses they gave for survey items 11 and 12, for which they reported that in their classrooms, students rarely designed their own experiments and/or analyzed data based on their own research. Teachers' responses to these survey items indicated a possible disconnect between teachers' inquiry practices and *full inquiry* as presented in the *NSES.*

In summary, teachers' responses to this survey elucidated the following: (1) teachers believed that they facilitated student-centered classrooms and provided student-centered instruction; (2) teachers believed that they focused on students understanding science concepts; (3) teachers were less likely to have students develop their own research designs and analyze data based on their own research results; (4) teachers were less likely to use discrepant events as an instructional strategy; and (5) teachers' responses to closed-ended survey items about their classroom practices did not completely align with *full inquiry* as described in the *NSES.*

Open-Ended Survey Items on Inquiry Practices

The remaining survey items were used to gather additional information on teachers' inquiry practices and provided a crosscheck for closed-ended survey items. For survey item 18, 19% of respondents stated that they had facilitated less than two inquiry projects during the last calendar school year, which meant that 81% of teachers reported doing 2 to 13 or more inquiry projects with students. Teachers believed that they were providing students with substantial inquiry experiences.

In survey item 14, which stated, "I have students read the research of others in the science community which related to their own inquiry prior to deciding on a research question," 30% of teachers responded *almost never* and 24% responded *seldom*. In sum, 46% of teachers did not report that students reading the research of others in the science community were an important part of their inquiry practice.

Teachers' responses to survey item 16 were not very favorable. Survey item 16 stated, "I have students share their research results in a formal out-of-class setting (for example, school, district and/or state science fair competitions)." Thirty-four percent of teachers said *almost never*, and 21% reported *seldom.* It was expected that more teachers would have responded more favorably to this survey item because schools across the country encourage and/or require students' participation in a schoolwide science fair competition. A follow up to this question is necessary to find out what perceptions teachers have of science competitions.

Survey item 19 was used to get information on the kinds of inquiry experiences teachers provided their students. An analysis of survey item 19, in which teachers were asked to "Name an inquiry project," revealed that four of the 67 respondents to this question likely used *full inquiry*. Examples of inquiry topics and their results which were likely conducted using *full inquiry* included (1) *Question:* "Will seeds grown in saltwater grow as well as seeds grown in freshwater?" *Result:* Seeds grown in freshwater sprouted while seeds grown in saltwater did not sprout; and (2) *Question:* "Which treatment to the palm seeds produced the most germination? *Result:* Sanded seeds germinated fastest. Three of the four questions that teachers reported were likely to be conducted using *full inquiry* related to plant growth, and one inquiry project referenced earthworm nutrition.

A closer examination of the descriptive data provided by teachers suggested that several other projects probably included various inquiry research skills; however, teachers' reported descriptions of the majority of these inquiry projects did not appear to align with the *NSES* (NRC, 1996) description of *full inquiry,* or needed more explanation so that the connection to *full inquiry* was evident. What follows are examples of inquiry topics and their descriptions as reported by teachers. These topics did not appear to incorporate *full inquiry* and/or did not have sufficient descriptive details included: (1) *Brain Works:* Students ages 5 to 12 researched how their brain works and designed experiments to test their theories; (2) *Fingerprint Mystery:* No description provided; (3) *Learning About Balances:* Students test methods of finding balance with manipulatives; (4) *Manatee Habitat:* A positive learning experience; (5) *Mountain Building:* Students discovered that mountains erode based on how they are formed; (6) *Bubbleology:* Students' interdisciplinary understanding of bubble experiments; and (7) *Diffusion and Cells:* Students produced a lab report which was shared with the class. This information, which was provided by teachers, indicated that some of them probably used *partial inquiry* but not *full inquiry.* That is, "in partial inquiry students develop abilities and understanding of selected aspects of the inquiry process" (NRC, 1996, p. 143).

There was additional survey data used to support the finding that these teachers did not use *full inquiry* as described in the *NSES.* Teachers' inquiry practices as revealed by their responses to survey items 20, 21, 22, and 23 were analyzed together to help describe the type of inquiry they likely used. The central focus of these survey items was to find out if teachers' responses included consistent references to using *full inquiry* processes. Additionally, these survey items provided a crosscheck for the closed-ended survey responses teachers provided in part one. The results of these survey items were as follows: 20: "How long did the inquiry occur?" Teachers reported that their inquiry projects occurred over a period of time that ranged from two days to 12 weeks; 21: "Where did it occur?" Overwhelmingly, teachers reported that the classroom was the central place in which the inquiry occurred, and the second most prevalent response was the schoolyard; 22: "What were the results of the inquiry?" For this item, teachers' responses were varied; however, the majority of their responses tended to focus on the development of students' group skills and content understanding; and 23: "How was student work assessed?" The most common responses teachers stated were rubrics, journals, observations, and cooperative group reports. These forms of assessments are easily aligned with activities that are performance-based and more inquiry and constructivist in nature. The focus here was to look for whether there was congruence between the assessment used and the nature of the inquiry project reported in survey item 19. Only one respondent stated that a quiz was the major tool used to assess students' understanding at the completion of the inquiry project. A quiz as the culminating assessment to an inquiry-based project is limiting and not likely to provide teachers with sufficient depth of information about what the students have learned, experienced, or can do. Hence, the majority of teachers' reported assessment strategies were aligned with performance-based types of assessments. Even so, teachers' responses to survey item 22, "What were the results of the inquiry?," did not indicate that they used *full inquiry* research processes. No respondent indicated that students had identified additional questions as a result of their inquiry, nor did anyone state that students needed to rethink their experimental design and/or that they needed to do their inquiry again. Based on analysis of the responses to the closed-ended survey items, which crosschecked with the open-ended items, a number of teachers likely carried out guided inquiry experiences, and *full inquiry*, as described in the *NSES* (NRC, 1996), was not a prevalent classroom practice.

