JOURNAL OF RESEARCH IN SCIENCE TEACHING VOL. 29, NO. 5, PP. 471–485 (1992)

The Beginning Science Teacher: Classroom Narratives of Convictions and Constraints

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Abstract

This article is a case study of a second-year middle school science teacher's beliefs about science and science teaching and how these beliefs influenced—or failed to influence—classroom instruction. It illustrates how beginning teachers struggle to reconcile (a) conflicting beliefs about what is desirable, and (b) conflicts between what they believe is desirable and what is possible within the constraints of their preparation and the institutions in which they work. This teacher, for example, struggled to reconcile his view of science as a creative endeavor with his belief that students need to be provided with a high degree of structure in order to learn within the context of formal schooling. He also had difficulty resolving the conflict between the informal ("messing about") type of science learning that he believed was desirable and the personal and institutional constraints he faced in the classroom.

The problem of teacher retention is a national concern. The first few years of teaching are particularly difficult (Marso & Pigge, 1987; Veenman, 1984); some districts report losing 40% of their beginning teachers within the first two years (Wise, Darling-Hammond, & Berry, 1987).

Case studies of first-year teachers have provided some understanding of how particular classroom events, institutional characteristics, and the personal qualities of the teacher interact (Clandinin, 1987; Cooney, 1985; Goodman, 1987; Ryan, 1970; Zeichner, Tabachnick, & Densmore, 1987). These case studies not only examine the attributes and beliefs of teachers, but also the constraints with which these teachers must deal. These constraints include standardized testing that may measure only superficial knowledge, extracurricular activities that take students from the class, and differences between the philosophy of the teacher and that of his or her supervisor.

Zeichner, Tabachnick, and Densmore (1987) examined the experiences of a beginning teacher who successfully redefined her teaching situation to fit her own perspective on teaching. Her success was due to a combination of factors: her coping skills and political savvy; the positive reaction of the students to instruction; an informal school

Published by John Wiley & Sons, Inc. CCC 0022-4308/92/050471-15$04.00

tradition that allowed teachers to work in their classrooms without interference; and the fact that her teaching perspective was well developed and strongly held at the beginning of the year. Goodman (1987) also found that the personal commitment of the teacher, institutional support systems, and students' reactions to the instruction were key components to the success of beginning teachers.

These studies have focused on elementary teachers instructing in a variety of disciplines. This article examines the teaching of science and the particular difficulties that may be unique to science classrooms. To do this we have analyzed the beliefs and the practices of a second-year middle school science teacher, Basil McGee,[1] to answer the following questions: (a) What does McGee believe he ought to be doing to teach science effectively? (b) What instruction does McGee carry out in his classroom? (c) What constraints hinder the implementation of instruction consistent with McGee's beliefs about what he ought to be doing to teach science effectively?

Research Design

To understand McGee's beliefs, it was necessary to use methodology that would allow him to express his ideas in depth and that would allow us to react to his ideas with appropriate follow-up questions. To understand McGee's classroom behaviors and the meaning of these behaviors required us to examine the complexity of classroom life and collect data that would provide us with rich descriptions of the actions of the teacher and his students. To probe his views about tasks and assignments required access to documents such as the assignments and tests he used in the classroom. To elucidate the contextual detail we sought, a case-study approach was adopted (Erickson, 1986; Lincoln & Guba, 1985). Three primary sources of data were used: (a) interviews with the teacher, (b) observations of his class, and (c) written documents such as tests, homework, assignments, lab activities, and so on.

McGee was one of three teachers in a 10-month study of teacher beliefs and classroom instruction. He was selected for this study because of his relative inexperience as a teacher. The experienced teachers operated from a consistent, self-reinforcing belief system (Hollon & Anderson, 1987). Their classroom instruction was remarkably consistent from one day to the next, and they expressed personal philosophies that were congruent with their actions in the classroom. The constraints discussed in this article, which were highly problematic for McGee, were rarely mentioned by these teachers. This does not mean that such constraints have not influenced their teaching. It does suggest, however, that these teachers may have either created mechanisms to circumvent their constraints or adjusted their teaching to fit them.

Data were collected in McGee's classroom for seven months. During this time it became apparent that McGee's experiences as a beginning teacher were quite different from those of the more experienced teachers in the study. Data from his classroom were difficult to analyze, because the classroom instruction was variable and could not be predicted from interview data. Although McGee often knew what he wanted to do, lessons often took a different path than he intended. It was only by asking concrete questions about McGee's rationale after observing his instruction that we were able to separate what McGee believed was desirable from what he found possible.

