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Inquiry Teaching in High School Chemistry Classrooms: The Role of Knowledge and Beliefs

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In the past decade, the call for implementation of inquiry-based teaching in secondary classrooms has taken on a new sense of urgency *(1–2).* Several instructional models have been developed *(3–6)* to assist teachers in implementing inquiry in their classrooms. Yet in spite of the central role of inquiry in national science education standards *(7),* and the existence of these instructional models, inquiry-based instruction is rarely implemented in secondary classrooms. In fact, for the growing ranks of new science teachers entering the profession, it is estimated that only 10% engage in student-centered activities such as inquiry-based instruction in their classrooms *(7).*

Common constraints to implementing inquiry environments include: inadequate subject matter knowledge, including knowledge of the nature of science *(8–11),* lack of pedagogical skills *(12–13),* and inadequate access to appropriate curriculum materials *(12, 14–16).* In an analysis of national data, Ingersoll *(17)* found that 56% of students in secondary physical science classes were taught by teachers without at least a minor in physics, chemistry, geology, or earth science. While many science teachers are teaching out-of-field (having a non-science degree), the scope of the problem is camouflaged by the number of teachers with science degrees who are certified as *science* teachers and are therefore teaching *within* their general field but not their academic major or certified sub-discipline (out-of-discipline). Out-of-field and out-of-discipline teachers tend to rely on textbooks and are unable to focus on inquiry abilities and critical thinking skills in a discipline that they do not understand well themselves.

In response to teacher shortages in the areas of science and mathematics the creation of alternative pathways to teacher certification has expanded *(18).* Fewer than half of new teachers are new college graduates who have just finished a traditional university teacher certification program *(19).* These alternative routes vary greatly in their content, duration, and rigor; unfortunately, many teachers are not exposed to inquiry-based instruction, either in their science courses *(20)* or teacher preparation programs *(21).* Yet even those teachers who are exposed to strategies for implementing inquiry-based instruction tend to revert back to traditional practices as they enter the real world of the classroom *(7).*

Researchers have suggested that a teacher's beliefs, rather than subject matter knowledge, constitute the more important construct when considering classroom practice *(22).* Beliefs are personal constructs that are important to a teacher's practice: they guide instructional decisions, influence classroom management, and provide a lens for understanding classroom events. Beliefs, unlike knowledge, are propositions held to be true by the individual, can be non-evidential, based on personal judgment and evaluation, and are drawn from critical episodes and prior experiences *(22–24).* Beliefs influence what teachers learn in their certification programs, as well as the manner in which strategies from certification programs are implemented in the classroom. For example, Ernest *(25)* found that two mathematics teachers with similar knowledge from their certification program taught in different ways; an understanding of the teachers' beliefs was more useful in predicting their classroom practice.

This study explores the factors that influence the classroom practices of beginning secondary chemistry teachers. Specifically, we examine their beliefs and practices over a year in a context of their previous educational and science related experiences. Such an examination can give insight into the factors that are prevalent in terms of beginning teachers developing inquiry-based dispositions.

Study Overview

A qualitative study was designed to understand the practices and beliefs of secondary school chemistry teachers. The design was reviewed and approved by the university Institutional Review Board and consent from teachers was obtained prior to data collection. Multiple data sources were collected throughout the study; these sources included semi-structured interviews about teaching beliefs, monthly classroom observations, and a demographic and academic background survey. Multiple data sources and multiple researchers ensured that triangulation occurred in the collection and analysis of data *(26).* Individual cases of each beginning teacher were developed from these data *(27).* Cases were then compared and contrasted to one another to understand the trends that existed between teachers. Propositions (or hypotheses) were developed as potential explanations for observed practices and triangulated against all available data sources and between researchers, in order to determine the degree of support in the multiple data sets for each proposition. Then, in order

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to understand the trends that existed between the teachers, and to find out whether propositions developed in individual cases held across multiple cases, cases were compared and contrasted to one another by two research associates. Like-cases of teachers were grouped in two ways according to emergent themes relating to the teachers' classroom practices and certification program.

