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ABSTRACT

This paper reports on a three-year case study of a secondary biology teacher that explores the use of two instruments: The Teachers Pedagogical Philosophy Interview (L. Richardson and P. Simmons, 1994) and the Secondary Science Teacher Analysis Matrix (J. Gallagher and J. Parker, 1995). The a priori research questions that guided this case study pertained to how the instruments stimulate recall of secondary science preservice program experiences and the perceived impact of the use of the instruments on teaching as reported by the teacher and observed in his practice. Results of the study indicate the importance of longitudinal research in studying the impact of science teacher education programs and that universities and colleges should not relinquish responsibility for the professional development of teachers once they graduate from the program. The findings also indicate that the instruments provide a method of helping beginning teachers refocus on research-based instructional methods. Contains 50 references. (DDR)

RUNNING HEAD: Stimulating Professional Development

Stimulating Professional Development Through the Use of Interviews and Observations

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Stimulating Professional Development Through the Use of Interviews and Observations

Teacher preparation programs are often criticized for failing to look beyond the immediate task of preparing teachers. Once these individuals enter the profession few if any attempts are made to seek substantial feedback on their performance which could be used to improve the effectiveness of the program or assist teachers in the transition into the science teaching profession (cf. Anderson & Mitchener, 1994). As a result, preservice programs have been accused of being stagnant, ineffective, and unresponsive to the changing needs of future educators (Schnur & Golby, 1995; Kennedy, 1990). It is apparent that there is a need for additional research projects in the area of preservice teacher education and its translation into the praxis of beginning teachers (Anderson & Mitchener, 1994; Zeichner, Tabachnick, & Densmore, 1987). In response to the perceived failures of science education two projects were initiated that have the potential to significantly impact science teacher development and the teaching and learning of science: AAAS's Project 2061 which produced *Benchmarks for Science Literacy [Benchmarks]* (Project 2061, AAAS, 1993), and the National Academy of Sciences' NRC effort to establish standards for science education which produced the *National Science Education Standards [Standards]*(1996). Both of these efforts advocate reform in teaching science by the establishment of minimal process skills and content knowledge to be achieved by all students through use of student-centered methods of instruction such as collaborative groups and hands-on use of manipulatives. Further, both efforts assume that K-12 teachers will adapt their teaching style to achieve these goals; the *Standards* go so far as to lay out the nature and type of professional development activities that preservice and inservice K-12 teachers must experience to achieve the criterion these efforts have established for teaching and learning. However there is scant research on secondary science teacher development showing how and which university preservice program experiences translate into the praxis of beginning secondary science teachers, and that which has been done has neglected the long-term impact of the preservice program on a science teacher's professional development (Loughran, 1992, 1994; Cunliffe, 1994; Adams & Krockover, 1997a; Adams, 1996). Without this specific foundational knowledge these reform efforts probably will fail, as many have in the past (Klopfer & Champagne, 1990).

Another aspect of this situation is related to the socialization of teachers when they enter the teaching field. Zeichner and Tabachnick (1981) have expressed the opinion that the effects of the teacher preparation experience are often lost during the first year of teaching as teachers are socialized into their classroom environment. It is more likely that teachers adopt a survival mode and regress to teacher-centered styles of teaching, rather than the student-centered styles currently advocated by most science teacher preparation programs (cf. Fessler & Christensen, 1992, Fuller, 1969, Adams, 1996). Leib, quoted in Gold (1996) has noted that much of what teachers have learned disappears when they enter the classroom. Further, teachers appear to be "imprinted" by their first year experiences, which in turn influences future behavior (Gold, 1996). Given these observations, and the push for reforms in science teaching and learning, such as those advocated by the *Benchmarks* and *Standards*, it is apparent that there is a "need for data regarding effectiveness of different types and sources of support for new teachers" (Gold, 1996, p.560). Without a means of translating aspects of the preservice program into teacher praxis we may very well be doomed to maintenance of the status quo, and will fail in the reform of science teaching and learning. This research project is one study to address this critical issue.

Objectives

Two instruments were used as part of a national research study, Salish I Research Project[1], on the linkages of perservice program experiences in the secondary science program and the impact of these experiences over the first three years of their career (Yager, 1993). It became evident, during the course of the study, that two of the instruments being used, *The Teachers Pedagogical Philosophy Interview (TPPI)*[2] (Richardson & Simmons, 1994) and the *Secondary Science Teacher Analysis Matrix (SSTAM)*[3] (Gallagher

& Parker, 1995) a constructivist-based observation rubric, were not only providing information necessary to the study but also appeared to stimulate the professional development of teachers during the critical early years of their profession (cf., Adams, 1996, Fessler & Christensen, 1992; Kagan, 1992). This observation merited further investigation and provided the basis for this three-year case study of a secondary biology teacher identified as Bill. The *a priori* research questions which guided this case study were:

1. In what manner does the use of these instruments stimulate recall of secondary science preservice program experiences?
2. What was the perceived impact of the use of the TPPI and SSTAM on Bill's teaching as reported by Bill and observed in practice?

