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Curriculum Change, Student Evaluation, and Teacher Practical Knowledge

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INTRODUCTION

The purpose of this article is to explore how teachers make decisions concerning student evaluation of new content associated with teaching science through science-technology-society (STS).

The focus for many STS science curricula has become scientific literacy (Hart, 1989). New programs have been designed to provide students with the knowledge and skills necessary to be informed citizens in a world in which the interactions among science, technology, and society are becoming increasingly important. However, programs of study in themselves cannot bring about a change. The most influential factor in educational change is the teacher (Blosser, 1984; Fullan, 1982; Koballa and Crawley, 1985; Laforgia, 1988; Roberts, 1988).

Teachers adapt a curriculum in ways they think are the most appropriate for each specific teaching situation (Roberts, 1980; Shulman, 1987; White, 1988). Teachers make these adaptations based on feelings and impulses that are learned from life experiences and past teaching assignments. Furthermore, these adaptations are influenced by the content of the curriculum as well as the current teaching situation (Jackson, 1968; Lantz and Kass, 1987). Teachers react to teaching situations in a holistic and intuitive manner, and "in so doing they show that teachers' knowledge has the characteristics that philosophers have always attributed to prac-

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tical knowledge—that is, it is time bound, and situation specific, personally compelling and oriented toward action" (Feiman-Nemser and Floden, 1984, p. 31). Teachers use their practical knowledge to make decisions on all aspects of teaching. To understand the skills of teaching, it is useful to gain some insights into the practical knowledge that informs the decision-making process of teachers (Shulman, 1987).

When teachers contemplate the adaptation of a new curriculum, they give high priority to the issue of student evaluation (Aikenhead, 1984; Crocker et al., 1988). Student evaluation, therefore, promises to be a fruitful area of investigation for teacher decision making and teacher practical knowledge.

The article begins by developing a heuristic model of teacher practical knowledge. This heuristic guided the analysis of data collected in the study from teachers reflecting upon their evaluation practices, as they contemplated a new science curriculum.

TEACHER PRACTICAL KNOWLEDGE

Margenau (1964) wrote, "How often have we uttered in conversation the simple phrase, 'Yes I know'?" (p. 3). He explained that knowing is only a part of the human experience. Other components of the human experience include feeling, judging, willing, and acting. The practice of teaching can be visualized as the interaction among all the components of the human experience. The interactive elements of knowing, feeling, judging, willing, and action comprise teacher practical knowledge.

Teachers respond to teaching situations by drawing from their past experiences upon which they formulate decisions for action in an attempt to change the current situation into one which is better suited to their own beliefs, values, and vision of what the teaching situation should be. Teacher practical knowledge can take the form of implicit theories that "tend to be eclectic aggregations of cause–effect propositions from many sources, rules of thumb, generalizations drawn from personal experiences, beliefs, values, biases and prejudices" (Clark, 1988, p. 6). This knowledge is theoretical, experiential, and situation specific. It is practical knowledge.

Teacher practical knowledge can be thought of as having three levels: rules of practice, practical principles, and images (Elbaz, 1983). Rules of practice are clearly formulated statements of procedures for specific situations. They are the rules of pedagogy that are learned by teachers from their formal training and become modified by classroom experiences (Shulman, 1987). In contrast, a practical principle might be thought of as a rationale for the action taken. It includes the teacher's purposes, reasons, or aims, and involves reflection and choices that are influenced by the teaching situation. Used together in formulating decisions for action, rules of practice and practical principles are considered within the framework of the teacher's visions of how teaching should be. Visions orient the teacher's overall conduct by providing frames that enable the teacher to conceptualize his or her actions (Nespor, 1984). Visions are formed intuitively from a teacher's feelings, values, needs, belief, experiences, theoretical knowledge, and school folklore.

Visions provide a mental picture (an image) of how the teaching situation should be (Feimen-Nemser and Floden, 1986).

In the context of curriculum implementation (that is, when teachers modulate curriculum materials for classroom practice), Lantz and Kass (1987) discovered that teacher practical knowledge is heavily dependent upon a teacher's past experience, and the current teaching situation.

