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Conceptual Change Approaches to Teacher Education

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Throughout the past decade there have been sustained and far reaching efforts to reform education in the United States, These reform efforts began with calls for increased rigor and have moved towards an emphasis on the development of students' conceptual understanding. In 1983, the authors of A Nation at Risk criticized the dilution of curriculum and instruction in American schools and argued for an increased focus on academic subjects and higher standards for graduation. In the past five years there have been new calls for national curriculum reform (AAAS, 1989; NCTE, 1988; NCISE, 1989, NCTM, 1989; NRC, 1989, NCSSS, 1988; NSTA, 1989). This cycle of reform focuses not only on content--what should be taught--but also on pedagogy--how the content should be taught. It embodies a shift from the behavioral and didactic orientation of the 1970s and early 1980s to the conceptually-based egalitarian framework being propounded in the 1990s.

A "cognitive revolution" has radically changed educators views of the teaching and learning process (Case and Bereiter, 1984; Cohen and Ball, 1990; Putnam, Lambert and Peterson, 1990; Resnick, 1983; Shuell, 1986). A shift from behaviorism to constructivism has been accompanied by an emerging view of individuals as active participants in the learning process who construct meaning through experience and develop personal theories about the physical and social world. These new views of teaching and learning have provided the framework for the development of new instructional standards in the core subjects of science, mathematics, social studies, and language arts (AAAS, 1989; NCTE, 1988; NCISE, 1989, NCTM, 1989; NRC, 1989, NCSSS, 1988; NSTA, 1989). These reports advocate a shift in the focus of instruction from mechanical drill and practice towards teaching for understanding. This shift is accompanied by an emphasis on "hands on" inquiry oriented instruction designed to promote students' conceptual knowledge by building on prior understandings, active

engagement with the subject matter content and application to real world situations.

Although constructivist theories have exerted a powerful influence on policy and research relating to the education of students, they have not been so influential in the education of teachers. The fundamental assumption of constructivism is that learners construct understanding through personal experience. Educational reformers, however, typically expect teachers to change their pedagogical conceptions by being shown and told about innovative practice (Shulman, 1986; Stoddart, 1993). Teachers, however, are also learners and their understanding of content and pedagogy is powerfully influenced by their own experiences as students. Teachers tend to teach as they were taught and expect students to learn as they learned (Ball 1988; Knowles & Holt-Reynolds, 1991; Lortie, 1975; McDiarmid, Ball and Anderson, 1988). They often replicate the transmission methods they experienced as students in classrooms--making complete a didactic teaching-learning-teaching cycle.

This is the fundamental dilemma of the new reform movement--the expectation that teachers can learn to be constructivist teachers when they have not been constructivist learners. The challenge for teacher educators and educational reformers is the creation of learning experiences that help novice and experienced teachers reconstruct their understanding of content and pedagogy--to unlearn years of didactic practice. Breaking the didactic teaching-learning-teaching cycle will require an increased focus on teachers as learners, which will require changes in the pedagogy practiced in teacher education programs.

In the first part of this paper it is argued that in order to use constructivist methods, teachers need to learn content and pedagogy through the same authentic conceptually-based methods researchers and reformers advocate be used with grade school students. In many cases this entails going through a process of conceptual change: reconstructing their prior knowledge and beliefs. The author then goes on to discuss several examples of teacher education based on constructivist methods.

DIDACTIC VERSUS CONSTRUCTIVIST APPROACHES TO INSTRUCTION

Didactic approaches to instruction involving telling and accruing information have dominated U.S. classrooms since the inception of the common school (Cohen, 1989). In this approach the instructors' responsibility is to provide the information: the students' responsibility is to memorize it. Lecture, textbooks, drill and practice predominate in traditional classrooms: most instructors concentrate on covering the content not on assuring students understand it (Goodlad, 1984; Porter, 1989; Stodolsky, 1988). The essential ideas of transmission approaches are rooted in the objectivist view that learning should involve students in mastering and replicating the knowledge and skills transmitted to them in school (Lakoff, 1987; Duffy and Jonassen, 1991). In the 1950s, 60s and 70s the growth of behaviorism helped institutionalize transmission approaches in the U.S. education system through the development of a `technology of teaching' which focused on making the replication of knowledge more efficient (Gagne, 1963; 1968; Skinner, 1968.