[1] The name of the teacher has been changed to ensure confidentiality. We wish to express gratitude to McGee for his courage in sharing his thoughts and his classroom.

Interviews

The formal interviews were audiotaped and carried out as hypothesis-testing situations, in which hypotheses were generated and tested by subsequent interview questions (Skemp, 1982).

The initial interview was semistructured. It began with prepared questions that were open ended, such as: What is the difference between science and other forms of knowledge? How would you describe the ideal teaching situation? How does your teaching situation differ from the ideal? Responses to these questions led the interview in directions that were largely determined by the teacher. Three subsequent, formal interviews included both open-ended philosophical questions and specific questions about the rationale for the methods of instruction used or actions the teacher had taken in a particular classroom situation. These questions elicited concrete statements that could then be compared with the teacher's more abstract and divergent comments (Lortie, 1975).

In addition to these formal interviews, there were also informal discussions before and after classes which provided information on McGee's plans for the day, difficulties he was experiencing, and his reactions to the lesson. These interviews were not usually recorded directly; the researcher took written or oral notes which were later transcribed into the research journal.

Observations

McGee's seventh-grade life science class and his accelerated seventh-grade physical science class were observed for a combined total of 36 hours over a seven-month period. On the basis of interviews and observations, hypotheses concerning McGee's beliefs about science and science teaching were built, validated, and/or altered, as necessary (Skemp, 1982). Hypotheses were then checked by looking for supporting and/or contradicting evidence.

Observations were audiorecorded and transcribed verbatim into the field notes, which concentrated primarily on collecting data the tape recorder would miss, e.g., information on the chalk board, movement around the room, softly spoken dialogue. Unannounced classroom observations were made two to three times per week, which allowed transcription of recordings as well as data analysis to be treated as an ongoing process. Observations spanned seven months so that McGee could be observed teaching a variety of topics. To develop an understanding of the events of the classroom relative to its history, it was also important that some observations be made frequently for several weeks at a time. Subsequently, there were several weeks during the seven months in which no observations were made. However, no lesson types were purposely excluded.

Other Data Sources

In addition to field notes, audiorecorded observations and interviews, tests, quizzes, worksheets, and lab activity sheets were obtained and analyzed. Toward the end of the study, McGee was given a copy of the case study which was written to describe his classroom, and he was asked to check it for accuracy and to comment on ideas that he believed were misrepresented or incomplete. He expressed no disagreements with the case study and likened it to hearing his voice on a tape recorder.

Validity and Reliability

Research of this type is less interested in reality per se as it is in the perspectives of those involved in the research and the complexities of human action in particular contexts (Merriam, 1988). For this reason, it is crucial that the findings be credible to the individuals whose perspectives are portrayed. McGee's agreement provides strong evidence of the study's validity. Furthermore, other standard means of judging validity and reliability were also met (Merriam, 1988). These include the use of multiple methods of data collection, long-term observation, and examination of emerging findings by peers. The influence of researcher bias is accounted for in the description of the theoretical orientation.

Generalizability

The degree to which these or any other research findings are generalizable to other situations is dependent on the similarities between the two contexts. We have included as much detail about the context of the study as possible to help the readers make their own judgments regarding the extent to which these findings may inform their own work and experiences.

The Case Study

McGee teaches seventh-grade life science, physical science for gifted students, and health in a middle school located in a large Midwestern city. This is his second year as a teacher, but his first year with this school and this curriculum. McGee is a down-to-earth, outspoken person, who creates a relaxed and open classroom environment. McGee describes what he views as the perfect classroom as follows.

> I need to have my own classroom out in the woods. . . Have you ever seen Sam Houston's schoolhouse in Alcoa, Tennessee? You ought to see it. That's what it would look like—just a black spot in the woods with this old wooden house and just a place to get out of the rain if it starts raining too hard. . . And what we couldn't learn outside we just wouldn't learn.

Since McGee has a great deal of experience with the Boy Scots of America, it is not surprising that he values informal learning experiences. He believes that the varied background of experiences he has had—in the military, with the Boy Scouts, and in the coal mine construction industry—give him credibility with the students, because they see him "not as a science teacher, but as a guy who's teaching them science."