Figure 1 presents a heuristic of teacher practical knowledge that draws upon the Lantz and Kass conception. Integrated into the heuristic are the three levels of teacher practical knowledge discussed by Elbaz (1983). This heuristic suggests that teacher practical knowledge has three major components: (1) teachers' past experiences; (2) teachers' current teaching situation; and (3) teachers' visions of how the teaching situation should be. Each of these components is examined briefly.

Past Experience

A teacher's past experience (such as formal education, teaching assignments, and other encounters of life) form an encyclopedia of personal knowledge. From our formal education, for instance, we learn subject matter content, pedagogical strategies used by our teachers, and pedagogical theories from our preservice education courses (Carter, 1990). From our own teaching experiences, a myriad of positive and negative memories accumulate (Schon, 1987). Life's experiences beyond formal education can teach memorable lessons about people, their behaviors, and their expectations of us. Research into the practical knowledge of teachers indicates that all three types of past experiences (education, teaching, and life) mold our conceptual and experiential modes of knowing (Connelly and Clandinin, 1985; Roberts and Chastko, 1990).

From past experience, teachers idiosyncratically develop and eclectically distill pedagogical values, beliefs, and rules of practice (Clark, 1988; Roberts, 1980). Rules of practice are statements of procedures for specific situations (Elbaz, 1983). For example, we hear the advice, "Get students' attention before beginning a lesson," but the precise method for getting attention depends upon the particular circumstances we are in.

Values, beliefs, and rules of practice are the cognitive constructs, skills and tacit know-how that form one central aspect of a teacher's practical knowledge, knowledge which guides decisions on classroom practice. Rules of practice include some of, but are not restricted to, Shulman's (1988) categories of pedagogical content knowledge.

A teacher's past experience is a dynamic base that will change as new experiences interact with the old constructs. Even subject content knowledge changes over time as a consequence of teaching that subject (Arzi, 1991).

Current Teaching Situation

The current teaching situation influences a teacher's instructional decisions by imposing some constraints on what actions the teacher may take. The expectations

