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WHY DO SCIENCE TEACHERS TEACH THE WAY THEY DO AND HOW CAN THEY IMPROVE PRACTICE?

Research on teaching, learning and learning to teach can provide needed guidance for teacher education and education policy. As a science teacher educator my practices have been shaped consistently by a program of classroom-based research that began in 1973 and has continued to the present; an approach that was characterised by a dialectical relationship between theory and empirical studies. Over time the theoretical lenses I used to describe, interpret and raise questions evolved to take account of the historical constitution of science education and the sociocultural embeddedness of teaching and learning. Within the context of an ongoing program of research, the issue of metaphor became salient in 1985 during a sabbatical leave at the University of Georgia. Having read Lakoff and Johnson's (1980) *Metaphors we live by* I began to explore how metaphors were involved in conceptualising the roles teachers considered to have significance to their teaching. For more than a decade I then studied teaching and learning to teach through the lenses of the metaphors teachers used in their talk about science teaching and as referents for teaching science.

1. METAPHOR AND SCIENCE TEACHING

During a study of the teaching and learning of science in grade 10 one of the science teachers involved used metaphors to describe his roles in two very different classroom environments (Tobin, 1990). Peter used the metaphors of captain of the ship and entertainer to depict radically different teaching roles that appeared to constrain his identity as a teacher and the manner in which he interacted with students. The metaphors seemed to organise a variety of beliefs, values and practices. For example, Peter frequently taught as captain of the ship in whole class interactive activities, in which the teacher was clearly in charge, and the rule structure was consistent with the teacher, as captain, giving the orders and the students, as crew, following them. If transgressions occurred, penalties were

P. J. Aubusson et al. (eds.), Metaphor and Analogy in Science Education, 155-164.

administered by the captain. As captain of the ship, Peter's teaching incorporated values associated with efficiency and the teacher knowing best what to do in order to get tasks accomplished well. There was little time for digression and a fast pace was maintained by the teacher, who had firm control of the class.

When Peter switched from being captain of the ship to entertainer, a different set of beliefs, values and practices were evident in his teaching. The entertainer also was a central resource for learning, but a more relaxed atmosphere and a flexible rule structure allowed students to use humor and digress from the topic. The focus was not on efficiency but on establishing a relaxed and comfortable atmosphere in the classroom. As an entertainer Peter was humorous and personable. However, patterns of inequity were evident in his interactions with students. Some students were advantaged, others were disadvantaged, and issues of gender equity emerged. For example, Peter was serious with some female students, appeared to flirt with others, and ignored some entirely.

I regarded a change of metaphors as similar to throwing a master switch – a change in the metaphor used to frame teaching radically changed the enacted curriculum and the constituent roles, rules, and division of labor among participants. This idea was the underpinning for research on how learning environments could be engineered by changing metaphors for salient teaching roles. For example, in a study of a middle school science teacher, we investigated why Marsha was unable to teach as she wanted (Tobin & LaMaster, 1995). We examined Marsha's teaching in relation to the metaphors she used to make sense of roles such as facilitating learning, classroom management, and assessment of learning. Because the students in her class were extremely disruptive Marsha's reflective journal and talk about teaching focused primarily on ways in which she might control her students. She used a metaphor, teacher as comedian, to represent her role as a manager of student behavior. Her primary belief was that if she used humor, her students would like her, be cooperative, and learn more science. However, when she taught using the comedian metaphor to frame her teaching, she was unsuccessful in effectively managing her students; dysfunctional learning environments emerged in which Marsha spent nearly all of the time and her emotional energy on unsuccessful efforts to control the behavior of her students. Despite her efforts to be liked because of her humor, the students used Marsha's wisecracks as opportunities to show their dislike and disrespect for her.