Theoretical Perspective

To place this study in context a theory of how experiences might be integrated into cognitive structure is needed. Kelly's personal construct theory (Kelly, 1955) provides a model for cognitive development.

Constructive Alternativism

Kelly's theory arises from the philosophy of constructive alternativism (Kelly, 1955). Constructive alternativism maintains that there is an objective reality that "man is gradually coming to understand" and that "the correspondence between what people really think exists and what really does exist is a continually changing one" (Kelly, 1955, p. 6). The universe is integral, in that "it functions as a single unit with all its imaginable parts having an exact relationship with each other" (Kelly, 1955, p. 6). Finally, the universe is continually changing with respect to itself. These three beliefs, an objective reality, an integrated universe, and a continually changing universe, define the framework of the philosophy.

Personal Construct Theory

Kelly used the constructive alternativism philosophy to develop personal construct theory. The fundamental postulate of this theory is: "A person's processes are psychologically channelized by the ways in which he anticipates events" (Kelly, 1955, p. 46). This can be interpreted as: "A person lives his life by reaching out for what comes next and the only channels he has for reaching are the personal constructions he is able to place upon what may actually be happening" (p. 228). Constructs are the reference axes that individuals use to place events into perspective. Constructs are defined by the interweaving of the past, present, and future; events give definition to constructs and constructs give meaning to events. The implication is that reflection on an experience, which in essence is anticipating the event, can result in a reconstruing of a construct. Kelly's (1955) theory is a useful framework for understanding the development of cognitive structure in preservice and inservice teachers, and provides a necessary framework for interpreting the role of the TPPI and SSTAM as potential devices to stimulate recall of secondary science preservice program experiences and subsequent reconstruing of a teacher's concepts of teaching.

The Validity of Recalled Memories

A question that naturally arises from this conjecture, that recall of memories of the preservice experience can stimulate teachers to reconstrue their constructs of teaching, is the validity the teachers' memories. According to Ben-Peretz (1995), "everyday events and incidents become part of our memory and can determine to a large extent our behavior in diverse situations" (p. 7). The research literature on memories identifies two major types of memory: semantic and episodic. Episodic memory "consists of personal experiences stored as information about episodes or events," while semantic memory "consists of general knowledge about the world that is organized into schemes or categories and is context-free; its retrieval does not usually involve the experience of remembering" (Ben-Peretz, 1995, p. 8). Cohen (1989) states that these "two forms of knowledge are not separate compartmentalized structures but are in an interactive and interdependent relationship" (1989, p. 114-115) where semantic knowledge is derived from episodic memory through abstraction and generalization. This perspective agrees with that of Carter and Doyle (1987) who state:

> A central premise of cognitive science is that comprehension is a constructive process . . . . Meaning does not result from the reception or rehearsal of information. Rather understanding involves an active construction of a cognitive representation of events or concepts and their relationships in a specific context. (p. 149)

Cohen (1989) provides insight as to the ability of individuals to recall events involved in the construction of memory. According to Cohen (1989), "particular episodes that are sufficiently distinctive, novel, deviant, or recent are not absorbed into generalised representations but are represented at the most specific level where they can be identified by specific tags" (p. 128). This suggests that experiences that precipitate or change an individual's cognitive structure will not be lost in semantic memory but will be able to be recalled. Ben-Peretz (1995) reported in her study of retired Israeli school teachers, that their memories of seminal events in their careers had ecological validity. Ecological validity means, 'Did the recalled context of the memory concur with the historical record?'. Ben-Peretz found that the teachers' memories did reflect "real and significant events" (p. 16).

Methodology

Constructive alternativism and the personal construct theory offer "a theoretical framework which is potentially applicable to many teaching and learning issues, and therefore, [will begin] to have increasing influence in science education" (Bezzi, 1996, p. 181). This paradigm also has clear indications as to appropriate choice of methodology. According to Guba & Lincoln (1994) the "variable and personal (intramental) nature of social constructions suggests that individual constructions can be elicited and refined only through interaction between and among investigator and respondents" (p. 111). Within this theoretical paradigm, the researcher must "watch, listen, ask, record, and examine" (Schwandt, p. 119); that is qualitative methods should be employed.

Methodological Perspective

Associated with the decision of methodology is the choice of an interpretive style (cf. Guba & Lincoln, 1994; Denzin & Lincoln, 1994; Denzin, 1994). An appropriate interpretive style for this study is inductive analysis. According to Patton (1990) inductive analysis means that "the patterns, themes, and categories of analysis come from the data; they emerge out of the data rather than being imposed on them prior to data collection and analysis" (p. 390). Further, the "inductive search for patterns is guided by the . . . questions identified at the beginning of the study and focuses on how the findings are intended to be used" (p. 405).