> McGee emphasizes informal learning when talking about his classroom. Let them . . . stumble around, if you'll excuse the term, in that experiment. They will have seen it enough and handled it enough and got themselves dirty doing stuff that then you can follow up with a real quick review and then they become involved . . .
>
> I like having an informal classroom. I like the whole environment . . . letting them do their own thing. . . They're out in the garage experimenting with some junk they found on their dad's workbench. They'd just be talking and messing around and hopefully that's what we're trying to do in the classroom.

McGee also views science as an informal, and often anarchistic, endeavor. The stories about scientists that McGee tells in class depict them acting in very creative ways. The followig story he tells about the discovery of the alpha helix is an example:

> He said the way he figured that out was he was sick in bed and he was drawing this thing on a piece of paper. And while he was drawing, he got to fiddling with the paper and twisted it accidentally and noticed that when he twisted it a certain way that it repeated itself all the way around. And that's how he got the idea. . . It was just by accident.

McGee believes that scientists are curious, creative, and motivated purely by a desire to understand the natural world.

McGee's Actual Classroom

Common themes in McGee's discussion of what science teaching should be include: "getting dirty," "messing around," and "going off on tangents." In spite of this, the majority of the time in McGee's class involves whole-class discussions that closely follow the organization of the book and emphasize learning terms. This discrepancy can be understood by noting a recurring theme in his description of what students need in order to learn. Although McGee believes that science is a creative, anarchistic endeavor and that science teaching should ideally occur in an informal environment, he also believes that students need to be given a firm foundation of knowledge on which they can build. The struture of this knowledge can take the form of learning vocabulary words, studying detailed diagrams, taking class notes in a specified format, or following explicit procedures for solving numerical problems. Not until instruction in key concepts and vocabulary words has taken place can lab activities be introduced.

> Just introduce vocabulary and the concepts, basically, and . . . now that they've heard the terms, their schema can become evoked by when they see some of this stuff . . . in that experiment.

During the year before this study was done, McGee taught from the Intermediate Science Curriculum Study (ISCS) materials, which he liked because they were activity based. He complained, however, that ISCS "doesn't give you much of a road map." As a result, he developed lab activities for his second year of teaching that were designed to provide students with such a road map.

Consider four of the days on which his labs were observed—for example, when the emphasis was on finding and naming a large number of structures in the animals students were dissecting. Before these labs were performed, several days of class time had been spent discussing such structures. On the day of the lab, the students were given an additional 10–15 minutes of instruction on how to find these structures. In one lab, the students were asked to amputate appendages from a crayfish and lay them on top of a diagram of the same structure. During another lab, they were supposed to refer to labeled diagrams of crayfish that McGee had given them, locate the indicated structures on their crayfish, and then label these structures on another diagram.

Giving students an algorithm or a structure is also an important part of McGee's approach to solving numerical problems. During instruction on heat and temperature in the physical science class, for example, McGee wrote the following "formula for calculating specific heat" on the board.

$$H = mc\Delta T$$
$$= \text{mass} \times \text{sp. ht.} \times \text{change temp.}$$

During class, McGee emphasized to his students that the method they use is more important than getting the right answer.

> The system you use in solving the problem is more important than getting exactly the right answer. The problems are designed to make you think and to put two and two together and abstract thinking. If something doesn't work, all right, let's try this. Maybe that will work. So, learn to develop a problem solving technique that helps you look at different angles in solving a problem. Many problems look the same, but you can't solve them the same way. You've got to use a different technique.

When he works problems, however, McGee tells his students that he always wants to see their work and that they should use the formula step-by-step and always cancel out units. When one student asks McGee about doing the problem differently, McGee asks the student to learn it his way first.

> M: Do it my way, ok?
> S: But will it work?
> M: It might, but I don't want you to do it that way, not until you're able to do it this way. Then you can do it any way you want. You can manipulate the figures different ways but the formula says to multiply it straight through. And if you're doing all that . . . then that means you're not following the book. And when you deviate from the formula, you're taking the chance of making mistakes that are difficult to find.

McGee also tries to provide the students with structure in the form of a study skills seminar. In October, he began using one science class period each week to teach them how to study. He asks them to divide their paper into three columns, for example. When they read at home, they are to write terms and phrases in the center column. During the discussion of these terms in class, they are to write in the right-hand column any questions that he asked or additional information not in the book. Then, when they review their notes at night, they are to put in any additions or changes in the left-hand column. When he lectures, McGee sometimes tells his students explicitly what to put in their notes.