Participants

Over the past four years 53 beginning secondary science teachers have participated in our science-focused induction program designed to support beginning teachers in the classroom and promote inquiry-based instruction *(28).* Ten teachers held primary teaching assignments in chemistry. Demographic details of these ten teachers are shown in Table 1. Three teachers entered the profession with limited pedagogy coursework—none of these three had taken a science methods course or had any formal exposure to inquiry teaching strategies. The other seven had at least one methods course that allowed them both to experience "science as inquiry" as students and the opportunity to plan and implement these inquiry strategies in secondary classrooms.

Table 1. Educational Background of a Sample of High School Chemistry Teachers

Teacher Name (Pseudonym)	Degree(s): Major and (Minor) [a]	Teaching Certification Type	Teaching Assignment: Subject (Grade)
Pete	MS, Environmental Science; BS, Chemistry	Alternative	Chemistry, elective (10, 11, 12); Phys. Sci.[b] (9)
Michael	BS, Mathematics (Biology, Chemistry, Physics)	University	Phys. Sci.[b] (9)
John	MS, Ecology; BS, Biology (Chemistry, Physics)	University (MEd, Science Education)	Chemistry, elective (11, 12)
Dennis	PhD, Chemistry BS, Chemistry	Alternative	Chemistry, elective (10, 11, 12)
Ron	BS, Geology (Biology, Chemistry, Physics)	University	Chemistry, elective (11, 12)
Elaine	BS, Chemistry	University (MEd, Teaching and Teacher Education)	Chemistry, Honors Chemistry, required, (10)
Bill	BS, History (Biology, Chemistry)	University	Chemistry, elective (10, 11, 12)
Chris	MS, Chemistry; BS, Chemistry	Uncertified	AP Chemistry (9, 10)
Laura	BS, Chemistry	University	Chemistry (8)
Terry	MS, Ecology; BS, Biology (Chemistry, Physics)	University (MEd, Science Education)	Chemistry, elective (10, 11, 12)

[a]Teaching minors, if applicable, are indicated in parentheses.
[b]Physical Science courses include one full semester of Chemistry.

The induction program, Alternative Support for Induction Science Teachers (ASIST), was developed by university educators, with the assistance of local school district administrators, to support beginning secondary science teachers and to foster inquiry-based environments in secondary science classrooms. Any first-, second-, or third-year secondary science teacher in the region could participate in the program. Once enrolled, beginning teachers attended monthly Saturday workshops facilitated by a university science educator, mentor teachers, and graduate assistants. Beginning teachers also participated in online communications, were visited in their class monthly by project staff, and attended a national science teacher education conference. Classroom observations were used to provide feedback to the teacher on classroom management and instruction. Project staff also co-taught lessons with teachers when requested by the participant.

Inquiry-based instruction was modeled explicitly in ASIST by working from the definition of "science as inquiry" in national reform documents *(1–2).* Teaching strategies for inquiry were modeled to represent both open-ended and guided inquiry; for example in the Search, Solve, Create, Share model *(4)* students generate their own scientifically oriented questions, whereas in learning cycle formats *(3, 5)* students address questions provided by the teacher. Induction teachers experienced these modeled lessons as students—writing procedures, collecting and analyzing data to answer scientific research questions. Following the model lesson, teaching strategies were discussed in terms of both teacher–student actions and linked philosophically back to notions of students' learning and assessment.

Data Collection and Analysis

Teaching Beliefs

Teaching beliefs were captured using an open-ended interview at the beginning of the school year. The interview protocol included seven questions selected and modified from the Teacher's Pedagogical Philosophy Interview (TPPI) *(7, 29).* Questions were used to develop an understanding of how the beginning teachers viewed students and teaching, as well as what underlying beliefs affected their instructional decisions. Teachers were also asked to define inquiry in their classroom, to give representative examples of inquiry-based instruction from their practice, and to discuss their experiences implementing inquiry.