Research Strategy

One strategy that is appropriate for use with the theoretical paradigm is the interpretive case study method, a strategy which relies on "interviewing, observing, and document analysis" (Denzin & Lincoln, 1994, p. 14). According to Anderson and Mitchener (1994) case studies provide a "deeper understanding of science teachers and their development" (p. 28). The study reported here is a case study (Stake, 1994, p. 237) of Bill a secondary biology teacher at a rural/suburban high school in the midwest; he graduated from Glass University (GU), a pseudonym for a midwest land-grant university.

Program Setting

The participant in this study graduated from Glass University (a pseudonym), a land-grant university located near a midwestern city which has both an industrial and agricultural economic base. Graduates who receive certification in secondary science and mathematics teaching must complete a degree in their subject area (i.e., biology) that is not quantitatively or qualitatively different from that of any other science or mathematics major at the university. There are typically 50 secondary science and mathematics teachers graduating per year (half of these are mathematics graduates, the remaining half are from the science disciplines). In addition to the requisite subject-matter coursework, these graduates must also take appropriate pedagogy courses leading to certification in science or mathematics for grades 5-12. Typically this coursework consists of an introduction to secondary education, content area reading, subject-matter specific methods course (e.g., The Teaching of Earth/Physical Science in the Secondary Schools, The Teaching of Biology in Secondary Schools), an educational foundations course, an educational psychology course, an adolescent psychology course, a social implications of science course for science majors or a problem-solving course for mathematics majors, and supervised teaching.

The preservice teachers typically receive 20-40 hours of field experiences through their coursework prior to their ten-week student teaching experience. The first field experience occurs during the sophomore year and is focused on becoming aware of the public school environment. The second field experience occurs in the junior year during the methods course. The focus of this experience is on observing and practicing some of the methods and that have been illustrated in class. The experience can either be in a public school or through any other relevant teaching experience (e.g., coaching, teaching at a reading academy, undergraduate teaching assistantship). The ten-week student teaching experience is done under the supervision of a cooperating teacher and a university supervisor.

Teacher Participant

The participant for the case study was purposefully selected (Patton, 1990). Stake (1994) has noted that the "cases that seem to offer the opportunity to learn [the most]" (p. 243) should be utilized. The teacher participant, identified by the pseudonym Bill, was selected because he offered contrasting experiences and perceptions. These contrasts provided disconfirming evidence against which to limit, modify, or reject the assertions that arose out of the data analysis and thereby help establish trustworthiness and confirmability (Guba & Lincoln, 1994).

Bill, a biology teacher at a county high school in a suburban setting located near a small midwestern city, was in his third year of teaching at the conclusion of the study . Bill participated in a pilot study at the end of his first year of teaching designed to investigate the perceptions of beginning teachers in relation to their program experiences (Adams & Krockover, 1997a). Bill was strongly of the opinion that his content courses were not broad enough for teaching high school science. Bill also was confronted, during his first year of teaching, with the task of developing the curriculum for the state-mandated biology technical preparation course.

Bill's first year of teaching was a stressful event. He indicated:

> I was hired the day before school started . . . on a Thursday night about 6:00 p.m., and showed up the next morning at 8 a.m. I was living in Chattanooga, TN at the time.

His teaching assignment during his first year consisted of biotechnology, a course implemented for the first time that year, and freshman biology, along with coaching responsibilities.

The motivation to select Bill for this study was that his teaching style dramatically changed as determined by the SSTAM observation rubric (Gallagher & Parker, 1995). During Bill's first two years of teaching he was classified as a *didactic/transitional teacher*; at the beginning of his third year of teaching he had shifted to a *conceptual/transitional teacher*. A *constructivist teacher*, per the SSTAM scale, is one who exhibits actions such as: (a) negotiation of understanding of key ideas with students; (b) student-generated investigations; (c) leading students to reconstruct how evidence has been used to formulate scientific ideas; (d) utilization of student-centered methods such as group work, concept mapping, and writing to represent ideas; and (e) use of multiple forms of assessment that integrate with instruction. A *conceptual/transitional teacher*, per the SSTAM scale, is one who exhibits actions such as: (a) predominant use of teacher-centered methods of teaching; (b) cookbook investigations where the answer is already known; (c) instruction that seeks to correct unscientific ideas without consideration of students' prior knowledge; (d) writing to reconfigure information provided; and (e) limited use of alternative assessments. A *didactic/transitional teacher* is one who exhibits such actions as: (a) emphasis on factual information; (b) incorporation of real world examples without integration into other content components; (c) demonstrations or laboratories that are overly directed; (d) teachers questions call for factual recall; (e) short answers predominate over written explanations.