Structure is also provided by discouraging students who stray from the teacher's intended lesson. The following extract from a discussion of solids, liquids, and gases illustrates this point.

> B: What was the answer to 15?
> M: What I wanted you to say was "closeness of molecules."
> B: That's density.
> M: Well, ok, we haven't talked about density yet.
> B: Yeah, but that's what it means.

M: No, not yet. . . Our discussions and the text were more along the lines of the closeness of molecules . . . I went ahead and accepted "density" for you and some others who thought it was right. If you put it down and it was counted wrong, then look to see that you get credit for it.

This dialogue indicates that the students were encouraged to stick to the definition given in class—not to stray from the road map. Although the student did not actually lose points for getting ahead, there was no encouragement for thinking beyond where he was supposed to be.

The Dichotomy of Science versus School Science

McGee views science as an endeavor practiced by creative, purely motivated individuals, and he values informal learning experiences where kids are "messing around" and "going off on tangents." However, in the context of his classroom, science takes on a much more formal and structured image. McGee believes that in school, students need to be taught structure and ways of organizing themselves. He believes that he must give them knowledge in a structured format before they are able to do any "discovering." His actions, which indicate a belief that his role as the teacher is to transmit knowledge to his students in a way they can make sense of it, contradict his beliefs about formal schooling, in which he expresses a high regard for informal educational experiences.

One of the difficulties McGee has as a beginning teacher is that he has not reconciled this conflict between what science is and what it means to teach science. It is useful to consider McGee as a learner who is experiencing considerable dissonance between his belief that science is open-ended inquiry and his belief that students in school need the teacher to provide considerable structure in order to help students learn science. How this conflict will be resolved is likely to be influenced by his experiences in the classroom and the knowledge he constructs to explain them. Because his experiences in the classroom will be influenced by what he believes is possible, rather than by what he finds most desirable, it is important to consider the classroom and institutional factors that intervene to prevent McGee from implementing his desired instruction.

Classroom Constraints

Interactions between students and teachers influence the development of the teacher's perspectives on how learning occurs in the classroom. Two important interactive constraints on McGee's teaching are student attitudes toward grades and McGee's conceptual understanding of the content.

This study supports the conclusions of Cooney (1985) and Zeichner, Tabachnick, and Densmore (1987), who showed that students' reactions can be an important constraint on their teachers' behaviors. The primary factor motivating McGee's students is grades. The first comment following the announcement of an assignment was commonly directed toward how this assignment would affect their grades. The students in the gifted physical science class were as likely, if not more likely, to be motivated by grades. After McGee gave an assignment, the students negotiated with him to determine the minimum amount of work they could do to obtain the maximum number of points. The following discussion occurred after a writing assignment was announced.

> M: It's due Friday. You want to write a paper and it has to be long enough to tell the story but short enough to not bore me, right? The better job you do in comparing his work, the better your grade will be. Don't expect to hand in two paragraphs and expect, you know, he was born this day and died this day and before he died he did this. That's not—I want a good report. . .
> S1: Does it have to have a bibliography?
> M: Yes, it sure would enhance your grade if you had a bibliography . . .
> S2: Does it have to have three resources?
> M: Doesn't matter. The more research you have the more credible your report . . .
> S3: Do you want us to write it in pen or in pencil?
> M: Pen is the only way to do a report.
> S4: Black ink?
> M: I'll accept blue ink as long as it's in ink and double-spaced. . .
> S5: Do we need to type our report?
> M: You can type it, yes.
> S5: Will it enhance our grade?
> M: It enhances the neatness factor, definitely. But if you don't type it, that doesn't necessarily mean that you wouldn't get a good grade.

McGee describes scientists as being motivated by the pure pursuit of knowledge, but does not see his students as being motivated in the same way. This is of considerable concern to McGee, especially in the case of the gifted students. They are so competitive that he has a great deal of difficulty pairing them for laboratory activities, because students openly complain about being hindered by their partners. McGee describes the situation as follows.

> I tried everything with the [gifted] kids and nothing works. They're all so damned competitive. . . None of them work well together.

The one time during the year when the gifted students were less competitive and driven by grades was during the planning for National Energy Education Day (NEED). Although there was never any discussion of grades by either McGee or the students, some of the students were working on several different activities. When one of the boys complained that some people were being designated to do more than one task, the other students became very angry, telling him that there was much that had to be done on this project.

