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Rethinking Science Literacy: Enhancing Communication and Participation in School Science through Affirmational Dialogue Journal Writing

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Abstract

For many students the study of Science can be very disaffirming. This may lead to passivity in class, and a lifelong disaffection with science, outcomes which defeat the long-term purposes of trying to achieve scientific literacy for all students. This article represents a new way of framing scientific literacy with a "science for all" goal, based on a nexus of psychological, sociological and critical literacy theory. A science education researcher and a science teacher collaborated in trialing the use of affirmational dialogue journal writing with early adolescents in a high school situated in a low socio-economic status area. The intervention was found to be successful on a number of fronts. I conclude that an approach which affirms students' experience can lead to a deeper approach to learning for adolescent science students. ©1999 John Wiley & Sons, Inc. J Res Sci Teach 36: 699-717, 1999

Science literacy has traditionally been seen in terms of intellectual skills or knowledge and hence teachers may see becoming scientifically literate as a logical process which need not--and perhaps even *should* not--involve personal or relationship factors. I want to make a case for seeing literacy as being willing as well as able to participate authentically in the social practice of a particular community, that is, as "a way of being in the world" to which particular beliefs and values are integral (Lankshear, 1994a, citing Gee, 1993). If literacy is seen in this light, then what students believe and how they feel will be seen as significant factors in the process of learning science, since it then becomes a process of induction into the beliefs and values of the scientific community. I will center this discussion around a study of an intervention involving dialogue journal writing, since, even though my main goal in this study was to give students practice in developing language skills in Science, I believe that what made it effective in creating a more authentic environment for learning was the way it changed the nature of the power relationship between the teacher and his students.

The study reported here can be seen as the fourth stage of my research program investigating the problem of superficial learning in secondary level Science classrooms.

My three earlier studies had led me to the conclusion that motivational beliefs and cognitive engagement were affected by several factors relating to the psychosocial learning environment of the Science classroom including (a) the nature of the teacher-student relationship, (b) implicit messages in the curriculum discouraging autonomy, and (c) a serious gap between the literacy skills assumed by the Science curriculum and the actual skill levels of the students (Hanrahan, 1994, 1995, September, 1998). There had, however, been a subtle progression in my thinking over this research program as my principal goal changed from being the facilitation of what Pintrich, Marx and Boyle (1993) termed "cold conceptual change" in individual students to the facilitation of enhanced science literacy for all students (Fensham, 1985). In this study I was seeking ways to change the power relations in the classroom which might be responsible for producing what psychologists would call "dysfunctional motivational beliefs," critical theorists "disempowerment," and science educators "alienation from science."

Although later in the fourth study my host teacher and I did go on to address (c) more directly by using activities designed to demystify some school science genres (see Hanrahan, 1997, December), in this report I want to focus on (a) and (b). This is because I believe that the major obstacle to a deep approach to learning in Science classrooms may be the implicit messages to students that Science is authoritarian, that is, that they should put aside their own ideas and feelings and accept unquestioningly whatever the teacher tells them, even when this does not make sense to them (cf. Lemke, 1990). I believe that such messages are largely unintended on the part of teachers but may be implied from the lack of time and space in the curriculum for the expression of student concerns or resistance.

Towards More Meaningful Learning

An assumption underlying the research reported in this paper is that a particular kind of action would be necessary to prevent alienation from science, and go some way towards meeting the scientific literacy needs of discouraged students. This would involve affirming their right to have their own thoughts and feelings about what they were learning and experiencing in the Science classroom. Although constructivist theory could be implied as underlying such an assumption, it was a confluence of several schools of thought which impelled me to take the action I took in setting up this research study.

A constructivist approach.