Conclusions

Inquiry-based, student-centered classrooms are perceived as integral to cultivating the desired science teaching and learning culture that the *NSES* recommends (Crawford, 2000). The *NSES* (NRC, 1996) supports the notion that teachers are to be facilitators of student learning experiences. They should assist students in developing their own questions, designing their own experiments, analyzing and interpreting an array of data, and drawing and reporting conclusions. These processes are central to *full inquiry.*

In sum, teachers perceived that they provided student-centered classrooms and facilitated students' interests in their own learning, yet their responses to the survey items that specifically related to *full inquiry,* where students inquire into questions that they have generated and then follow their interests through in-depth research, were not prevalent classroom practices.

Full inquiry, as described in the *NSES*, was not supported. Chinn and Malhotra (2002) argued that what occur most often in K-12 classrooms are simple inquiry tasks. In a simple inquiry task, inquiry is presented in a way that students get the sense that inquiry always proceeds directly from question to conclusion without any conflicts to resolve and or rethinking of the problem, which in actuality is a false conception of scientists' work: "In simple experiments, what needs to be controlled is usually straight-forward. For example, when conducting experiments to see whether seeds sprout faster in the light or dark, students considers a few variables such as type of seed used [and] depth of seed" (pp. 183-184). Inquiry as described in the *NSES* requires that teachers develop students' abilities to do scientific inquiry. *Simple inquiry* tasks may be appropriate first steps for teachers prior to facilitating *full inquiry.*

Partial inquiry experiences as described in the *NSES* (NRC, 1996) are "where students developed abilities and understanding of selected aspects of the inquiry process" (p. 143). Some teachers may not be ready to facilitate sophisticated *full inquiry* experiences in their classrooms and may need to begin with *partial inquiry* or *simple inquiry* tasks, which are familiar and manageable.

For teachers to use *full inquiry* as supported in the *NSES* (NRC, 1996), they may need to have experiences which foster the development of "deep" science content knowledge and understanding and have numerous opportunities to practice using integrated science inquiry processes and research skills (Jeanpierre, Oberhauser, & Freeman, 2005). Teachers must have opportunities "to discuss, think about, try out, and hone new practices" (Lieberman, 1995, p. 593). For many teachers, *full inquiry* as described in the *NSES* is new terrain that they may not have experienced. Many of the K-8 teachers consistently reported using various inquiry research skills during instruction, but few of the inquiry experiences they reported could actually be identified as *full inquiry.* In order for teachers to orchestrate *full inquiry* as defined in the *NSES*, they may need to have the same kinds of experiences that are recommended in the *NSES* for students.

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Correspondence regarding this article should be directed to

Dr. Bobby Jeanpierre
University of Central Florida
College of Education
Department of Teaching and Learning Principles
P. O. Box 1250
Orlando, FL 32816-1250
bjeanpie@mail.ucf.edu
(407) 823-4930

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Appendix A

Section Two: Inquiry Beliefs and Practices

Please use the rating which best describes your inquiry teaching and learning beliefs.

5 = almost always, 4 = often, 3 = sometimes, 2 = seldom, 1 = almost never

1.	I am a facilitator of students' learning.	5	4	3	2	1
2.	I welcome students' questions.	5	4	3	2	1
3.	I encourage students to seek answers to their own questions.	5	4	3	2	1
4.	I ask students what they are interested in learning.	5	4	3	2	1
5.	I use students' interests as a guide when constructing my lessons.	5	4	3	2	1
6.	I use discrepant events to motivate students.	5	4	3	2	1
7.	I do not depend on the textbook.	5	4	3	2	1
8.	I focus on students' understanding of science concepts.	5	4	3	2	1
9.	I have students working on different research questions during a class period.	5	4	3	2	1
10.	I have students develop their own hypotheses.	5	4	3	2	1
11.	I have students design their own experiments.	5	4	3	2	1
12.	I have students analyze data based on their own research.	5	4	3	2	1
13.	I have students interpret their data based on their research evidence.	5	4	3	2	1
14.	I have students read the research of others in the science community which relates to their own research prior to deciding on a research question.	5	4	3	2	1
15.	I have students communicate their research results to their peers.	5	4	3	2	1
16.	I have students share their research results in a formal out-of-class setting (i.e., science fair competition).	5	4	3	2	1
17.	I provide students with science inquiry experiences that are balanced between developing their research skills and concept understanding.	5	4	3	2	1

Section Three

18. How many inquiry projects did you facilitate during the last calendar year?

- ❑ Less than two
- ❑ 2 to 4
- ❑ 5 to 6
- ❑ 7 to 8
- ❑ 9 to 12
- ❑ 13 or more

19. Name an inquiry project.

20. What was the length of the project (#19) in number of class sessions?

21. Where did the inquiry occur?

22. What was the result of the inquiry?

23. How was students’ work assessed?