I asked McGee if he believed that the students were more cooperative in planning for NEED.

> Yeah, well because NEED was . . . an activity [that] was extracurricular-like . . . to them . . . They were unable to conceive that NEED project as actually a part of their grade . . .

McGee felt that the students perceived the NEED project as extracurricular rather than being part of science class. Because students do not expect grades for extracurricular activities, they were surprised to find that McGee had actually given them a grade for this, based on their ability to work as a team. It is interesting to note that while McGee is concerned about his students being competitive and driven by grades, his concept of a reward for working cooperatively is to give them a grade for it. I asked McGee what he thought might have happened if he had not given the students a grade for the NEED project.

> Nothing would have happened other than they would have not been aware . . . of a concern for them to be a total rounded kid, and that means be concerned about working with other people and that true science is going to occur when people work as a team and when they're not just trying to serve their own purpose.

Another classroom constraint that influenced McGee's teaching is his concern about the effect that the low grades students received in his life science classes would have on their self-esteem.

> And so what you're doing is you keep on trying to pound that square peg into a round hole. They're not going to succeed. They're just going to continue to say, "you're a failure, you're a failure, you're a failure." Somewhere you're gonna have to design a success in their life.

Because he wants his students to succeed, McGee uses several strategies to help them bring up their grades. These include: (1) conducting study skills seminars, (2) basing grades on a variety of activities, (3) giving bonus points, and (4) telling the students explicitly what would be on the tests.

Another important classroom constraint for McGee was the need to learn the content while he was teaching it. As so many other teachers have found, it was only when he tried to communicate a topic to his students that he was able to recognize the deficiencies in his own understanding. McGee's primary certification is in earth science and his secondary certification is in mathematics. Because of his earth science certification, he is permitted to teach all other sciences at the middle school level, even though his background in the other sciences may be weaker.

Although he said he believed that the teacher should not play the role of an expert, he showed noticeable discomfort when confronted with questions for which an immediate answer was not possible. In areas such as heat and temperature, where he had difficulty himself, he was less likely to accept alternative solutions to problems that students proposed. This may have resulted from fear that he would not be able to detect mistakes the student could make.

In spite of some insecurity that arose from his recognition of gaps in his mastery of the content knowledge, McGee was able to create a classroom environment in which many of students felt free to ask questions. This created a difficult situation for McGee. He knew that the students were going to ask questions he could not answer, yet chose to take that risk rather than shut down the discussion.

Institutional Constraints

Constraints faced by McGee as a result of the structure of the institution in which he taught can be examined using categories established by management/labor-relations researchers (Zeichner, Tabachnick, & Densmore, 1987). Edwards (1979) described three forms of control over laborers' work used by management: personal, bureaucratic, and technical. In the context of the classroom, personal control involves the impact of supervisors, such as principals, on the teachers' work; bureaucratic control involves regulations and social hierarchies; and technical control is a result of scheduling of classes, building designs, texts and other materials for instruction, and the events that occur within the classroom.

Personal Control

Teachers' work is generally regarded as an activity marked by its isolation from colleagues and supervisors or other practitioners (Lortie, 1975). This is the case for McGee as well. He had hoped that since the school was organized in teaching teams, the teachers would work together and there would be a strong sense of collegiality. But this was not the case. He describes his situation as follows:

> The new teacher in an old system—and this new teacher's kind of held in a bind because nobody wants to be real close to him until they find out what color he is.

McGee speaks fondly of the relationships built with teachers last year in a different school system, but with disappointment with respect to the teachers in this school. He perceives them as closed to new ideas and, at times, threatened by a new, enthusiastic teacher. Perhaps most importantly, they are insensitive to his personal need for camaraderie and emotional support. This issue came to mind immediately when McGee was asked how the school could have provided him with more support.

> . . . being concerned about me as a person, you know, who I am and what I am and that would have been very helpful. I would have felt more comfortable approaching other teachers for ideas and this sort of thing. And the way it was, animosity grew there and I had to continually bite my lip and look around and that sort of thing.

The other seventh-grade science teacher had 32 years of experience, yet provided McGee with no assistance. McGee tried to obtain supplies in staff meetings, but was not able to obtain them because the veteran teacher would not back him up and the others viewed the veteran as the authority.