Each one-hour interview was conducted and audiotaped by two research associates. Completed interviews were coded by a research associate using TPPI coding charts *(7, 29),* and participants' responses to each question from the TPPI were categorized as didactic, transitional, conceptual, early constructivist, or experienced constructivist beliefs. Didactic and transitional responses represent teacher-centered beliefs, while early constructivist and experienced constructivist responses represent student-centered beliefs. Conceptual responses indicate beliefs that are predominantly teacher-centered, as they are focused on content rather than students; however, they differ from teacher-centered (didactic and transitional) responses in that the content is focused on the overarching ideas of science and science instruction rather than factual information. The coding maps provide sample responses, derived from both existing data sets and the research underlying the constructivist approach to reform-based teaching as outlined in the NSES *(2),* which allow researchers to categorize the responses to each question.

Observations of Practice

Each teacher was observed at least seven times during the school year by project staff (two graduate associates and a professor). Observation data were analyzed to understand the participants' common instructional practices and to check for any evidence of inquiry-based lessons. The nature of inquiry-based instruction was analyzed using the guidelines of the *National Science Education Standards for Inquiry (30);* an analysis of the five essential features of inquiry was used to determine whether the observed lesson was an inquiry lesson and the nature of the inquiry lesson on a continuum from guided to open-ended inquiry. In guided inquiry activities the question is often provided by the teacher to focus on specific scientific concepts, whereas more open inquiry activities are designed for students to acquire abilities with inquiry and scientific reasoning.

Additional Artifacts

Throughout the study, additional documents were collected in order to capture the experiences, practices, and beliefs of the participants. These included personal and listserv email messages, observations from induction workshops, and telephone calls to research staff from participants. Some of the documents were solicited by researchers; most were not.

Findings

First, we discuss two groups of teachers: the inquiry teachers and the conventional teachers. These groups are delineated by classroom practices; for each group, individual cases will be presented to document the classroom practices and experiences of these teachers. Following the individual cases, the teaching beliefs held by chemistry teachers will be discussed. Second, we compare teachers within their certification program to look at the differing classroom practices of teachers with similar inquiry training and experiences. Pseudonyms will be used in each case and in the subsequent discussion of the cases.

Teacher Cases—The Inquiry Teachers

Five of the teachers were observed implementing at least one inquiry-based activity[1] during the year: Laura, Terry, Chris, John, and Bill. Their experiences with inquiry were different, and individual cases are used to exemplify some of the issues relating to the interactions of beliefs and classroom practice.

John is an ecologist by training, with many graduate hours in ecology. His M.Ed. in science education and his two student-teaching placements in middle school life sciences and high school biology provided him with a depth of understanding about inquiry-based instruction, student learning, and experiences using inquiry. John's first teaching position, however, was freshman earth science and an elective chemistry course for 10th–12th graders. John implemented only two inquiry activities; both of these inquiry activities were implemented early in the year and were guided inquiry activities, with John providing the question to be investigated and in one case the procedure to be used. For example, during John's first observation, students were completing a worksheet-driven laboratory activity that directed students to measure the mass and volume of various numbers of pennies with the goal that students would discover the concept of density. During the post-conference, John voiced his frustrations about his teaching. He stated:

> My administrators think I am a good science teacher just because they see my students doing labs. But we both know that expecting the students to magically discover density is not inquiry, but it was the best I could come up with. I am reasonably familiar with chemistry, however I am still struggling. I simply have never thought enough about the content and I have not thought about teaching the content. I do not know what obstacles to expect the students to face and I do not always know ways around these obstacles.