Constructivism challenges some of the fundamental assumptions of didactic and behavioral approaches to instruction. While the behavioral theorists focus on the effective transmission and replication of knowledge. Constructivist theorists focus on the personal transformation of knowledge. The emphasis is on what the students learn through their personal experiences over what is taught. According to Piaget (1970):

> Each time one prematurely teaches a child something he could have discovered for himself, the child is kept from inventing it and consequently from understanding it completely. (P. 715)

In contrast with transmission views of teaching and learning, cognitive approaches to instruction view learners as active participants in the learning process who construct meaning through experience and develop personal theories about the physical and social world (Piaget, 1970). Knowledge is an internal personal representation of objective reality. When they enter classrooms, students bring with them knowledge and beliefs about the content to be learned: these preconceptions form a filter through which new

information is processed and understood (Anderson, 1984; diSessa, 1982; Posner, Strike, Hewson & Gertzog, 1982; Schoenfeld, 1987).

The process of learning, therefore, involves more than a simple adding on or replication content. It involves the development of a new conceptual perspective through which content--facts, principles, and instructional practices--can be personally mediated and understood. Learning often requires students to change their beliefs about what is being taught and show and tell methods are rarely sufficient to convince them to do this. Constructivists argue that developing new understanding requires an authentic experience which is more powerful than prior knowledge and beliefs. They advocate the use of "hands on" inquiry oriented instruction designed to promote students' conceptual knowledge by building on prior understandings, active engagement with the subject matter content and application to real world situations (Driver, 1983; Hewson and Hewson, 1988; Lampert, 1985; 1988; Smith and Anderson, 1984).

The key difference between didactic and constructivist approaches to instruction is in the emphasis put on the role of personal experience. Proponents of transmission and behavioral approaches to teaching view personal construction of knowledge is an inefficient approach to learning because it asks students to reinvent knowledge that has been discovered over hundreds of years (Gagne, 1963, 1968; Skinner 1968). Constructivist theorists, on the other hand, argue that going through the process of discovery is the most productive way to help learners develop conceptual understanding.

> When Piaget, in his writings on education asserts "to understand is to discover" the inventions are new to the child but seen from the adult's point of view, they are recreations. Our children do not have to invent the wheel: they can begin to understand the

properties of wheels as they exist in our society. (Sinclair, 1988, p.7)

This same perspective can be applied to adults. To a greater degree, however, the learning experience may involve the reconstruction of previously established knowledge and belief systems.

TRADITIONAL APPROACHES TO TEACHER EDUCATION

Teaching and learning at the college level follows the same ineffective traditional didactic pattern common to grade schools. Faculty treat undergraduate students as passive recipients of knowledge which is presented primarily in lecture, textbooks and demonstrations (McDiarmid, 1989; Boyer,1987). Teacher educators are no exception. They tend to take prospective teachers' subject matter knowledge for granted and provide them with techniques and materials for presenting it (Ball and Feiman-Nemser, 1989; Floden, McDiarmid and Weimers, 1990). Even when teachers are taught about cognitive approaches to instruction they are presented with this knowledge in the form of lectures about children's naive scientific theories or the difference between procedural and conceptual knowledge in mathematics (Ball, 1988b). Rarely are they treated as learners who actively construct understandings themselves.

Goodman (1986) in a study of teacher education methods classes found that they tended to focus on providing students with techniques of teaching that would help them to "fit into" the public schools.

> Although liberal phrases about educating children were common in the class sessions observed, and individual professors often gave students materials that would "make learning fun," most

> methods classes and field experiences seemed like partners in the development of traditional teaching beliefs and practices among students....these "liberal" messages were little more than rhetorical slogans without much substance. (347)

The findings of this research support the view put forward by other educators that teacher education programs do not promote innovation or conceptual understanding in their students (Bartholomew, 1976; Bowden, 1972; Popkewitz, 1979; Giroux, 1980; Lanier and Little, 1986; Zeichner & Tabachnick, 1985). Indeed, some teacher educators argue strongly for the transmission approach.