His principal made one visit to his classroom in October for evaluating McGee and did not return that year; yet the principal criticized McGee for letting his students distract him from his lesson plans.

> Like my principal observed me and he was extremely analytical . . . but one little kid started asking "what if" questions and . . . all the sudden they found something that was interesting. They wanted to find out about it. And so I went with it . . . I didn't think that we were digressing that much . . . He thought I should have said "well we'll talk about that later." How do you tell a seventh grader, "hey, hold that thought"?

McGee believes that some deviation from lesson plans is all right and is consistent with how he believes scientists work. "My principal told me, 'sometimes I don't think you know where you're going.' And I told him . . . 'sometimes I don't. . . . Did Nobel know where he was going?' People just don't understand science that way."

McGee believed that neither his colleagues or his supervisors provided positive support for him during the year this study was done—his first year in the school system. But the principal's evaluation made McGee more conscious of strictly adhering to preplanned teaching schedules in the future.

Although institutional support systems have been found to be important by Goodman (1987), others (Zeichner, Tabachnick, & Densmore; 1987) have found that it is possible for a beginning teacher to thrive in an institution in which there is little interference in the classroom. Although these may appear as contradictory findings, it is important to address the nature of the support systems that are offered and the fact that different teachers may need different forms of support. The only interventions attempted in McGee's classroom had potentially damaging effects. What he needed, in terms of emotional support, was not offered.

Bureaucratic Control

McGee teaches from a textbook which he does not like and did not choose. The supplies needed to do the experiments in the textbook were not ordered when the text was chosen and were not present in the classroom; nor was McGee allowed to purchase anything prior to the start of school. By the time he had figured out what he needed, there was very little money left in the budget. Whereas an experienced teacher may have had the skills, time, and knowledge to overcome such constraints, it was very difficult for a new teacher in unfamiliar surroundings, carrying a heavy teaching load, to do so.

> McGee has had to struggle to adjust to the hectic classroom environment. I could just as easily teach him to do that with some more creative stuff and . . . the good question is well then, why don't you? Because I only have maybe one class period to do that and then I've got to get right into something else. And in that class period I've got a kid walking in with a lousy attendance sheet or I've got somebody wanting me to pass out pictures for the photograph session and we've got all this other b.s. going on . . .

The difficulties McGee faced in dealing with the complexities of the classroom are especially common for beginning teachers.

Another factor which McGee perceives as a constraint on his teaching is the need to cover the textbook.

> If they would give me a textbook and I would say, ok, I'm going to pick out five chapters, instead of eighteen chapters, or if they could come to me and say, ok, at the end of school our corporation wants our kids to know these five things. That would be wonderful. Then I could take those five things and use those as a center for all these creative thinking ideas . . . But no, I have to go . . . step-by-step . . . The curriculum looks like they're trying to make Ph.D.'s out of these people. They're trying to teach the kids too much I think.

This quotation helps us understand a great deal about the instruction seen in McGee's classroom. The most efficient way to cover the textbook is by encouraging the students to memorize the vocabulary words in the chapters. This type of instruction also helps the students pass the chapter tests that are provided by the curriculum and used by

McGee. Since this district did not provide McGee with a curriculum guide, he assumed that the textbook was the curriculum. It was not until he read his case study that he realized that there may have been other possibilities.

Technical Control

Although technical control is one of the most pervasive forms of control in the classroom, it is also the most invisible and unquestioned form of control. Teachers' responsibilities are segmented into time periods over which they have no control. McGee's students move in and out of enclosed rooms and McGee has tremendous difficulty finding the time to meet all demands on him. In addition to teaching seven classes per day, including life science, physical science, and health, McGee plans special events for the gifted class, sponsors the yearbook staff, and, at home, cares for an infant daughter.

Another aspect of technical control is the curriculum materials. Despite the fact that McGee did not choose his textbook and does not like it, he is still very dependent on it. Often, when McGee does not know the answer to a student's question, he will thumb through the textbook, which for him is the source of authority about science and contains what the students should know about science. McGee, like many beginning teachers, relies on the textbook to meet the daily demands of teaching.