In response to her failure to control students Marsha created two metaphors as referents for her roles as a facilitator and an assessor of learning; both metaphors intended to be consistent with constructivism. As a facilitator of learning, Marsha argued that she would be more successful if she adopted the metaphor of social director, whose role was to invite students to a party for learning. The metaphor recognised that she did not have direct control over students' learning; all she could do was to manipulate the environment such that the party was appealing to students, who would want to come and be cordial to her and one another. Planning an appealing party (lesson) was central to the metaphor of social director, as was a reduced rule system in which students did not interfere with one another's learning and showed respect for the teacher and their peers. Embodied in this metaphor and its enactment, however, was the enforcement of rules. If students were disrespectful

or interfered with one another's learning Marsha punished them. There was no provision for collective responsibility for adhering to the rules and Marsha's efforts to create an improved environment using the social director metaphor seemed to fail because of the punishments and associated student resentment and negative emotional energy.

Marsha's efforts to create social capital with her students were minimised because of students' perceptions that she was unfair especially in her assessment of science learning. Hence she needed to change her practices as an assessor of their learning and allow students to start again in the process of earning credit in the class. Consistent with constructivism, Marsha created a metaphor for assessment as a window into the mind, an opportunity for learners to show what they know. This metaphor was potentially revolutionary because it involved a transfer of power from the teacher to students who would make decisions about what they had learned, what to show teachers, and when to show it.

Over time the learning environments in Marsha's class improved and students began to cooperate with her; she earned the right to teach them, or perhaps more accurately, they showed a willingness to be learners in her class and adopted roles that led to increased participation and learning. Rather than spend most of her time and energy establishing control over students, Marsha demonstrated a willingness to cede autonomy for assessment to students, a field in which traditionally they had little control. Not only did Marsha's practices establish a fresh system of incentives to pass the course, but students also felt respected and were more likely to show Marsha respect and assist her to succeed.

2. PERSONAL USES OF METAPHOR

A key idea with significant implications for improving the quality of science teaching was that metaphors operated as a master switch and allowed sets of practices and associated beliefs and values to be enacted without consciously having to deal with each of them as a separate entity. For example, in earlier research I showed that teachers could increase the science achievement of students by incorporating an average wait time of more than three seconds into their teaching (Tobin, 1987). This was a simple strategy that teachers readily accepted as common sense. For as long as they concentrated on so doing, teachers could incorporate longer pauses into their teaching; however, as the lesson unfolded their practices usually reverted to their habitual use of shorter wait times, averaging about a half second. The research on metaphor raises the possibility that teachers planning to enact a long wait time could create a metaphor to take account of waiting and using time to improve the quality of learning. Perhaps a metaphor of the teacher as an attentive listener would encourage teachers to pause for longer, take account of what students said during an interaction, and encourage teaching practices that were synchronised with those of students. I found this idea appealing and created metaphors for my teaching.

As a college professor it was useful to conceptualise my teaching metaphorically. For example, when I taught graduate students I preferred to be a provocateur. Verbally I would prod and probe so that students would be disequilibrated and become uncomfortable with their understandings. Verbal jabs were intended to catalyse deep thinking and create a form of inquiry that I felt was appropriate in graduate science education courses. Although all students were not comfortable with this approach, it was graduate school and I expected them to accommodate to my approach and assume responsibility for their own learning.

During the mid 1990s my research focused on equity issues in science education in urban high schools. So that I could avoid studying others teaching and probably falling short of my expectations, I decided to study my own teaching in a large urban high school in which most students were African American from home circumstances of economic hardship (Tobin, 2000). I opted to teach and undertake research with students who were at greatest risk of dropping out of school. Approximately 200 students (i.e., about 10 percent of the school population) were organised as a school within a school, constituting the lowest academic track, intended for students who were unsuccessful and in danger of dropping out because of poor academic performance, repeated absence, and in some cases ongoing problems associated with the law, parenting, and poverty.

When I started to teach I felt confident that I would create productive learning environments that would become models for prospective and practicing teachers and serve as a site for my research. However, analyses of videotapes reveal that my teaching was out of synch with the practices of students (Tobin, in press). I was teaching in a reactive way and seemed unable to create and sustain a flow of activity. My students seemed to deny me the right to teach them. Even though I knew I had to earn their respect and build rapport with them; I could not do it. Furthermore, I was afraid that my efforts to teach them would create struggles for control and I had little confidence that I could deal with any physical conflicts that might arise. To my surprise and disappointment, my efforts to improve the quality of the learning environments were unsuccessful and most efforts to succeed ended in failure. The students did not appear to respect me and I was too deliberative in my efforts to teach them. Continuously I searched for solutions, especially by creating metaphors to serve as referents for my teaching in what I described as event full classrooms. The following excerpt from my field notes provides insights into my efforts to use metaphor to frame my teaching.