Like John, Terry has an extensive background in the life sciences and a M.Ed. in science education, but was assigned his first year to teach four periods of chemistry and one period of biology. Terry was very clear about his beliefs about student learning. He stated: "I don't want my students to memorize trivial factoids, I want them to be able to design procedures to solve scientific problems and to be able to organize their data so it is convincing to others." Consequently, Terry implemented many student-centered activities throughout the year. These activities were frequent and often open-ended with students answering their own researchable questions and designing their own data collection and analysis schemes. The activities Terry implemented in his biology class were rich in opportunities for students to develop an understanding of both science processes and content. In his chemistry classes, however, Terry's activities were often more focused on process skills. For example, Terry's students investigated the cleaning effect of hot sauce on dirty pennies. Students were assessed on their ability to control variables, to represent their data in charts and graphs, and to communicate their data to the class. Although this activity presented several opportunities to discuss chemistry content, Terry did not use it as a vehicle for developing content knowledge.

Chris has a M.S. in chemistry and extensive experience as a graduate teaching assistant. On completing his degree he took a position at a local charter school that did not require a teaching certificate. Consequently, Chris started his teaching career with little or no formal knowledge about inquiry teaching. Chris taught both seventh grade life science and AP chemistry. For AP chemistry he used traditional verification laboratory activities that were familiar from his college courses. He believed that students learn, however, by having to explain their reasoning to each other. "They need to be talking with each other and interacting with the concepts—they need to engage in the content." Through his participation in the science-focused induction program, Chris was able to learn some strategies for inquiry-based instruction and implemented one open-ended inquiry lesson with his seventh grade students. For AP chemistry, however, the curriculum did not allow him the time or flexibility to incorporate inquiry. As Chris stated:

> This is a crazy idea teaching AP chemistry in one year to 9th graders, we drill and kill all day just to get the basics across. Next year we are changing the format so chemistry is a two-year course with the AP test at the end of the second year–this may give me some time to incorporate some inquiry into the curriculum.

Laura has a B.S. in chemistry and some laboratory research experience. She completed a teacher certification program that provided her with strategies for inquiry teaching. Her teaching situation, however, was unique in that she taught an entire year of chemistry to eighth graders. Her beliefs about how to teach this course were conflicting. She strongly believed that students learned best by engaging in "research-like experiences where they have an opportunity to devise their own procedures and develop content knowledge through hands-on experience." However, she also felt that her students were not capable of learning in this way. She reached a compromise strategy where she would "wean them off" relying on the teacher so at the end of the year they would be able to engage in their own scientific inquiries. Her inquiry lessons moved from being initially guided to more open-ended at the end of the year with students designing their own experimental procedures.

Bill was assigned to teach five periods of ninth grade physical science—one semester of physics and one semester of chemistry—despite his non-science background. By his own confession, Bill struggled to learn the content before he was required to teach it. When asked how he decided what to teach, Bill responded, "When I understand the concepts and have the materials I need I will teach the topic." However, Bill believed that students learned best when they were "doing science—making their own decisions about procedures and data collection like real scientists" and wanted to implement inquiry-based instruction in his classes. Bill worked closely with a mentor teacher from the science-focused induction program and used some of her inquiry-based lesson plans. Bill was observed using a guided inquiry lesson on the concept of gas behavior and students were expected to develop an understanding of the interrelationships between the volume, pressure, and temperature of gases. The students were given a procedure to follow that involved heating a soda can with a small volume of water followed by inverting the can into a bucket of ice, causing the can to be crushed. After the activity, Bill planned to lead an interactive discussion that would allow students to develop explanations for the observed phenomena. However, this session became a detailed lecture to the students. After the observed lesson Bill commented,

> It is too difficult to let them pose their own explanations; they came up with ideas that were wrong and I didn't know how to guide them towards the right answer. It was easier just to tell them.

Teacher Cases—The Conventional Teachers

Five of the teachers were observed to implement only conventional classroom practices throughout the year—Elaine, Dennis, Pete, Ron, and Michael. Their classroom practices showed two predominant orientations—frequent use of verification or cookbook labs (Elaine, Dennis, and Pete) and frequent use of lecture and worksheet with very few labs (Michael and Ron). Individual cases are used to exemplify these differing patterns of classroom practice.