Teachers as Learners

We believe that learning is a process in which learners construct knowledge in order to make sense of their observations and experiences and to predict future events (von Glasersfeld, 1984). Schools are generally conceived of as places where students learn from teachers (Wildman, Niles, Magliaro, & McLaughlin, 1989). If we consider learning to be a process in which individuals actively make sense of their environment, we must consider the learning of teachers as well as students (Shapiro & Roberts, 1989). Teachers construct knowledge about science, their students, and the science classroom that fits their experiences and meets the goals they set for themselves and their students. Some of this learning takes place in teacher-education courses, but most of it occurs in the schools in which they teach. We must therefore examine the learning of teachers in schools to fully understand why they teach as they do.

During the course of this study, McGee learned a great deal about his students, his colleagues, and the way his school functions. He learned that what he wanted was difficult to achieve. He did not learn how to achieve his ideal; instead he learned how to make compromises to meet the demands of classroom teaching.

In particular, we believe McGee learned that gifted students may be very competitive, wandering too far from the textbook may be dangerous (especially if your principal is evaluating you), and never expect help from your colleagues. Certainly this is not all that McGee learned. However, is this what he ought to be learning? Rather than learning skills to survive, should he not be learning how to assess the students' interpretations of lessons and how to rethink those lessons so that they provide the students with the optimal conditions for learning? To create the opportunity for learning of this nature, we need to reconsider both teacher education and programs for the induction of new teachers.

Implications for Teacher Education

Although much of this article has focused attention on the institutional constraints that prevented McGee from achieving his ideal instruction, McGee's own cognitive conflicts could be addressed in teacher-preparation programs.

McGee's beliefs about science contradict his beliefs about what students need to learn science. Although he believes that scientific inquiry is a highly creative, perhaps chaotic activity, he has great difficulty reconciling this with his belief that learning school science requires the teacher to lay out the knowledge structure of the discipline for the students. This dichotomy could have been resolved during his teacher-training program if someone could have helped him understand how students construct knowledge and how this construction is compatible with the nature of scientific inquiry.

Teacher education should not only help teachers develop a rationale for teaching science, but also provide ways of actually accomplishing this in a classroom seting. This type of content-specific understanding of teaching and learning has been described by Shulman (1986) as pedagogical content knowledge and can be an important influence on teaching science (Brickhouse, 1989). Once these competencies are developed, schools must be reorganized so that they foster the continued development of pedagogical content knowledge.

Implications for Teacher-Induction programs

Unlike other professions, teachers are often treated as if they were "finished products" when they graduate from their teacher-education programs. Not only are they considered to be complete teachers, they are given the same or even greater amounts of responsibility than experienced teachers. Beginning teachers often have more preparations and are asked to teach classes that experienced teachers choose not to teach (Sanford, 1988; Thorman, 1988). The demands on the time of beginning teachers are often so enormous that they must rely heavily on the textbook materials just to get through the day. The lack of support for beginning teachers is not only evidenced by "sink or swim" feelings among beginning teachers, but, as in the case of McGee, by a lack of understanding of what their district believes "swimming" is.

The sink or swim experience is damaging to beginning teachers, because it forces them to devote time to devising survival strategies rather than designing thoughtful instruction. One potential solution is induction programs for beginning teachers (Hudson, 1988), although it is too early to judge the effectiveness of such programs. When new faculty are hired at many colleges and universities, they are given a lighter teaching load during their first semester. Unfortunately, this trend seldom extends to the beginning teacher at the elementary or secondary level.

The use of mentor teachers shows promise for helping new teachers understand the events of the classroom and the expectations of the school. However, it is important that these mentors play a supportive rather than evaluative role for several reasons. The mentor and the beginning teacher may have radically different views about learning and the novice teacher must not feel forced to accept someone else's view of student learning just because he or she is in a position of authority (Brickhouse, Bodner, & Neie, 1987). Furthermore, beginning teachers should be expected to have some failures in their classrooms and need to have someone with whom they can discuss these failures honestly and analytically, without fear of retribution. If we want teachers to develop powerful understandings of their students and their learning, we must create an environment that gives them time for careful reflection and planning, along with support for dealing with the needs of their classroom and the rules and expectations of the school.

Future Research

To understand teachers' learning, longitudinal research that monitors the change in teachers' beliefs and actions is needed. We also need to understand how teachers interpret their experiences in the classroom and how this influences the changes they make in instruction. These studies should also include an examination of the impact of teacher-induction programs designed to account for the teachers' interpretations of the nature of that support. Finally, future research should strive to guide the development testing of model programs that achieve the goal of providing teachers the opportunity to learn about their students' learning in ways that improve their teaching.

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Manuscript accepted July 20, 1990.