Methods of Inquiry

Data was collected in relation to the case over the period from January, 1994 to May, 1996. These consisted of formal interviews (such as the TPPI) (8 hours total) , informal interviews following classroom observations (24 hours total), direct classroom observations (50 hours total), video taped observations (15 hours total) assessed using SSTAM, and document analysis of classroom handouts. The focus of the informal interviews was to ascertain the Bill's motivation for his classroom praxis. In June of 1995, Bill was provided with a copy of the SSTAM observation rubric to triangulate the researchers' perception of the classroom with his perception; he was also asked to project his preferred teaching style.

Researcher Role

My goal as a researcher was guided by personal construct theory in that I was striving to anticipate the participant's actions. As Kelly (1955) explains:

> The clinician [researcher] should establish for himself a true role relationship to his client....It is not enough that the clinician [researcher] be able to think *about* [italics in the original] the client's [participant's] actions or even at times *think* [italics in the original]; he must be able to *subsume* [italics in the original] the client's [participant's] thoughts. (p. 764)

To achieve this goal I assumed the role of participant observer (Denzin cited in Patton, 1990).

Data Analysis

Methods of single case analytic induction (Patton, 1990) were used to analyze the data. Verbatim transcriptions were completed for all interviews. The observation field notes, SSTAM analysis, and salient constructs in the data were recorded with memos which then became part of the case record. The study progressed through two stages of data analysis.

The first stage involved the daily inductive analysis of simultaneous observation, initial coding of data, interpretation of data, memo writing, and generation of post-observation interview questions. The second stage of data analysis consisted of detailed coding to triangulate and seek disconfirming evidence, and reduction of the codes into themes and patterns representative of the codings. Memos were used extensively at this stage in anticipation of collapsing the discrete data codings into encompassing themes. After this, the case study was written using analytic narrative vignettes to support the empirical assertions (Gallagher & Tobin, 1991; Erickson, 1986).

Findings

Bill was observed to have dramatically changed his teaching style from that of a didactic teacher to one more focused on conceptual development in the Fall of 1995. When asked about this change, Bill credited SSTAM for providing him with a picture of how he wanted to see himself as a teacher. In essence SSTAM became a heuristic device for guiding him in his development as a teacher. As Bill was observed in his class, changes in his teaching style were further examined (Adams, 1996). Through the informal and formal interviews it became evident that Bill was drawing on his preservice program experiences to fulfill his vision of the classroom he had created through his personal use of SSTAM and interviews done with the TPPI. Thus it appears that these two instruments stimulated Bill's professional development by having him recall his program experiences.

Based on the framework of Kelly's personal construct theory it would appear that this stimulated recall prompted Bill to reconstrue his conceptions of teaching and learning. Viewed from this framework Bill was channelized into the most familiar teaching method (e.g., didactic) due to the stresses experienced in his first year. It was not until his third year of teaching that he was ready to consider other options for teaching. SSTAM and TPPI provided a mechanism to recall the student-centered teaching strategies advocated by his program by their fortuitous use at a critical juncture in the career cycle of Bill (Fessler & Christensen, 1992). The remainder of this section will focus on the impact of SSTAM with a cursory summary of the perceived impact of the TPPI.

Teaching Vignettes

To better characterize the teaching style of Bill, two vignettes will be described. The first was video taped and observed in May 1995, the second in the Fall of 1995.

The first teaching sequence occurred at the end of Bill's second year of teaching during his six-week project unit in freshman biology. The lesson was adapted from his high school teacher. The opening scene showed the students involved with various projects. Some were dissecting a frog in order to identify its internal organs. Others were working with the human internal organ model in order to learn its parts, watching a slide show to learn how to identify the birds of the state, or looking through books about dinosaurs to answer specific questions. All told, there were ten different projects that the students were to complete. During the three days of this sequence students were seen completing projects and moving on to other projects. The endpoint of different projects varied. For some it was a project, such as a notebook with pictures and classification of animals. For the starfish project, it was identification of the internal organs of a dissected starfish. The students would go to Bill, who was generally sitting at his desk during these sessions, and ask to be quizzed. The pace of the class and sequence of events was very much controlled by the students. Bill, if asked, would come and help students, especially with dissections. He took one day to lead students through the dissection of a frog.

This sequence is difficult to classify. Part of this difficulty stems from Bill's goals for the unit which are to: (1) teach time management, (2) teach responsibility, and (3) learn how to identify items related to biology. As measured against these goals the structure of his lesson was successful; however, it does not align well with current reforms in science education, or the goals of his preservice science education program (Adams & Krockover, 1997b). When observed through the filter of SSTAM, even though his methods tended towards conceptual learning, his emphasize on content and interaction with students was clearly didactic. The two prior observations, one from late in his first year of teaching the other early in his second year of teaching, were classified in the same manner.

The observation made during his third year of teaching, in the Fall of 1995, showed a dramatic change in his teaching style. Instead of being classified somewhere between didactic and transitional, Bill had changed his style to somewhere between conceptual and transitional. The three-day sequence follows.

Bill started the biotechnology class by asking the 25 students to take out a piece of paper. He then reviewed laboratory techniques related to the study of bacteria. He pointed out that they have yet to really talk about what bacteria are.