> I will be a cork on a stormy ocean on Monday. They will be the waves, the current, the wind, and the tide. At times I am certain to be pulled adrift and even under the surface. However, I will be resilient and bob on the surface, following their lead as I find my way toward a destination that is dynamic and probably never ending. I will have more metaphors by the time I arrive in class, but for now this is a reassuring way to think about my role. I will not be a counter puncher, no weapons, totally responsive; but also mediating whenever the waters are calm.

Analyses of my teaching reveal that in the first month or two I was constantly considering my options and making changes to accommodate to the unfolding circumstances of the classroom. My efforts did not appear to produce events as I anticipated and anxiety was written on my face as the curriculum unfolded. There

was hardly any flow to my teaching and, in terms of emotional energy, the lessons were flat. Unlike Marsha's problems, which involved boisterous interruptions to her efforts to teach, the students in my class were often silent, did not appear enthusiastic, and there was evidence of peer to peer playing among females (Elmesky, in press), which I endeavored to quash. Usually my attempts to control playful interactions were ineffective and seemed to catalyse disruptive practices, evident in the tone, pace and emotional content of student outbursts. When I used the floating cork metaphor as a referent I tended to back off and I did not escalate conflicts with the students or among students.

Even though the use of the metaphor might be seen as working, it is an oversimplification to claim success in any absolute sense. Analyses of the videotapes reveal that my efforts to distribute the teacher resource among the students were not appreciated by them; they translated my presence at their groups as checking up and not trusting them. Similarly, proximity desists where I moved closer to students who were becoming restless often sparked outbursts of the sort I was trying to avoid. My efforts to teach were not welcomed by many of the students and as I revealed anxiety and sometimes frustration, some students seized the opportunity to disrespect me openly, possibly seeking to earn the respect of peers.

Although I was aware of the importance of showing and earning the respect of students, I was unaware that respect was analogous to a currency students could earn through accomplishments that were valued by peers. For example respect could be earned by being a good fighter, being physically attractive, wearing new sneakers, or pertinent to the problems I experienced, showing disrespect for a peer or an authority figure, like me. Also, it was considered important for students not to act in ways that would earn the disrespect of peers. Hence, students were generally unwilling to be too cooperative with a teacher and often they acted to disrespect me.

In two ways I learned about the centrality of respect, a form of symbolic capital and part of the schema that structured life within this youth culture. First, I learned from the student researchers from my class who I hired to advise me on "how to teach kids like them." As they experienced my teaching and reviewed it on video tape they consistently advised me to "back off man." "Get outta their faces!" "You gonna get hurt ol' head[2]. Let 'em come to you when they wanna learn." Ever so reluctantly I began to teach in accordance with such advice and endeavored to stop many habitual practices, such as my circulation around the class. Similarly, I consciously did not use proximity desists to quiet students who were becoming restless and nor did I ask students to raise their heads when they appeared to be taking a nap or ignoring me. Instead I decided that learning was the students' responsibility and, like Marsha, my chief role was to act in ways that would allow students to learn when they so desired. If the signs suggested that too few students were participating I had an obligation to enact changes to stimulate more of them to get involved. I endeavored consciously to create attractive learning environments and left it to students to get involved when and how they chose. This approach held students accountable for participation and allowed them to accept the consequences

of the quality and quantity of their involvement. In adopting this stance I reduced the opportunities for students to "treat me like a ho[3]!" Since fewer students challenged my right to teach and there were fewer instances of disrespect, my comfort levels grew and it became easier to build social networks with students who wanted to learn from me (as distinct from trying to get involvement from those who were disinclined to participate). As I created social capital more students accepted me as their teacher, and an upward spiral occurred as social and symbolic capital interacted positively, allowing me to teach, build rapport with students, and attain status to support my identity as a "good" science teacher.