> The preservice student should not be exposed to theories and practices derived from ideologies and philosophies about the way schools **should be**. The rule should be to teach, and to teach thoroughly, the knowledge and skills that equip beginning teachers to work successfully in today's classrooms (pp 23-24. Emphasis in the original).

It is not surprising, therefore, that teachers tend to teach just as they were taught.

TEACHER PRECONCEPTIONS

Teacher candidates do not enter teacher education as blank slates ready to be filled with pedagogical knowledge: they bring with them powerful preconceptions about subject matter and pedagogy (Buchman 1988, 1989; Buchman & Schwille, 1983; Hollingsworth, 1989; Gomez & Stoddart, 1991; Lortie, 1975; Zeichner & Liston, 1987; Zeichner, Tabachnick and Densmore, 1988). These preconceptions serve as

> Culturally biased filters to help make sense of the program content, their roles as student teachers, their observations of classrooms at work, and their translation of program content into teaching/learning situations (Hollingsworth, 1986, p. 162)

A variety of life experiences--early childhood, grade school and work experiences--contribute to the development of teachers' preconceptions about schooling (Bullough, Crow and Knowles, in press; Goodman, 1988; Lortie, 1975; Zeichner & Gore, 1989). Of particular importance is the "apprenticeship of observation"--the thousands of hours they spent as pupils in grade school classrooms (Lortie, 1975). They draw upon the positive and negative models of teaching provided by their own teachers. Teachers also draw upon their own experiences as learners and seek to create in their own teaching those conditions that were missing from their own education (Knowles & Holt-Reynolds, 1991; Shumsky, 1958).

After spending thousands of hours in traditional classrooms many teacher candidates enter professional training with didactic views of teaching. Most believe the teachers' job is to tell the student what they need to know and the students' job is to memorize it (Ball, 1988; McDiarmid, 1990). Developing novice teachers' ability to teach using the constructivist methods will often involve changing their understanding and beliefs about what it means to teach and learn. Traditional approaches to teacher education have little impact on teachers' knowledge and belief structures (Gomez & Stoddart, 1991; Goodman, 1988; Hollingsworth, 1989; Holt-Reynolds, 1992; Knowles and Holt-Reynolds, 1991; Zeichner & Liston, 1987; Zeichner & Tabachnick, 1985; Zeichner, Tabachnick and Densmore, 1988). Teachers tend to reject new ideas or experiences that contradict established structures and assimilate skills and knowledge that support their current perspective (Goodman, 1988).

Many teacher candidates, therefore, enter teacher education with traditional preconceptions about teaching and learning and leave professional training with those preconceptions strengthened (Zeichner & Tabachnick, 1985). For the most part, they do not develop new perspectives but became more articulate in expressing and more skillful in implementing the perspectives they already possessed. Breaking this cycle of replication will require new approaches to teacher education. As Knowles and Holt-Reynolds (1991) point out novice teachers

> cannot be talked out of what they know and believe about schools.....What they know and believe about teaching is constructed out of personal experience, not out of formal study.

> We cannot tell them to discount experience and the processes by which they have come to understand the meaning of those experiences. The lessons they have learned from experience are not amendable via direct instruction to the contrary. Experiences with classrooms as students are far more powerful teachers than mere classroom talk about teachers (p103).

CONSTRUCTIVIST APPROACHES TO TEACHER EDUCATION

Changing the dominant mode of instructional practice in the public schools may require that both novice and experienced teachers reconstruct their understanding of both content and pedagogy in a way that enables them to organize it meaningfully, learn its method of inquiry, and to see its significance to every day life (McDiarmid, Ball and Anderson, 1989). Conventional subject matter or methods courses will not ensure the development of these kinds of understandings. As Wood, Cobb and Yackel, (1990) point out:

> If research on children's learning is to be integrated with research on teaching, it is crucial that the processes by which teachers reorganize their beliefs and practices in order to teach in a manner compatible with a cognitive view be examined.