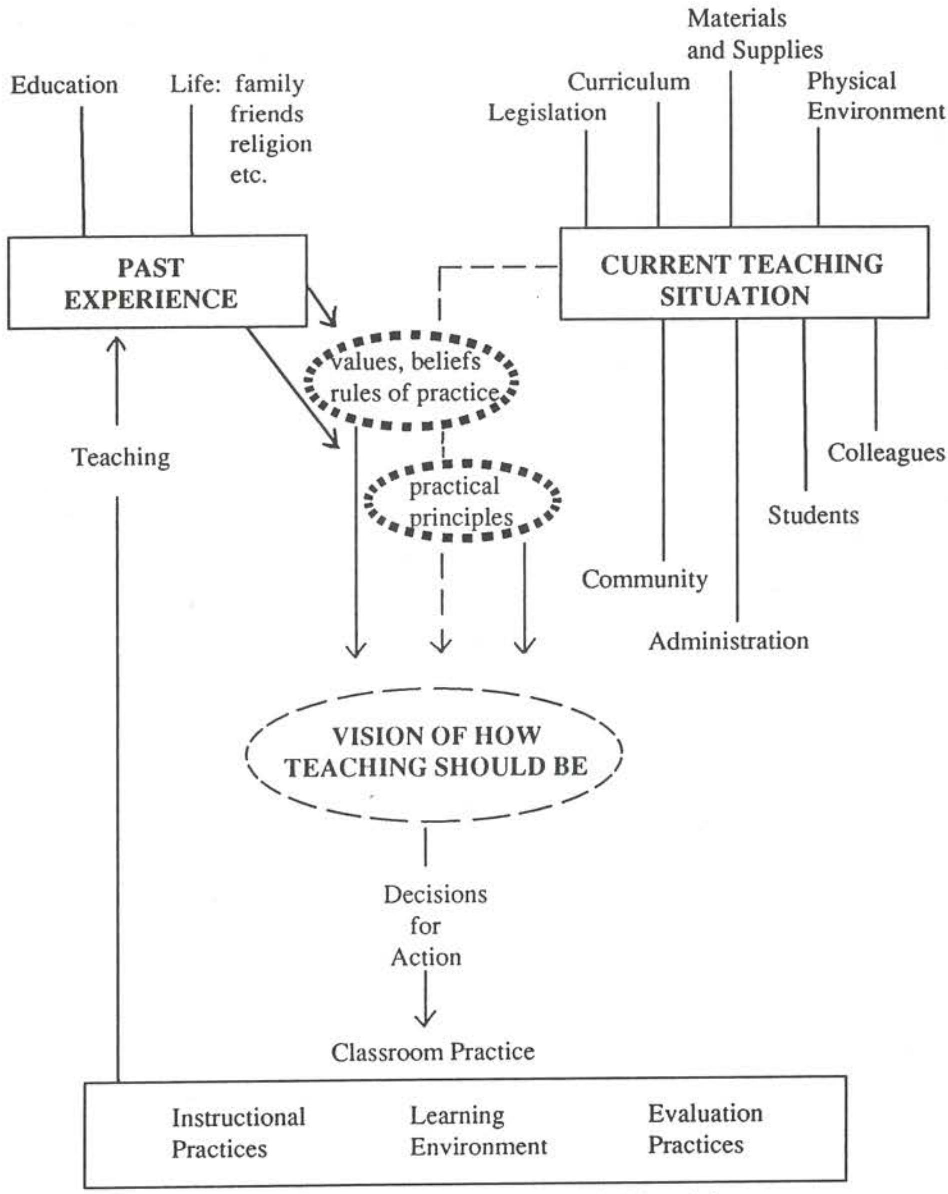

Figure 1. A heuristic for teacher practical knowledge.

of the community, students, administration, and colleagues, as well as the dictates of the curriculum, give direction for choosing actions (Lantz and Kass, 1987).

A teacher's perceptions of the current teaching situation are filtered through a set of practical principles about how to teach (Figure 1). These principles are similar to, but not restricted to, Shulman's (1988) pedagogical content knowledge. Practical principles are rationales for action (Elbaz, 1983). They emerge from past experience, but they (1) include the teacher's purposes or aims for the current teaching situation; and (2) involve reflection and choices dependent upon the current teaching situation.

By conceptualizing teacher practical knowledge on temporal grounds (past experience versus *current* teaching situation—Figure 1), the heuristic caters to "paradigm shifts" in classroom practice (Crocker, 1983; Crocker et al., 1988). For instance, the implementation of an STS science course involves a paradigm shift in classroom practice. Teachers' reflections on practice tend to dichotomize naturally into talking about "past experiences" and "current teaching situations."

Vision of the Ideal

Before a teacher actually reaches a decision for action, the teaching situation and all pertinent solutions are reconsidered in terms of the teacher's vision of what teaching should be like. Such images guide and inspire classroom action, in response to a specific teaching situation (Feiman-Nemser and Floden, 1986; Nespor, 1984). For example, a teacher may hold the image of an emotionally supportive classroom in which students are encouraged to take intellectual risks and to think independently. The images that come into focus depend upon a teacher's feelings, values, needs, beliefs, experiences, theoretical knowledge, and pedagogical knowledge. The vision of the ideal is a mental picture of how the teaching situation *should* be. This image provides the teacher with a framework with which to make the adjustments that align (1) the rules and principles of practice and the teacher's beliefs and values, with (2) the demands of the current situation. Most decisions for action reflect this image. When they do not, painful dilemmas confront the teacher (Olson, 1982). The greater the misalignment, the more painful the dilemma becomes.

Overview

The construct "teacher practical knowledge" represents a holistic, interactive, and organic set of ideas. The solid arrows in Figure 1 should not be interpreted, therefore, as expressing a strictly linear relationship. The arrows simply suggest a pervasive flow of influence among the elements in the heuristic. Each element can modify, and be modified by, other elements. Sometimes a modification occurs in a manner suggested by the flow, for instance, when past experience influences practical principles. Other times the modification occurs in an organically interactive manner not captured by Figure 1, for instance, when past experience is interpreted in terms of practical principles and a vision of teaching.