A second resource to teach me about the centrality of respect was the research of Elijah Anderson. An African American sociologist, Anderson studied the culture of African American youth, especially the culture of being in the streets of West Philadelphia (Anderson, 1999). Anderson pointed out that successful street life necessitated the following of a code; which was important for all those who had to navigate the streets in order to get to where they were going. His analyses showed that street practices would often involve earning and maintaining respect and that disrespecting others was part of street life. As soon as I read Anderson's book on street code I realised its relevance to my teaching and the power of using cultural lenses to interpret my teaching experiences.

In an effort to learn more I searched for graduate courses in my university that were relevant to what I needed to know. As part of a course on the psychology of the African American I studied an article by Wade Boykin concerning the dispositions that African Americans construct while living with other African Americans; learning from one another by being together in different fields of activity (Boykin, 1986). Among the dispositions identified by Boykin were several that were highly salient to teaching and learning of science; oral fluency, communalism rather than individualism, verve, movement and rhythm, adherence to social time rather then a linear time perspective, and spirituality. Since almost all of my students were African American I was challenged to consider that by being together in the field of the science classroom they might experience tendencies to act in accordance with the dispositions identified by Boykin. Furthermore, they might participate and learn more if I structured learning environments to encourage such practices. Since I regarded habitus (Bourdieu & Wacquant, 1992) as a form of cultural capital I was eager to plan and enact teaching so that students could use the dispositions identified by Boykin. I needed to adapt my teaching to recognise and build on these dispositions in ways that supported higher levels of student participation in science. I was determined not to inadvertently shut down practices associated with dispositions created in other fields, which might be foundations for higher levels of performance in science. More research was needed to guide practice since my shut downs and the students' dispositional practices might be enacted without awareness. Currently we are studying practices enacted in fields outside of science classrooms (e.g., streets, home, youth clubs, and sporting fields); hoping to identify those with the potential to provide a foundation for becoming fluent in science (Elmesky, 2003).

Longitudinal research on my teaching of urban high school youth shows clearly that my teaching has become adaptive to the practices of the students. Some of the changes were intended and I was conscious about them, and most just happened without me being aware of them. For example, my pace of speaking became much quicker, I was less repetitive, and I exhibited greater variation in intonation and pitch. If others were speaking when I began to speak I continued to speak rather than stop and permit the oral fluency of students to disrupt the flow of my teaching and the learning of others. I was teaching for those who wanted to learn from me. My classroom was no longer modeled on one person speaking at a time. I also used many more expressions that might be regarded as Australian idioms and used humor in my interactions with students. Like my students I became more playful in class. These changes are consistent with the oral traditions that Boykin attributed to African Americans. On the one hand I allowed students to participate orally if and when they felt it was appropriate and I demonstrated my own oral strengths, thereby earning symbolic capital as a fluent speaker who was quick witted. No longer did I talk slowly to make sure students understood what I was saying. I disregarded my earlier work on wait time and focused on fluency. In so doing I allowed overlapping speech and made conscious efforts to keep things moving.

I am a much more animated teacher and employ more body movement and verve when I teach; as if being with these students in a school that consisted almost entirely of African American students allowed me to create dispositions like those of these youth. Of significance, unless I undertook the research on teaching I would still have been unaware of these changes to my teaching. In my conscious efforts to allow students to be themselves I created environments in which I was able to build social and symbolic capital. Gradually I became accepted and respected and, instead of having to conform to the students' images of what a teacher had to be, I was able to be myself and still be accepted by them as a teacher. My teaching practices afforded those of the youths I was teaching and in that sense the structure of the field, which included my practices, created resources that could be picked up by students and used to meet their goals of learning science. My practices could be appropriated by students to learn science and my teaching minimised shut downs that would create negative emotional energy and feelings of not wanting to participate.