> B: We are yet to find out anything about bacteria itself. That's the plan for the next couple of days. I'm going to try something new. What this actually requires from you is to actually use your brain. Put forth a little effort. . . . There are going to be three stages related to this activity . . . . The first stage, you are going to answer three questions, with no knowledge or what knowledge you have right now. The second stage, you are going to take the microscope and three slides and go look at bacteria. The third stage you will go back to your seat and answer five questions using the information you just gained by looking through the microscope, I'll also have the TV on to help you out [it is connected to a video microscope camera], using that information that you just gained on your own to hopefully help you answer the questions when you are a little more informed. Then tomorrow be prepared because I'm going to talk the whole hour. We'll discuss these. Right now, what I need for you to do, using your best imagination possible, I want you to answer the three questions on the board as best as possible. Using the best brain power you have. Think about it a little bit, don't just write yes or I don't know. Put a little effort into it.
>
> S1: Can I draw pictures?
>
> B: However you want to answer it you are totally on your own. Just do it by yourself.

The three questions were: (a) What shape is bacteria?; (b) What color is bacteria? What causes the color?; and (c) What do you see inside the bacteria? What might this be used for? The two post laboratory questions were: (d) Can you see anything which indicates how bacteria move? Explain.; (e) Explain why the bacteria on the petri plates looks the way it does when a single bacteria looks like it does.

The students were then given time to respond to the questions. As the students finished Bill passed out prepared slides to lab partners. The bacteria on the three slides were, respectively, bacillus, salmonella, and staphylococcus. He directed them to observe under all three powers of magnification. He instructed the students to look at all three slides, then, after this, go back to their seats and answer questions four and five. With this charge the students went to the microscopes. Bill set up the video microscope at the front of the room. After that he circulated among the students to determine what they had observed. Some of the students had difficulty using the microscopes; Bill determined that either they had not used a microscope before or they had forgotten how to use it. He provided separate instruction as needed. As the students finished up, he monitored student progress and explained the procedure to those who asked.

One student inquired about shape. Bill provided an example of why a cylindrical shape may be more beneficial in some cases than a spherical shape. As he explained (using arm motions):

> B: In order for bacteria to get food in and out, it has to pass through its skin right?
>
> S2: It doesn't have skin.
>
> B: Well we'll call it a cell membrane that it has to pass through. So if there was something this big around [shapes arms in a large circle and points with one finger to the center of the circle] something in the middle would be a long way from the outside. So it would be difficult to get stuff from over here to over here. But if it were this shape [moves arms into long oval], its still

the same amount of stuff inside, but here [the center] is not very far from the end. So its easier to get stuff in and out with, so that's why

S2: Do the bacteria eat?
B: Not eating as you think of it; they only need certain nutrients.
S2: So what should I put down.
B: Whatever you want, there really is not a wrong answer as long as you put forth effort.

Bill continued to assist students as needed. One student claimed that the bacteria looked like cotton fiber. Bill said that they could check it out on the video microscope. He prepared this for the class to examine on the monitor. They did and it answered the student's question. Bill said "It don't look like a cotton fiber to me!" The students then continued to answer their questions. He further elaborated on the fifth question by showing them one of their petri dishes that the students had previously streaked. The papers were collected at the end of class.

The second day of the sequence began with a review of what had been going on the last two weeks. He pointed out that the course had emphasized laboratory technique for working with bacteria. Yesterday was the first day that they had the opportunity to look at bacteria. Today is going to be an informational session on bacteria. What is bacteria? What makes it up? Structures, food, etc. He first introduces shapes. He asks students to describe what they saw in lab yesterday. He keeps asking students questions until he can pull out the features he wants. He did not reject any answers, rather he had students expand on what they said. As he gathered and expanded on the information from the students he entered it into a table he had drawn on the board to help students organize their notes. He elaborated on students answers and used analogies. He maintained rapport with students through questioning, albeit low level questioning. He then told students that on a test they would have to remember the types and shapes of bacteria and those that live in colonies and as single cells. He in essence is providing the outline of what will be on the test.

Bill worked with the students to develop a sense of size develop a sense of relative size of bacteria. As he said:

B: Protozoan are up here [draws line at the top of chalkboard], and bacteria is smaller [a line just below the previous one]. Now a virus. Is a virus, like AIDS and Ebola and all the others you hear about on TV. Does it fit, up here, between here or is it even smaller yet than bacteria.
S5: Smaller.
B: It is smaller so its going to go down here. So we've got protozoan, bacteria in the middle, and a virus. So bacteria, it is somewhere along the line of .1 micron to 100 microns. A micron is 10^{-6} m. 10^{-6} m doesn't mean anything to me. 10^{-3} m is a mm, that means there are 1000 mm in a m. About this long for a 1000 mm. Here there's going to be a million microns in 1 meter. Here is a little tool that they use in a lot of machine shops
S5: A caliper
B: To judge the preciseness of parts they are making like an engine and stuff. If the parts aren't right the engines won't run. This little tool is called a micrometer, looks like a little C-clamp, little fancier. This measures in microns. If we take a piece of paper and we put it in our micrometer here and we measure it...I come out to...all right. [he does not tell students the answer]. How many bacteria will fit laid end-to-end across this piece of paper [edge of paper]. What do you think?
S4: 1000
S5: 1000
S3: 100, 000
S6: 700,000
S7: 1,000,000