On the other hand, the broken arrow in Figure 1 represents a key characteristic of teacher decision making. The broken arrow suggests that the current teaching situation interacts with two syntheses of past experience—(1) values, beliefs, and rules of practice; and (2) practical principles—before being evaluated in terms of the teacher's ideal image of what the current teaching situation should be. These images themselves are influenced by a teacher's values, beliefs, rules of practice, and practical principles, as indicated by the heuristic.

Teacher practical knowledge is more fluid and historical than Shulman's (1988) pedagogical knowledge categories, but is more structured than teacher narratives (Connelly and Clandinin, 1985). The heuristic attempts to clarify a researchable functional paradigm (Crocker, 1983; Lantz and Kass, 1987) in a way that encompasses a wide range of elements and processes recently reviewed by Carter (1990). The heuristic is used in the present study as a "clue structure" for analyzing qualitative data, a research process developed by Roberts and Russell (1975).

THE STUDY

The purpose of this study was to examine science teachers' reasons for using or not using certain evaluation practices to assess student knowledge in three areas of STS science: (1) nature of science; (2) science-technology-society interrelationships; and (3) the values that underlie science. These areas were defined by a provincial education department which was field testing a new science curriculum for grade 10 (Hart, 1989). It should be noted that teachers in this study were at the initial stages of implementing this new curriculum. At the time of this study (1990), the new curriculum and its accompanying teaching materials were at a "pilot" stage. The new curriculum would not become mandatory until September 1991. Consequently, the teachers in the study talked about an old curriculum (1980) and a new curriculum (1991). Three new areas are included in this new curriculum: the nature of science, STS interrelationships, and values that underlie science. The results of the study, therefore, have the potential of describing how teachers approach these new ideas found in their new curriculum.

To gain insight into teachers' decision making, this study focused on the evaluation practices of six high school science teachers. Much of the literature indicates that student evaluation is rarely based on the science of measurement (Dorr-Bremme, 1983; McLean, 1985; Wilson, 1989). Teachers become skilled at evaluating students as a result of interacting with students and other teachers (Anderson, 1989; Dorr-Bremme, 1983; Gullickson, 1986; McLean, 1985). Thus, as the literature suggests, teachers select evaluation practices based almost exclusively on their practical knowledge.

The study answered three questions:

1. What evaluation techniques are being used by a representative group of tenth grade science teachers to assess students' knowledge of science?
2. What are the teachers' reasons, within the framework of teacher practical knowledge, for selecting the evaluation practices that they use to evaluate student knowledge?
3. What are the teachers' reasons, within the framework of teacher practical knowledge, for including or excluding evaluation practices that could evaluate student knowledge of the three STS content areas?

Interview data were collected from six urban, male science teachers, all of whom had or were currently teaching grade ten science. These six teachers were all aware of the proposed changes to the grade ten science curriculum. The number six was chosen because (1) it was large enough to yield a reasonably representative group of teachers whose diversity would reflect, but not represent in any generalizable way, grade 10 science teachers; and (2) it was small enough to be a manageable size for a qualitative study.

Two semistructured, 90-minute interviews were conducted with each participant. Guided by the heuristic of teacher practical knowledge (Figure 1), teacher profiles were developed from the information recorded on the interview audio tapes and garnered from the examples of student evaluation that the teachers provided as evidence. Each participant was asked to review his completed profile and to make any changes that would increase its accuracy and anonymity. These profiles were used to analyze each teacher's practical knowledge as reflected in his evaluation practices.

DATA AND INTERPRETATION

The pseudonyms given to the six teachers are Sam, John, Ray, Dale, Jim, and Tom. A summary of their profiles is found in Table 1. While Table 1 does not do justice to the complexity of each teacher's profile, it does give the reader an overview of some of the more salient aspects of the data collected. The profiles are described and interpreted here in a manner that sheds light on the study's three questions. Four teachers (Dale, Jim, Tom, and Ray) did evaluate students in terms of (1) the nature of science; (2) STS interrelationships; and (3) the values that underlie science. Two teachers (Sam and John) did not. The similarities among all six teachers are discussed before analyzing their differences.