In this paper the importance of personal learning experience is emphasized: it is argued that many novice and experienced teachers need to reconstruct their understanding of content and pedagogy. The following section contains descriptions of several teacher education projects that emphasize the role of personal experience in developing teachers' pedagogical knowledge and skill.

CHALLENGING PRECONCEPTIONS IN SCIENCE

Recently, researchers have begun to argue that in order to teach science conceptually to students teacher candidates need to have personal experience learning science content through hands on experiential methods designed to challenge their preconceptions (Neale & Smith, 1989; Stofflett & Stoddart, 1991). Conceptual change approaches to instruction assume that the development of understanding often involves a process of cognitive restructuring in which the learners' naive preconceptions need to be

disconfirmed and restructured in order for scientifically validated theories to be accepted (Posner, Strike, Hewson and Gertzog, 1983). This approach has typically been used with children. Two recent studies, however, have reported the effective use of conceptual change strategies with novice and experienced teachers (Neale and Smith, 1989; Stofflett and Stoddart, 1991).

Stofflett and Stoddart (1991) argue that teacher education should be based on a view of teacher as learner:

> Teachers are also learners who construct understandings on the basis of experience and develop personal theories about the physical and social world. They bring to pre-service and in-service education powerful preconceptions about science content and pedagogy which influence their learning and subsequent approaches to instruction.... They frequently assimilate innovative science pedagogy into didactic preconceptions....Teacher educators must do more than provide instruction about innovative science curricula, they must help teachers' restructure their pedagogical preunderstandings. (pp. 2-3)

They developed a conceptual change approach to teaching science methods designed to help teachers through personal learning experiences reconstruct their understandings of science content and pedagogy. The approach, based on research on students' science learning ((Driver, 1985; Driver, Guesne & Tiberghien, 1985; Hewson and Hewson, 1988; Posner, Strike, Hewson and Gertzog, 1983), involves five steps: (1) eliciting teacher candidates preconceptions, (2) guiding exploration of phenomena including disconfirmatory experiences, (3) questioning and discussion to lead teacher candidates to scientifically accepted explanations, (4) comparing new conceptions to original preconceptions to create disequilibrium, and (5) applying new concepts to real world situations. The main purpose was to get teacher candidates to experience learning science content through the same pedagogy they would use to teach students.

To evaluate the effectiveness of this approach the researchers compared the content and pedagogical understandings of 17 elementary teacher candidates' enrolled in a conceptual change science methods course

with those of 10 enrolled in a traditional didactic science methods class. The key difference between the two groups was in their experience learning science content. In the conceptual change class teacher candidates learned science content through the five step conceptual change science teaching method described above. The traditional group learned their science content through reading, lectures, demonstrations and verification laboratories. After six sessions of either conceptual change or traditional content instruction, both groups received the same instruction in using conceptual change pedagogy. They engaged in readings and discussions about conceptual change pedagogy and science education applications of the theory. All students then wrote three conceptual change lessons and taught then in student teaching placements.

Teacher candidates in both groups entered their methods courses with serious scientific misconceptions and traditional views of instruction. Pre and post content assessments, however, demonstrated that teacher candidates in the conceptual change group had significantly better understandings of the science following the content instruction than their counterparts in the traditional group. Analysis of interviews with teacher candidates showed that the conceptual change group were more likely to plan to use innovative hands on methods in their science instruction and less likely to use worksheets and textbooks. The traditional group on the other hand plan to use textbooks, worksheets, and hoped to stay one chapter ahead of their students. The candidates in the conceptual change group believed that their experiences in learning science through conceptual change strategies helped them learn to use the innovative pedagogy. Teacher candidates in the traditional group expressed more frustration in their practice teaching (planning and practice), were less flexible while teaching their lessons and were less reflective about their practice.