3. LOOKING AHEAD

One critical advance that has emerged from our studies on learning to teach in urban science classes has been associated with the use of coteaching and cogenerative dialogues (LaVan & Beers, in press). In coteaching we assign from two to four teachers to plan and teach a class together so that participants learn to teach by teaching with others. Such an approach permits each teacher to experience many ways of teaching by being with other teachers as they are teaching and to become like the other quite unconsciously (Tobin, Zurbano, Ford & Carambo, 2003). Of course not all changes are desirable and, through coteaching, teachers "pick up"

good and bad habits. Cogenerative dialogues can help participants to become aware of their practices and arrive at collective decisions about what is and is not acceptable practice, and what is to happen in the future.

Cogenerative dialogues that involve students, teachers, researchers, and sometimes administrators in discussions over shared experiences of teaching and learning can address the extent to which teaching benefits learners, the roles of the teacher and students, what appears to work and what does not, and the associated divisions of labor and power relationships. We endeavor to convene as equals with the goal of identifying contradictions and patterns of coherence that occur in the practices so that we can reach collective understandings on how to resolve contradictions that are identified. Agreement can be reached on patterns that ought to be strengthened and others regarded as deleterious and in need of elimination. Similarly, environments can be enhanced by eliminating some contradictions and strengthening others; making patterns of coherence by increasing the frequency of contradictory practices. By actively involving students in cogenerative dialogues there is a potential to have them identify maladaptive practices that lead them to experience symbolic violence as dispositions to act are shut down unintentionally by teaching practices, and even to identify instances when adherence to rules or schema leads to the oppression of some students.

4. CODA

William Sewell (1999) described culture in terms of a dialectical relationship between practices and an associated system of schema. Hence any exploration of a field in which social life occurs can focus on the practices of participants and the schema as they are enacted in ways that are both structured and structuring. That is, the agency, or power to act, of any individual is always mediated by structure and in that sense no individual is free to act without experiencing the practices of others and other elements of structure (social, material and symbolic; Sewell, 1992). Hence, if as part of agency, an individual creates a metaphor that is to be a referent for his or her practices as a teacher, it is imperative to remember that whatever happens as teaching is enacted can only occur in the context of the dynamic structure of the field, which includes the practices and schema brought by others to the field. From Sewell's perspective on culture, metaphor is part of the schematic resources that can structure social life for individuals in a field (Sewell, 1999). If a metaphor becomes an object for discussion in cogenerative dialogue then the practices, beliefs, roles, power distributions and rules associated with the metaphor can be discussed in relation to all facets of a community and collective understandings can emerge on how the metaphor can structure social life in the field. In this sense, metaphors might be useful if they are constructed to be consistent with shared visions for social life in a field. Hence a metaphor might contrast in many ways with existing experiences and can be a mutual focus around which cogenerated agreements are constructed. Alternatively, metaphors can be constructed as explanations for experience and stand for that experience metonymically, providing an object for discussion and potential change. In this way the changed metaphor can

be a referent for conscious actions as curricula are enacted and then for review in subsequent cogenerative dialogues.

I conclude this chapter with a sense of being at a rest stop on a long journey. The research I have experienced on metaphor has greatly shaped my practices as a teacher educator, teacher and researcher. As I have participated in a theoretical journey that has taken me from Piagetian roots through constructivism to embrace more social and cultural perspectives on social life, metaphor has been an integral part of my theorising. Within my current bricolage of theories, drawn from cultural sociology (e.g., Sewell, 1999), activity theory (e.g., Cole & Engeström, 1993) and the sociology of emotions (Collins, 2004), metaphor is still central and potentially valuable. However, any use of metaphor must be undertaken with the realisation that much of social life is beyond what is and can be captured metaphorically and discursively. Those parts of social life that are enacted by being with others in many fields of activity can be wonderful teachers and what is learned through the experience of enacting culture, without awareness and without conscious rationale are not only critical to productive social life, but may be the most useful constituents of becoming educated not only in science, but also for life in the modern world.

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5. ACKNOWLEDGMENTS

The research in this paper is supported by the National Science Foundation under Grant No. REC-0107022. Any opinions, findings, and conclusions or recommendations expressed in this chapter are those of the authors and do not necessarily reflect the views of the National Science Foundation.

5.1 Notes

[1] Ol' head is a colloquialism for old head which refers to an elder within a community; a person who is shown respect.

[2] Ho is a colloquialism for whore.

5.2 References

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