All six teachers used a variety of evaluation techniques to assess students' knowledge in science in general, but the two techniques that received the heaviest weighting in the determination of a final mark were tests and lab assignments. These results confirmed the findings of other research studies (Anderson, 1989; Dorr-Bremme, 1983; McLean, 1985; Wilson, 1989). Although some teachers in this study did not rank testing as their most important evaluation tool, all six teachers weighted at least 50% of a student's final mark on test performance. This weighting of tests illustrated that teachers in this study did in fact place a high value on tests as a practical evaluative tool. What varied with each teacher was the knowledge that the tests evaluated. The range of knowledge being evaluated extended from the ability to recall factual information to the ability to solve problems critically.

Both Sam and John used multiple-choice tests to measure students' knowledge of science "facts" found in the curriculum. As John suggested, this type of test allowed him to objectively evaluate students' knowledge of concepts, to check if students are paying attention, and to determine if students can do the required calculations. Ray was attempting to change his testing procedures to allow students greater opportunities for explaining and reasoning. Dale used tests as learning situations that would encourage students to build science constructs. He developed questions that required students to reflect on, and to apply, their own science models. The emphasis of Dale's questions was processing information rather than recalling information. Jim used both individual and group tests. Group tests assessed the more difficult concepts. He used tests to evaluate students' understanding

TABLE 1
Summary of Data

Teacher	Evaluation Techniques	Influences: Past Experiences	Influences: Current Teaching Situation	Science Teaching
Sam	tests, quizzes, lab assignments	student of physical sciences	students, colleagues, textbook, curriculum	teacher presents science facts
John	tests, quizzes, lab assignments, homework	student of physical sciences, father, teacher, colleague	students, curriculum	teacher presents science facts
Ray*	tests, lab assignments, projects, lab skills	new STS courses, CHEM Study, job outside of teaching, colleague	students, course, new STS	problem solving
Dale*	tests, lab assignments, research projects, notebooks	reality therapy	students, new science programs	model building
Jim*	tests, lab assignments, oral reports	communications related job, group dynamics, family	students, new science programs	personal growth and group dynamics
Tom*	tests, lab assignments, reports, oral interviews, checklists	psychology, philosophy, family	students, new science programs	varied learning experiences

*These teachers evaluated the nature of science, the STS interconnections, and the values that underlie science.

of science and their ability to interact with other students when solving problems. Jim suggested that he was attempting to include more oral testing to evaluate students' understanding of science concepts. Tom also used some group testing situations, as well as oral testing situations. For individual tests, Tom evaluated a student's ability to solve problems in a logical manner, and to arrive at conclusions that the student could defend using science concepts.

Lab work was considered to be an important part of science. All six teachers evaluated student lab work, although the focus of what was being evaluated differed from teacher to teacher. Sam focused on the knowledge that students gained from the activity by evaluating their abilities to answer questions based on past lab work. John used lab work to evaluate students' abilities to collect data accurately and to use the data to do numerical calculations. Ray tested lab techniques, accuracy of data collection, and problem solving skills. Dale focused on the students' abilities to build models and to apply these models in new situations. Jim evaluated students' interactions in group activities, while Tom evaluated students' abilities to solve problems.

Although students' daily work played a part in each teacher's evaluation practice, the techniques selected varied from teacher to teacher. Sam evaluated assignments and quizzes to ensure that students were learning the daily work. John assigned marks for homework. He also used quizzes to give students a chance to learn the concepts covered during absences or in homework assignments. Ray assessed lab skills to ensure that students were learning these skills. Dale evaluated student notebooks to encourage students to continuously build and modify their models. Jim and Tom stressed responsibility, but in different ways. Jim accepted no late assignments and Tom had his students record the tasks that each student was responsible for in group activities.