In terms of constructivism, proposed solutions to the problem of superficial learning have involved a conscious effort to help students reconstruct their conceptual frameworks, either individually or in a group setting (Baird & Northfield, 1992; Cosgrove & Osborne, 1985; Driver, 1988; Fensham, Gunstone & White, 1994; Posner, Strike, Hewson & Gertzog, 1982; Roth, 1990; Tobin, 1993). The success of approaches based on constructivist theories seemed to me to depend to a significant extent on both the level of intrinsic motivation of the students and on the nature of the power relationships between teachers and students. To begin with, it seemed to be assumed that students would generally react positively to the idea of exposing their "naive" concepts and having these compared with those of scientists. It also seemed to be assumed that one could easily convince students that they really had permission to *not* know the "right" answers.

Although I could see that these assumptions would probably hold true for highly motivated, successful students, whose reputations of success would protect them from threat to their ego, my knowledge of ordinary adolescent students suggested that the remainder might react quite differently (cf. Claxton, 1989; Head, 1989). I believed that students needed to feel empowered before they would begin to construct their own understanding of science, and that this was generally not the case in Science classrooms

where student interpretation and criticism were not encouraged and "only one authoritative voice is heard" (O'Loughlin, 1992, cf. Lemke, 1990).

Learning environment theory.

This sociocultural point of view is supported by the literature relating to the psychosocial learning environment and its effects on student learning and/or motivation (e.g., Marshall, 1992; Pintrich, Marx & Boyle, 1993; Roth, 1992; Tobin & McRobbie, 1996), and especially by the literature placing an emphasis on the teacher-student interpersonal relationship and implied structural constraints on student self-regulation of learning (e.g., Lankshear, 1994b; Lloyd, 1990; O'Loughlin, 1992; Taylor, Fraser & White, 1994; Watts & Bentley, 1987; Wubbels, 1993).

Sociological theory.

At the same time, in science and in other disciplines, researchers have stressed the importance of a community setting for developing positive learning-related beliefs or for changing dysfunctional epistemological beliefs as in, for example, Roth's (1992) "learning community" model of learning, and the cognitive apprenticeship model of learning (Collins, Brown & Newman, 1989). Whereas the earlier proposed solutions seemed to assume all students would want to strive to be like scientists and therefore concentrated on cognitive factors (Claxton, 1989), the latter models allow for a variety of sociological needs including the need to belong to a meaningful community of learning. As Claxton (1989) has argued, students have `whole person' responses to classroom situations, and attempt to balance many agendas in order to maximize goals and minimise threats in the classroom and outside. When learning is divided up between subject specialist teachers, this fact of students being *people* is perhaps neglected in a way which is not the case when one teacher is responsible for a students' overall development.

Adult learning.

What brought it home to me that students at the secondary level of schooling were often treated more like learning machines than people was my most recent classroom experience in adult teaching, particularly as it followed on after a second degree in which I specialised in psychology. After many years of secondary teaching and prior to beginning my doctoral degree, I had returned to study and then happened to get involved in adult literacy education. In the latter practice tended to be based on a nexus of humanistic psychology, critical pedagogy theory and androgogy theory (e.g, Boud, 1987). Both my adult literacy teaching experience and what I had learned in clinical and cognitive psychology left me with a strong conviction of the importance of feelings such as self-worth and autonomy in processes of learning and change. Hence I came to believe that change would require cultural action as well as individual action, including giving students' more "voice" in the classroom. This would necessitate a "non-threatening learning environment" (Watts & Bentley, 1987), that is, positive teacher-student and student-student relationships which could help re-empower students to become self-directed learners who would use deep approaches to learning.

If we accept that such psychosocial factors are important in influencing what it is possible to achieve in the Science classroom, then we need to find new ways of teaching and learning in secondary Science classrooms, which take into account how students feel about participating in Science learning, rather than concentrating most of our attention on intellectual factors in learning. Constructivism has lead to more congenial collaborative approaches to learning, and feminist scholars have gone some way in bringing about changes in Science curricula and textbooks to change the way many students, particularly girls, feel about Science (Head, 1989). However, practice in Science classrooms is slow to

change and more ways need to be found to convince teachers that the traditional methods of teacher-and-text centered classrooms, and impersonal methods of communicating serve neither the interests of a wider range of students (Prain and Hand, 1995) nor their own best interests.

Affirmational Dialogue Journals as a Possible Solution.