Neale and Smith (1989) report similar findings with experienced teachers. They conducted a four week summer institute with 10 experienced teachers from grades K-3. The project included interventions aimed at improving both the science content and pedagogical understandings held by the practicing elementary teachers. The researchers report the conceptual change process for teachers was very similar to that of children: the steps

followed were basically the same, the teachers felt frustrated when their preconceptions were challenged and cognitive restructuring took place over a period of time. The teachers' made progress, however, in eliciting and diagnosing students' misconceptions, providing appropriate activities and allowing students to develop experimental skills. They were less successful in presenting discrepant events to confront students' misconceptions, in having children represent the results of their experiments, helping students reconstruct their knowledge and providing applications of the phenomena for students to discuss (Neale & Smith, 1989). The results of these two studies indicate that the use of conceptual change techniques, even for a short period, can help teachers begin to use constructivist methods.

THE ROLE OF PERSONAL EXPERIENCE IN LEARNING TO TEACH MATHEMATICS

Teacher educators have also begun to explore the use of personal content learning in mathematics methods courses. Ball (1988, 1989) has described how she has helped elementary pre-service teachers to "break with experience" in mathematics methods courses. In a ten week unit teacher candidates are engaged in three types of experiences involving learning the concept of permutation: (1) personal experiences as learners, (2) observation of children learning, and (3) as tutors helping someone-child or adult--to learn permutation. Throughout this process the novices engage in group discussion and reflection on what they were thinking, doing, and feeling.

In the learning phase teacher candidates explore the concept through discussion and the development of concrete representations using physical materials such as Cuisenaire rods. Ball facilitated the metacognitive process by getting the candidates to talk about their reasoning process, soliciting alternative approaches and asking questions such as "Why are you multiplying these numbers?" or "Do you see a pattern here?" In the next phase teacher candidates observed children (age 6, 7, or 8) exploring the concept of permutations. The children were learning through the same methods the candidates had experienced earlier. As they observe, Ball has the novice teacher focus on (1) her interaction with the child, (2) her selection and structuring of tasks and (3) what the child is saying or doing. In the third phase of the project the candidates take on the role of teacher using the same method and focusing on what helped them understand the concept. Finally the novice teachers write a case study of teaching and learning in which they reflect upon what they have learned from these different experiences.

Ball (1989) reports that this approach challenged students conceptions of "what it means to <u>teach</u> as well as what it means to <u>learn</u>" and gets them to reexamine their assumptions about themselves as learners. She quotes from one teachers' reflection on her personal learning experience:

> I realize now that I didn't understand many of the manipulations that I could produce the correct response for. Working with the (fraction problem) was a real eye opener for me. While I could

> quickly come up with a correct answer to the problem, I had no idea how to write a story for it. Finally, through discussion with others and my own thinking out loud, I realized what the problem was asking me to do. After 16 years plus of school I understood division of fractions for the first time. (p. 10)

Similar findings are reported by Stoddart et al (in press). They developed a constructivist mathematics methods class in which teacher candidates reconstructed their understanding of elementary mathematics content--part-whole relationships, ratio, rate, quotient, number line, decimals, and functional relations--through hands on constructivist methods. In this approach, learners actively construct mathematical understandings through active engagement with concrete materials and a ongoing process of Socratic questioning and discussion designed to challenge preconceptions and replace them with mathematically accurate conceptions. Student and teacher act as collaborators in the problem- solving process. The methods class involved a three step process: (1) teacher candidates and instructor used discussion and modelling to create a commonly understood definition of terms in which problem-solving could take place, (2) teacher candidates solved problems using concrete materials and use them to develop new problems and problem representations and (3) teacher candidates developed abstract representations using graphics to help them create mental images. These representations build a bridge to the formalized mathematical symbols. The aim of the course is to push teacher candidates students to generate physical, graphic, and symbolic representations of mathematic problems which they can use in teaching children. The mathematics content was taught in the first five weeks of the class. The second five weeks were spent on teaching methods and practice teaching in the public schools.