Elaine, Dennis, and Pete all had industrial research experiences before deciding to become teachers. Their frequent laboratory activities occurred after formal lectures on a topic and emphasized precise procedural skills, careful documentation and report writing, and correct application of equations learned in class. Elaine consistently used an industrial analogy with her class. She told her students:

> In the real world you are hired and fired based on your laboratory notebook; if it is not accurate your company could lose a patent. Real scientists are expected to be accurate and get the right result, they are not employed for trying hard!

The goal of laboratory activities was to reinforce material learned in lecture and to develop skills that would help the students to succeed in industry or college.

Michael and Ron relied heavily on their textbooks and students were frequently observed taking lecture notes on a given topic and answering questions from the book. Any laboratory activities that Ron and Michael used in their classroom came from the textbook, although they did not use all of the recommended laboratory activities. Both avoided any activity that used chemicals other than household materials due to concerns about how to prepare solutions, safety in the classroom, and disposal of chemicals.

Teaching Beliefs

The incoming teaching beliefs of the ten beginning chemistry teachers in this study are summarized in Table 2. The seven dots for each teacher represent the coded responses to the seven TPPI questions. The response to each individual question was compared to the representative responses for each category (didactic, transitional, conceptual, early constructivist, and experienced constructivist) to generate the summary shown in Table 2. Details on the coding charts and representative responses for each category have been previously published *(7, 29).* Teachers who tried to implement at least one inquiry lesson during the year can be seen to have at least one response on the TPPI in either the early or experienced constructivist categories. Teachers with the most frequent and open-ended inquiry instruction (Terry and Laura) have a greater number of constructivist responses than other teachers.

In the following section, the beliefs of teachers are discussed in groups organized by common experiences and exposure to inquiry teaching from their certification programs to develop a fuller understanding of the impact of inquiry experiences and beliefs on classroom practice. Three certification groups exist: limited preparation (no science methods), conventional university program (one science methods course), and Masters of Education (science emphasis) (two science methods courses). As seen in Table 2, in spite of common knowledge and training in inquiry-based instruction there are large differences in classroom practices that cannot be explained solely by content and pedagogical preparation.

Limited Preparation

Dennis, Pete, and Chris entered the teaching profession with strong chemistry content knowledge but no experiences or training with inquiry-based instruction or teaching. Like other teachers with strong content knowledge they tended to add topics to the curriculum or to elaborate on existing topics that they believed were necessary for students who would continue in college or industry. Without any other instructional models to draw upon these teachers used traditional teaching models that were successful for them in college. For example, Dennis explained during his TPPI interview that a basic lesson plan should involve examples of how to work problems and an opportunity for students to work problems by themselves. Labs were important once concepts and formulas had been introduced to give students an opportunity to apply their calculations in a laboratory situation. These teachers were constrained by their limited pedagogical training, yet even after learning a variety of inquiry teaching strategies only Chris resolved to implement an inquiry activity in his second year. Chris, unlike Dennis and Pete, believed that students learned by engaging in the content at a level beyond working problems. He believed that students needed to have opportunities to share ideas with each other and discover things for themselves and was able to put these beliefs into action during his second year implementing a guided inquiry activity with his middle school students.

Traditional University Preparation

Laura, Elaine, Michael, Ron, and Bill all completed a traditional university certification program with a single science methods courses that included experiences with inquiry-based instruction. Yet in spite of their common knowledge of inquiry strategies from their teacher preparation classes, not all of these teachers implemented that knowledge in the classroom.