B: Any other guesses? We are laying them end to end, like stacking school buses, how many do you think?
S8: 30,000,000
B: That paper is about 100 microns thick. A 100 microns thick, and we have a bacteria that is 0.1 microns across, you're going to be able to stack a 1000 bacteria end-to-end across that piece of paper [worked out math on board]. So on that piece of paper you can put 1000 bacteria end-to-end. So on a test when you are asked for the size of a bacteria you'll have to come up with something between 0.1 and 500 microns. Small won't work.

He then changed topics to energy sources. He posed a question of how do bacteria get their food and then answered that there are three ways. He wrote heterotroph on the board. He then tried to see if any students knew this term. They did not so he proceeded to write down the definition and expand on what each part means. He did this by trying to have students relate the bacteria actions to ways that humans gather food. For example he suggested they recall what they learned in health class. He then introduced phototroph. Again he tried to draw from students what this definition was; he was successful in doing so. He did the same type of questioning cycle as before. The third term was chemotroph.

Bill then entered the third column (bacteria, energy, air) and introduced the terms of aerobic and anaerobic. He stated that the chart was all fair game for the test. He then indicated that it was time to switch gears and began discussion about the structure of bacteria.

He started this discussion with a drawing of a bacteria and its structures. Students were asked to identify each of the structures by term and function:

B: Cell membrane. Any ideas?
S: Is it like a cover or something
B: No
S2: It allows stuff to go in and out
B: It allows stuff to go in and out, all right. It controls what goes in and out of the cell. Controls what comes in and goes out. So all the food and nutrients and stuff like that that comes in, the cell membrane controls that. All the waste and stuff like that the cell membrane controls that. All right, I like to think of this as the policeman at the jail. They let some people come in the jail, and they don't let every body out. Like it holds in the organelles and stuff like that in, it doesn't let virus and other bacteria in to like kill it.

To finish the discussion, Bill asked students to recall their prior knowledge about protozoans and flagella. He related that in bacteria the flagella point in several directions and stick-out all over; they move the cell . He provided an analogy of how you might get to a pizza if you could not see. You would use your sense of smell to keep changing directions to get to the pizza; the path is erratic. He stated that bacteria will do something similar to locate its food. The sensors inside the body will guide it on its way. He finished the day by outlining the next class dealing with Gram stains.

The third day began with the students taking a series of notes that dealt with the procedure for the day's laboratory. He first reviewed the basics of the five questions laboratory, and the lecture on size, energy, and structure. Today's goal is to learn how to take bacteria and prepare it for observing. He pointed out that the color on the first day of the sequence was due to a dye, the Gram stain. He then proceeded to give a bit of history of the Gram stain, he indicated that he usually does not do this but he decided to do so today. He shared that the purpose for using stains with bacteria is to determine type of material used in the cell wall. He related the use of these stains by doctors to determine choice of antibiotics and cell identification. He then introduced saffron and iodine.

The next step was a demonstration of how to do step-by-step Gram stains. He worked with the students to develop the list of steps necessary to produce a slide to observe the bacteria; the list was developed in part from their previous work with bacteria in making streak plates. He then divided the students into groups of four to begin the laboratory. The students were told to write up a laboratory report as the outcome of the laboratory.

As students produced and looked at their slides, Bill helped them observe and checked the quality of their work. Some groups were sent back to produce a new slide. He dealt with student questions by asking them to check their observations again. The goal of the lab was to identify what color, what shape, and if the bacteria is Gram positive or Gram negative. For example:

S8: How am I to get the shape.
B: Did you look at it under the microscope?
S8 No.
B: So look at that first and then try to answer the questions.

He placed a great deal of emphasis on students making and interpreting their observations.

It appears that we have two very contradictory examples between the two video sequences. Bill's presentation style during his first two years of teaching tended to be very didactic. He acknowledged that his primary teaching strategy, where students work on projects that only require factual knowledge and not understanding, was adopted from his high school teacher:

> My high school biology teacher actually is where I get a lot of my ideas [for teaching]. That's the reason why I'm a biology teacher and actually there's another teacher right across the hall that had him as a student teacher and we both use some of the same ideas that we got from him.

Thus, in his first two years of teaching Bill based his style on his observations of his high school teacher.

SSTAM: An Instrument with the Potential for Change

Assertion 1: SSTAM provides a heuristic for teachers to reconstrue their teaching style.