Stoddart et al report significant shifts in student teachers understanding of mathematics content and views of pedagogy. On entering the class, none of the students had a conceptual understanding of rational numbers necessary to teach it to children. They were unable to explain or represent concepts. All held traditional didactic views of mathematics instruction. After relearning the rational number concepts through constructivist methods, however, 95% of the teacher candidates could provide mathematically accurate explanations

of rational number concepts. Eighty percent of these novice teachers were able to effectively use these physical and graphic representation in their teaching practice.

The studies in mathematics and science discussed above indicate a strong relationship between teachers personal learning experiences, their developing conceptual understanding of subject matter, and their ability to understand and use constructivist teaching methods. In all of these approaches active experience with learning content through constructivist pedagogy is combined with discussion and reflection on the learning experience. It is not sufficient to know rather one must also analyze how one comes to know.

THE IMPORTANCE OF REFLECTION

The importance of reflection on the learning experience is emphasized by Gunstone and Northfield (1992, 1987). They agree with the teacher education researchers discussed, arguing that:

> The student teacher is a learner who is actively constructing views of teaching and learning based on personal experiences and strongly shaped by conceptions/perceptions/attributes/skills previously constructed and now brought to the course (Gunstone and Northfield, 1992, p.1)

These authors stress, however, that teacher candidates must first be helped to recognize and evaluate their ideas about teaching and learning and then decide whether or not to reconstruct their beliefs. They emphasize the importance of metacognition in changing novice teachers' conceptions of teaching and learning (Gunstone and Baird, 1988). In the program the teacher candidates are engaged in a series of personal learning experiences and reflections on those experiences. For example, at the beginning of the program they are given a "bad lecture" on science content. The lecturer talks rapidly in a monotone, makes no eye contact with the students, does not use gestures and stands motionless behind a large lectern. At the end of the lecture teacher candidates move into small groups where they begin to discuss the content but are then encouraged by the group facilitator to discuss the pedagogy demonstrated in the lecture. Later the same day the "bad

lecturer" returns to review with the purposes of the experience and introduce a set of questions that the teacher candidates which the novice teachers are encouraged to use throughout the program as one way of analyzing their experiences.

Students are helped to reflect on this experience by relating it back to their own experiences as learners in written responses to four questions: (1) What have I learned about physics? (2) What have I learned about my own learning? (3) What have I learned about the learning of others? and (4) What links are there between my learning or lack of learning and the teaching approach? Teacher candidates' responses to these questions are anonymously collated and copies given to and discussed with the group. The purpose of this exercise is to challenge students' preconception that all that matters for teaching is presenting content accurately to students. For example, one student comments, "Just because I understand doesn't mean others can 'know' what I am saying if I don't use their "language' and another "How I learn will probably be how I teach". The program continues to push students to make connections between their own way of knowing the subject and how they teach it by requiring them to teach a scientific concept they will have to teach in school but which they do not currently understand. The connections between personal learning and teaching experiences and reflection are pulled together throughout the program in a journal which becomes a personal communication between the candidates and their instructor.

Several studies of the Monash program indicate that these pedagogical experiences bring about major shifts in teacher candidates views of teaching and learning (Champagne, Gunstone and Klopfer, 1985; Baird, Fensham, Gunstone, & White, 1989).

RELATING PERSONAL LEARNING EXPERIENCES TO LEARNERS

Teachers' personal experience as learners help shape the views of teaching and learning they apply in their instructional practice. It has been argued in this paper that to become a constructivist teacher one needs to have experience as a constructivist learner and to reflect on that experience. There is, however, another facet to this situation. Teachers expect to teach as they

were taught. A corollary of this is that they expect students to learn as they learned and to be similar to themselves. Gomez & Stoddart (1991) in case studies of four of novice secondary school teachers learning to use the process approach to teach writing--a constructivist approach--found that novice teachers had difficulty in using the pedagogy with students who came from different ethnic and social groups to themselves.