Only Laura and Elaine had majors in chemistry with Michael, Ron, and Bill having split science minors that included some chemistry. Both Laura and Elaine believed there were certain topics that students should learn in a chemistry course and that students learned these topics best “by doing.” For Elaine, “by doing” meant that her students were engaged in worksheets rather than taking notes from a lecture. She expounded on the subject: “the students don’t learn by watching me do problems on the board, what needs to happen is I show them an example and then they jump in and try it for themselves.” This mirrored how Elaine had learned in college—by practicing the problems in the back of the book. While Elaine used frequent laboratory activities, the activities were designed to have students apply an equation learned in lecture or learn a laboratory technique. Students were assessed on the precision of their lab skills and correct mathematical manipulation of the data. For Laura “by doing” meant that students were working cooperatively on activities and making decisions about how to proceed rather

Table 2. Teaching Beliefs of a Sample of High School Chemistry Teachers

Teacher Name (Pseudonym)	Teaching Prep. Program Type[a]	Didactic Characteristic Present[b]	Transitional Characteristic Present	Conceptual Characteristic Present	Early Construct. Characteristic Present	Experienced Construct. Characteristic Present	Classroom Instructional Practice[c]
Ron	Traditional	• • • •	•	• • •			Traditional
Michael	Traditional		• •	• • • • •			Traditional
Bill	Traditional		• • •	•	• •	•	Inquiry
Elaine	Traditional	• • •	•	• • • •			Traditional
Laura	Traditional		• •	• •	• •	•	Inquiry
Dennis	Limited	•	•	• • • • •			Traditional
Pete	Limited		• • • •	• • •			Traditional
Chris	Limited		• • •	• • •	•		Inquiry
John	M.Ed		• • •	• •	•	•	Inquiry
Terry	M.Ed			• •	• • • •	•	Inquiry

[a]Teaching preparation program type is based on the rigor and depth of science methods instruction: limited (no methods courses), traditional (one methods course), and M.Ed. (two methods courses with supporting courses in history and philosophy of science and cognition).
[b]Each mark represents the coded response to one of the seven TPPI questions.
[c]Practice is determined by evidence or lack of evidence of implementation of inquiry-based lessons.

than following a cookbook verification laboratory, where all of the steps, including how to calculate the answer, are predetermined. She believed that students needed to talk with each other and defend their ideas. She also believed that for learning to occur, students needed to be engaged in a topic that was not only in the standards but also inherently interesting to the students. For example, Laura stated: “If I asked my students who wants to learn how to titrate I would get no takers. However, if I couch it in a real-life problem about the water you drink, or swim in, you can hook them in. They still learn how to titrate and about the pH scale but in a manner that is engaging and where they get to make some decisions about their own learning.” These two teachers with similar pedagogical training and knowledge of chemistry held differing beliefs about teaching which ultimately impacted their decision about implementing inquiry-based instruction.

Michael, Ron, and Bill did not have strong backgrounds in chemistry and they used the standards as a menu from which they selected material that they felt comfortable teaching. While all three admitted that there were certain topics that they did not teach due to their own comfort level with the content there were differences with the teaching strategies implemented. Both Michael and Ron believed that learning was occurring in their class when students did well on tests and quizzes which mirrored their beliefs about their own learning. As Ron stated: “I know that I have learned if after the topic is covered I can still retrieve it from my memory.” Bill however believed that learning was occurring when students were doing the work and explaining ideas to each other rather than listening to his explanations. These differing beliefs about learning produced different classroom practices with Michael and Ron relying on lecture and worksheets and Bill implementing more inquiry activities to promote student discussion.

Masters of Education (Science Emphasis)

Coming from the same certification program, Terry and John had the most extensive preparation to implement inquiry-based instruction. Their first teaching assignments included chemistry courses (out-of-field placements) at predominantly Hispanic schools. Both started the school year with inquiry-based activities designed to model scientific thought processes and inquiry to their students. Students were expected to generate and use evidence to support their ideas during these activities. Terry held strong beliefs about the content and skills his students should learn. He stated that “in reality many of these students are not going to college and if they do they are not going to be science majors. It isn’t important that they can memorize the periodic table, or the parts of the cell in biology, but that they can defend a position using evidence, that they know how to evaluate evidence and determine the validity of something ‘scientific’.” This belief was evident throughout the school year in his frequent implementation of inquiry-based activities. John, however, believed that there was certain content students needed to know to go on to “the next level” and that he would be doing a disservice to students if he did not cover the material. A combination of this belief about content coverage and his belief about his students’ lack of ability to do inquiry led John to scaffold his activities to the point where they could no longer be classified as inquiry activities.