When asked about his approaches on the first day of the third year sequence he indicated that it came from his reading of SSTAM. Bill was provided with a copy of SSTAM in the August prior to his third year as part of the Salish I Research Project efforts at Glass University. This was done to compare Bill's perceptions of his teaching against ours. However in September, we found that the instrument had an impact on Bill's teaching style, as the following conversation illustrates:

I: What motivated you to teach the laboratory like you did today?
Bill: SSTAM. SSTAM motivated me.
I: Gee!
Bill: I got to looking [at SSTAM] and I wish I had this style [points to the *experienced constructivist* category]. It seems like what [students need], learning on their own an not just me filling it out. Student with teacher's guidance where you construct how evidence are used to formulate scientific ideas and stuff like that. So you know they're guided using their own stuff. I bet [I] guide them where I wanted them to go with the questions, you know. I wanted [students] to know, to learn, to see how bacteria's small.

This is quite different than Bill's perspective on his project work. His concern here is not learning facts, but rather building concepts. His indication is that SSTAM provided the impetus to reconstrue his constructs for teaching and learning. He also is guided in this motivation by his beliefs about what students need:

> **Bill:** Of the 6 categories [6 classifications of SSTAM], I would like to see myself develop into an experienced constructivist. This category allows for both learning through investigation and learning through memorization. This type of instruction is similar to what students will receive in college with a mixture of lab and lecture classes.

Assertion 2: SSTAM stimulates recall of program experiences to aid in the reconstruing of teaching style.

The question that remains is the manner in which SSTAM caused Bill to reconstrue his understanding and actions for teaching and learning. When probed about his choice of classroom actions he indicated:

> **Bill:** I had never tried it before and actually I just came up with it. I had a list of where I wanted to go and that was a question I posed at the top of my list, what does a bacteria look like? I thought about it and then the question got me thinking again and last night I kind of formulated my plan of attack on the way home from work.
>
> **I:** Did you do any of this style of teaching in your methods class?
>
> **Bill:** I do remember some of this stuff [use of pre-laboratory assessment]. I don't remember what any of them [were called], but I remember talking about this. Probably some to this stuff that I'm making reference to. Unfortunately, I didn't pay attention to this stuff and truthfully I'm not sure that its important when you start out.

The interpretation of this is that Bill is recalling some of his program experiences, albeit the recall is weak. This may be in part to the fact that it had been four years since Bill had taken his methods courses. There is a connection to SSTAM in that it motivated Bill to reconstrue his teaching, and thus consider classroom actions. This process, when viewed through the lens of Kelly's theory of personal constructs (Kelly, 1955), is indicative of recalling earlier experiences that align with the desired action. In this instance, it was pulling up his recollection of techniques used in his methods courses. The memories appear not to be major episodic events, since it is apparent that he does not have clarity of his ideas. None-the-less, it appears that SSTAM has helped Bill reconstrue his teaching.

Assertion 3: There is a time critical component with the use of devices such as SSTAM.

Despite the indicators that SSTAM can be useful in helping teachers reconstrue their thinking about teaching, it may not be effective until teachers move pass their beginning teaching concerns (cf. Fuller, 1969; Fessler & Christensen, 1992; Sprinthall, Reiman, Thies-Sprinthall, 1996). Bill also provided insight related to this assertion:

> **Bill:** Starting out its going to be hard to [teach in a student-centered style]. See, your first year of teaching, teaching is easy. It is all the other [job responsibilities] that is hard. But for the first year teacher to try to [do these type of activities] can hardly be done. I wasn't coming up with ideas like this because I was to busy trying to figure out where I could take this slip to the dean's office, how to do attendance, and [how to] get down to the gymnasium without getting lost. But now that I've got a couple of years of experience I enjoy doing this. . . to try and do an activity that might fit into this category [points to *experienced constructivist* on the SSTAM scale] and see how it goes. I can see that, my first year definitely, I was didactic and gave lectures with just content and facts. But now, as you learn about how to manage your classrooms and how to improve your teaching; you first have to learn how to manage your classroom. I was ready to roll this year [his third year of teaching].

Thus it appears that Bill received SSTAM at the juncture in his career when he was ready to begin improving his teaching. SSTAM provided a heuristic that Bill could follow to alter his teaching style into one that is focused on students. It is not clear what would have happened had Bill not had access to SSTAM. It is possible that he could have developed more student-centered teaching of his own volition. However, SSTAM provided a model from which he could contemplate instruction and stimulate recall. It is possible, had he access to this earlier, that he would have begun altering his teaching style earlier as he learned to manage the classroom. This merits further consideration as SSTAM may provide a mechanism to retain the effect of the preservice science teacher program even during the first year.