The four young white female English teachers who had grown up in mainstream suburban settings began teaching in urban schools with large populations of low-income and minority students. They had received extensive preparation in teaching the process approach to writing. In contrast to didactic approaches to writing instruction which emphasize technical correctness, the process approach emphasize the personal construction of meaning through the writing process. Learners are viewed as authors who own the text: the creative process is emphasized over the mechanics of writing. During the program the novice teachers had personal experience of learning through the process approach in writers workshops. The novice teachers also participated in a series of student teaching experiences throughout the program where they practiced using the process approach. These experiences included a variety of grade and ability level taught as well as work with culturally and socio-economically diverse student populations.

At the end of their teacher education program all four novices candidates viewed themselves as writers, engaged in personal writing--journals, short stories, poetry, and viewed it as a pleasurable and important part of their lives. In line with the writing process philosophy, they talked of their writing as an important way of processing and understanding events in their personal lives. They had also developed extensive knowledge for teaching the process approach to writing. In interviews at the end of their program they spoke authoratively about the recursive stages of the composing process: drafting, revising, editing and publishing the students' work. All four novices also advocated a pedagogy of writing that emphasized opportunity for <u>all</u> individuals to make sense of their world through written expression. By the end of the program, interviews with the four novice

teachers indicated that they had a well developed understanding of the process approach to writing and a commitment to using it in their teaching.

In practice, however, only one of the novice teachers implemented a writing process curriculum in her first year of teaching. Three of the novice teachers adopted a skills based drill and practice curriculum. It was apparent from interviews with all four novices in the middle of their first year of teaching that their instructional choices were linked to their views of learners. The three teachers who used standard didactic practice emphasized the differences between themselves and their students. One novice teacher said for example:

> I have a feeling maybe part of the reason I'm having a difficult time is because I'm from a different language background than they are. They're mostly minority, black and not too wealthy. And I come in dressed like a professional. So I often wonder if that's a barrier, a social barrier.

These three young white middle class teachers evaluate these perceived social differences between themselves and their students as a cultural deficit which makes such students difficult to teach. One argued that "the lower level, the lower academic kids, kids who are not part of the mainstream, the white majority...cannot think abstractly and will not do as well as the others can; they won't pick up on the concepts as fast". Her statement implies that students who are not like her cannot think or learn like her. All three used perceived deficits in the students they were teaching as a justification for using a drill and practice approach to instruction. The one teacher who used the process approach to writing viewed her students as equals. This teacher was also the only one who had experience of a non-traditional lifestyle--she belongs to a social minority group.dents in an equitable manner, tries and succeeds in using the process approach to writing with her students.

This study indicates that constructivist pedagogy may or may not be applied when there is dissonance or consonance between the view of learners inherent in the pedagogy and the teacher's view of the students she is instructing.

CONCLUSION

Reformers are once again attempting to restructure education. The current wave of reform reports emphasize the need to develop students' conceptual understanding of subject matter ((AAAS, 1989; NCTE, 1988; NCISE, 1989, NCTM, 1989; NRC, 1989, NCSSS, 1988; NSTA, 1989). Recommendations for change include moving from depth to breadth of coverage--the development of a deep structural understanding of key concepts and principles--and the integration concepts. This round of reform efforts, however, is likely to fail, as previous rounds have, unless the recommendations on teaching and learning are applied to teachers as well as students.

Showing teachers how to use innovative curriculum and instructional materials and modelling innovative practice will not be sufficient to bring about changes in their science teaching. As previous research has demonstrated, teachers will tend to assimilate the innovation into their existing didactic practice (McLaughlin, 1990; Zeichner, Tabachnick & Densmore, 1987). Teachers must experience the innovative pedagogy first as learners and reflect on this process.

The research and development projects on teacher education discussed in this paper indicate that bringing about a shift from didactic to constructivist pedagogy in the public schools will require many teacher candidates, teachers and teacher educators to change their conceptions of teaching, learning and subject matter. Teachers tend to teach as they were taught and most were taught didactically. Changing teachers' conceptions about content and pedagogy frequently requires a personal learning experience which facilitates the reconstruction of content and pedagogical knowledge: a process of conceptual change.

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