All six teachers suggested that their evaluation practices had evolved as a result of much trial and error. They all expressed the view that they had little academic training that specifically equipped them to evaluate student work. All stated that they were influenced greatly by their own personal experiences of being evaluated as a student or by observing the evaluation of others such as their own children at school.

This *development* of a teacher's understanding of student assessment is illuminated by the differences that existed among the six teachers. Although the evaluation techniques (tests and lab assignments) were relatively common to all six teachers, the content that teachers evaluated differed greatly with each teacher. Differences in content can be explained by differences in teachers' beliefs and values. Ray illustrated the belief of all the teachers in the study when he explained, "Evaluation has to reflect your teaching. This is why what works for me may not work for you." Three of the four teachers (Dale, Jim, and Tom) who addressed the nature of science, STS interrelationships, and the values that underlie science, did so because these aspects of science fit their own personal views of what science is and how it should be taught. The fourth teacher, Ray, included this STS content because it was the current practice of his school. Each of their views is examined in turn.

Dale believed that science is a process of model building to explain reality, and that models change and grow with experience. He described his belief as:

> Meaning comes when the model is there before the formula is. I think science teachers are model builders. . . . (Students need to) get an appreciation for the whole and then the relationships will fall from the whole and then, in the end, maybe we'll write something down. If something has to wait, let the writing wait. Let the model grow.

This belief resulted from his personal interest in reality therapy (Glaser, 1965). He suggested that his experiences in reality therapy had impacted on the adjustments which he made to the traditional science curriculum. He evaluated students' abilities to apply their personal models of reality to solve science problems. Dale adjusted the content of the science courses and his evaluation practices to accommodate his belief that science is a process of model building.

To Jim, science was a social process of learning. He stated, "I spend quite a bit of time not teaching science, but teaching skills, interpersonal skills, discussion skills, those kinds of things." Influenced by his past work experience as a communications consultant, Jim envisioned school science as a vehicle to teach students interpersonal skills. Jim's decision to include the nature of science, STS interrelationships, and the values that underlie science, reflected his belief in the social aspects of learning. He selected evaluation techniques that focused on students' abilities to interact with each other in a supportive environment. Like Dale, Jim found that the traditional curriculum did not lend itself to the type of teaching that he wanted to do. Thus, he chose to alter the content of the curriculum and his evaluation practices so that they were more compatible with his own beliefs, values, and vision of teaching.

Tom believed that science should relate to the natural world. His vision of teaching was to teach the whole child by providing varied learning situations. He stated, "I was frustrated with my teaching in the sense that I didn't believe that I was dealing with the whole child and what I was teaching wasn't being related to the world around them." Tom had found himself in a dilemma. His personal beliefs had been incompatible with the traditional science syllabus he was teaching. When asked about his practical knowledge, Tom suggested that his practical knowledge was influenced by his interest in philosophy and psychology and by his reflection upon the education of his own children. In order to cope with his dilemma, Tom, too, had changed the courses he taught. As a consequence, what he taught and evaluated were more consistent with his belief that students learn science better in a cooperative environment where students are led to discover their own knowledge in a variety of learning situations. He selected a variety of evaluation practices because he believed that different students have different academic strengths. If he was to assess students' knowledge, he thought it was important to provide students with opportunities to display that knowledge in a fashion that allowed the student the most freedom.

Each of the three teachers discussed above (Dale, Jim, and Tom) had found himself in conflict with the traditional philosophy and content of the prescribed (old) science curriculum. The extent of the conflict is illustrated by Tom, who stated that if he had not made the changes he described, he would likely have quit teaching. Because of the conflict, each teacher had modulated both the content of the course and his evaluation practices so that the practices became more compatible with his own personal beliefs, values, and vision. The most recent changes that the teachers made to their course content and evaluation practices were informed by, and therefore consistent with, the new curriculum. All three teachers believed strongly that students should be exposed to the nature of science, STS interrelationships, and the values that underlie science. Consequently, all three incorporated these aspects of the new curriculum into their science program, and all three developed techniques to evaluate students' knowledge in these areas.