The TPPI: A Method for Promoting Reflection

The TPPI provided a means for Bill to examine his current practice and place his preservice program into perspective. The impact of the TPPI was more subtle and lead to many 'ah-ha' experiences when Bill realized that some of his teaching strategies were a result of his program experiences. The greatest impact of the TPPI, as indicated by Bill and several other teachers involved in the Salish I Research Project at Glass University, was that it caused them to examine and reflect on their praxis. Indications from other research projects indicate that reflection promotes individual professional development (Sprinthall, Reiman, Thies-Sprinthall, 1996). The impact, indicated by Bill and others, is that the TPPI caused them to ask themselves why they do what they do.

Implications

This study indicates the importance of longitudinal research in studying the impact of science teacher education programs, as the impact of the program may not be evident until 2 or 3 years after the experience, as appears to be the case with Bill. Further, the study indicates that the universities and colleges should not relinquish responsibility for the professional development of teachers once they graduate from the program. Use of devices such as SSTAM and the TPPI provide a method of helping beginning teachers re-focus their conceptions of teaching and learning along the lines of effective research-based teaching strategies, rather than allowing them to be channelized into more traditional didactic methods of teaching (cf. Zeichner, & Gore, 1990; Zeichner, & Tabachnick, 1981). The investment in time and resources is minimal when compared to the potential impact such university follow-up can have on the professional development of beginning science teachers at a time when they are most amicable to change.

The other significant aspect of SSTAM is that it provides a means for science teachers to meet many of the goals for teachers established by the *National Science Education Standards* related to professional development. SSTAM provides a mechanism to conduct self assessment as well as a heuristic to guide the teacher into the student-centered styles of teaching advocated by the *Standards*. This device can help fill the void of appropriate developmental materials that are needed to achieve the vision of the Standards. Krockover (Personal Communication, March 6, 1997) has made use of SSTAM with inservice science teachers and student teachers in the sciences. He reports that the devices have help these individuals improve their teaching.

Clearly there is a need for further investigation of the use of SSTAM and the TPPI as devices for professional development of science teachers. A systematic study with greater control is needed to support or refute the exploratory findings reported in this paper. The investigation is warranted, as the potential to provide teachers with a device to monitor and alter their teaching style to achieve the vision of the *Standards* will have a long and significant impact on science education.

Footnotes

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[2]*The Teachers' Pedagogical Philosophy Interview* (TPPI) (Richardson & Simmons, 1994), is a 44-question interview developed by Richardson and Simmons (1994) to investigate the role of values and beliefs in guiding teacher actions. The consensus of the nine institutions in the Salish I Research Project[1], after initial field testing of the protocol, was that the TPPI elicits meaningful data in relation to teacher beliefs, knowledge, and philosophy about science teaching. The interview questions were designed to obtain data relevant to nine categories: self as teacher, teaching and learning, good learner vs. intelligent person, knowledge, educational environment, facts and values, curriculum, teacher's content area, undergraduate education, big picture, and constraints. Thus responses in these categories were useful for addressing the research questions in this study, and therefore form part of the case record (Patton, 1990). To facilitate cross-site comparisons a standardized coding scheme was developed through inductive analysis (Patton, 1990) by the participants in the Salish I Research Project. The average inter-site-reliability (Miles & Huberman, 1994) between two coders at GU, on two different training sets of codes (one was four questions, eight interviews, the other six questions, four interviews) was $r = 0.81$. For purposes of examining tendencies of a group, Lauer and Asher (1988, p. 139) indicate that an $r = 0.70$ or higher is sufficient. It should be further noted that the two raters at GU discussed their separate codings in order to achieve consensus or agreed to the generation of a new code as needed. Check-coding reliability (Miles & Huberman, 1994, p. 64) with a time delay of one week was $r = 0.84$.

[3]The *Secondary Science Teacher Analysis Matrix* (SSTAM) (Gallagher & Parker, 1995) is an observation rubric to classify teacher's and students' actions in relation to content, teacher's actions and assessment, students' actions, resources, environment, teacher reflection, and classroom management. SSTAM assists researchers in assigning a teacher to one of six teaching styles: didactic, transitional, conceptual, early constructivist, experienced constructivist, and constructivist inquiry in each of 22 dimensions that are subdivided into the categories previously identified. The rubric for each teaching style in each of the dimensions is empirically based, deriving the divisions from the research literature on classroom interactions between teachers and students, teacher knowledge and beliefs and their impact on teacher, constructivist learning, and the personal experiences of the developers (J. J. Gallagher, personal communication, May 20, 1995); the research teams at each site in the Salish I Research Project[1] have concurred with the structure and content of the SSTAM rubric, thereby indicating content validity. Inter-site-rater reliability (Miles and Huberman ,1994), on four training video tapes was $r = 0.83$ using the two coders at the research site. Check-coding reliability (Miles & Huberman, 1994, p. 64) with a time delay of six weeks was $r = 0.86$. These values are significantly greater than per chance; there are six choices for each of the 22 dimensions. This indicates, then, that "more than one observer agrees that the perceived phenomena does exist" (Lauer & Asher, 1988, p. 138), supporting the reliability of this instrument.

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