Discussion

This study considered three possible factors that influence beginning chemistry teachers’ decisions about implementing inquiry-based instruction in their classrooms: content preparation, pedagogical preparation, and beliefs. Seven of the ten teachers in this study entered the teaching profession from a preparation program that provided them with strategies to implement inquiry instruction. The other three teachers received instruction on how to implement inquiry teaching through the science-focused induction program. Despite having knowledge of strategies for inquiry teaching, only five of the teachers implemented inquiry strategies in their classrooms, and only Terry frequently used inquiry-based instruction. The teachers holding at least some constructivist beliefs about teaching were those who implemented inquiry teaching; Terry was the most frequent implementer of inquiry teaching and held the most constructivist teaching beliefs (see Table 2). This study shows a connection between teaching beliefs and classroom practice for secondary chemistry teachers that holds for a range of content and pedagogical preparedness. Providing teachers with knowledge of inquiry strategies is not sufficient to meet the expectation that beginning teachers will in fact implement inquiry in their classrooms.

Strong knowledge of chemistry content is not predictive of inquiry implementation in the classroom. The teachers with the highest degrees in chemistry were in fact the most traditional teachers in this study. All of their experiences in chemistry courses were with traditional testing and laboratories designed to master specific laboratory techniques that were graded for precision and accuracy. Their high school classrooms were modeled on their beliefs about teaching gained from these experiences as undergraduates and graduate students. Content knowledge, however, does appear to play a critical role in how effectively a teacher can translate their beliefs and intentions to implement inquiry into actual classroom practice. These teachers did not have access to any inquiry-based chemistry materials and struggled to translate their knowledge of general inquiry strategies for science into specific inquiry lessons for chemistry. Content knowledge may be necessary, in the presence of constructivist teaching beliefs, to develop inquiry lessons designed for students to learn content rather than to develop general process and inquiry skills.

The high demand and limited supply of science teachers, particularly in the physical sciences, is forcing inadequately prepared teachers into chemistry classrooms. Teachers with chemistry degrees are being recruited into the classroom as second-career professionals at a growing rate. Like Dennis, Pete, and Chris they are often uncertified or alternatively certified and enter teaching unprepared to teach inquiry-based lessons. These teachers are forced to fall back on what they know best—their traditional college laboratory courses. Another growing group of teachers is those with science certifications but without a background in chemistry. These teachers need specialized content support and inservice training to translate their knowledge of inquiry teaching into inquiry-based chemistry teaching. Inquiry-based high school chemistry curricula are rare, and these teachers are usually forced to modify traditional textbooks and laboratory manuals for themselves without the necessary knowledge of chemistry.

Given that beginning teachers are still in the process of establishing classroom management and routines, it is not surprising that most of the inquiry implementers only implemented one inquiry lesson in spite of their student-centered beliefs and induction support. We propose that this is the first step in the development of beginning teachers in becoming consistent inquiry implementers and that with continued induction and professional development support we will be able to follow these teacher's development as inquiry implementers.

Another critical factor in the development of inquiry teachers is the presence of appropriate curricular materials *(31)*. One of us (GHR) is currently researching the impact of providing out-of-field chemistry teachers with an inquiry-based curriculum since this was clearly a factor related to teachers' abilities to translate their constructivist teaching beliefs into classroom practice and this may also be a factor that can accelerate teachers' development as inquiry implementers.

Note

1. Classification as an inquiry implementer does not imply an overarching inquiry orientation to chemistry teaching; these teachers were willing to try an inquiry lesson, unlike their more conventional counterparts.

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