Ray, on the other hand, was a teacher in transition. He was introduced to an STS program for the first time that year. Although the decision to teach this program was a school-based decision, he did not experience any conflict between the course's STS emphasis and his personal beliefs. He commented that as he became more familiar with the content of the course, his biggest adjustment was in his evaluation techniques. He stated, "The type of evaluation that you use will depend on the type of material that you are trying to present." He believed that the STS program required more subjective evaluation; that is, students were required to solve problems critically and to justify their answers.

All four teachers (Dale, Jim, Tom, and Ray) recognized the need to change the evaluation practices to fit what they taught. Reflected in their evaluation were the beliefs, values, and personal vision of each teacher. The teachers chose practices that they believed best evaluated what they were teaching. They taught and evaluated aspects of science that they believed to be important.

Two teachers, John and Sam, chose not to teach the nature of science, STS interrelationships, and the values that underlie science. Therefore, they did not evaluate students' knowledge of these areas. Their reasons for this choice were also based on their past experiences, personal beliefs, values, and vision of teaching.

John said that his beliefs about science teaching were partly a result of the influence of his father, a scientist, and his grade 11 teacher who had been a chemical engineer. John taught science with an emphasis on career preparation. Similarly, Sam attributed his beliefs and vision of teaching to his experiences as a student of science. Many of the practices he used to teach and evaluate students were patterned after those experiences. Both Sam and John believed that science knowledge is factual and that it is the teacher's role to transmit the facts to students. As John stated, "We deal with things that are absolute, quantitative, laws, the observable. As a result, that's why we can solve problems." Because John's and Sam's beliefs, values, and visions of teaching science were not in conflict with the content of the traditional science program, they did not feel the need to modulate radically that curriculum (as Dale, Jim and Tom had done).

CONCLUSIONS

The six teachers in the study used tests, lab work, and various forms of assignments to assess students' knowledge of science. Four teachers integrated the nature of science, STS interrelationships, and the values that underlie science into their courses. These four teachers assessed students' abilities to solve problems critically, both independently and in group situations. The four teachers worked toward more subjective types of evaluation in an attempt to understand students' reasoning. Although much of the evaluation relied on pen and pencil techniques (tests, assignments, reports), students were required to solve problems and to provide support for their answers. On the other hand, the two teachers who considered science to be factual relied on more objectively scored evaluation practices that focused on factual knowledge and on questions that had only one correct answer.

The data from this study are in agreement with Briscoe et al. (1990), who found that the assessment practices of teachers are a reflection of their own personal understanding of the assessment process. This present study would add that teachers' understanding of student assessment develops over time from personal experiences such as teaching experience, experiences of personal evaluations, family influences, and interaction with colleagues.

The data also suggest that the six teachers' decisions about student evaluation were influenced by the teachers' personal beliefs and values. These beliefs and values are deeply rooted; for example, Dale's involvement with reality therapy, Jim's earlier job experience in communications, Tom's preoccupation with psychology and philosophy, John's identification with his father's profession, and Sam's indelible experiences as a science student. On the other hand, some teachers, similar to Ray, may not have deeply rooted beliefs and values related to the three topics investigated. Such teachers may be amenable to adopting an STS type of curriculum as long as they are provided with the collegial pressure and the classroom materials as Ray was. The current teaching situation can definitely have an effect on classroom practice.

Studies into science teachers' beliefs about the philosophy of science have also revealed the deep-rooted nature of those beliefs (Gallagher, 1991). The present study suggests new avenues to explore in order to understand these roots better. The more refined the heuristic of teacher practical knowledge (Figure 1), the more powerful it will be at guiding such research.

The results of the present study have implications to employers and teacher educators. When recruiting teachers to instruct new types of science courses (such as STS science), one should consider the candidate's background with respect to his or her nonscience orientation. The science teacher who can most easily adapt to an STS type of course will *not* likely be the teacher who has a narrow orientation toward pure science. In-service programs must provide teachers with a dramatically memorable experience in order for the programs to compete with the deep-rooted, well-established elements of teacher practical knowledge. A dramatic experience may entail a professional development, four-week internship with a "master" teacher (Aikenhead, 1984).

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