The strategy which I decided would address all these issues and combine essential aspects of constructivist, humanist and critical theory approaches was the use of "affirmational dialogue journal writing." The term "journal writing" in the school context generally refers to a process whereby students record their experiences regularly, and it may be limited to a simple log of happenings, or be extended in various ways. In this case it was extended in two main directions. Firstly, students were invited to express their opinions and feelings as well as record their observations of events. Secondly--and I consider this an important factor in its success--it was affirmational in the sense that the teacher or researcher responded to a student's writing in a way which affirmed its legitimacy for that student at that particular time. According to those who had used it, making journal writing part of classes would give implicit messages of endorsement of students' expression of their own experience (Collins, 1985), and provide explicit practice, in a non-threatening context, in constructing understandings from experience as students came to terms with new concepts (e.g., Fulwiler, 1987; Roth, 1992). I also thought it might make visible aspects of the culture which were not previously visible, but which needed to be taken into account.

Design and Methods

The Research Context

The study took place in what I supposed to be an average Year 8 class in a parochial Catholic high school servicing a lower socioeconomic status area. Such a context suited my interest in class equity issues in Science education. It chanced that this particular Science group, however, were not average in that they had demonstrated a particularly low mean level of basic literacy on their entry tests, in spite of the fact that some of the students were quite able. (Year 8 is the first year of high school in Queensland, and students enter it at about 12 or 13 years of age.) There were 15 boys and 9 girls.

The teacher (whom I shall call TY) was an experienced Science teacher who was typical of most established Science teachers that I have met or read about, in using what Prain and Hand (1995) term "teacher-and-text dominated" methods of instruction, amplified by practical demonstrations, and interspersed with sessions in which students performed "recipe" type practical investigations, with minimal surrounding discussion. On the whole, the teacher was successful in engaging his students' attention with his demonstrations and the personal stories he sometimes told, and the students enjoyed the practical work. Yet few showed much interest in or understanding of scientific concepts and most reported finding the language of both teacher talk and written tests very difficult.

The teacher was initially somewhat sceptical about my desire to achieve a "non-threatening learning environment," pointing out the fact that both teachers and students preferred a well-controlled classroom. However, he was open to trying new ways to improve his students' learning. He had volunteered when, as part of my doctoral dissertation, I had appealed to several schools for teachers to collaborate with me in trialing a journal-writing intervention designed to investigate the effect of the learning environment on science literacy. I chose to work with him because he seemed prepared to contribute his

practical ideas to the research, and to act as a "critical friend" to me in my theorising.

I did not want to set myself up as an expert for the classroom teacher to learn from. In fact, in spite of my also having a bachelor of science degree, I had had most of my training and teaching experience in the language and literacy areas. Rather, I hoped that, given the importance of language in science, some cross-fertilisation of teaching methods and theory would be possible. Furthermore, as a doctoral student mindful of my host's other priorities, and not wishing to take too much advantage of his generosity, I did not feel entitled to make large demands in terms of either time or changes to the curriculum, and preferred to aim for small changes responsively over an extended period (most of one school year) rather than large changes in a short time.

Methodology

The methodology I chose for the study was participatory action research and I chose it for several reasons. Among them was the fact that it provided the flexibility necessary for trialing a collaborative intervention in a complex social setting such as a school classroom, where any change in one part of a system in equilibrium could not fail to have implications for the rest of the system. Another reason was that action research allowed participation of the teacher and students in interpreting the data and in decision-making. This meant that change could be progressively negotiated between the different parties. As can be argued from a Habermasian "communicative action" perspective (Kemmis, 1995) or a more pragmatic organisational psychology perspective (Dick, 1996), negotiation is an important component of cultural change.

The methodology I used also resembled an ethnographic case study in having such features as prolonged and intensive observation and continuous participation in the setting (Erickson, 1986; Guba & Lincoln, 1989). These features allowed in-depth analysis of the cultural context, a necessary basis for understanding and problematising the taken-for-granted practices in that context.

Methods

Because the methodology was a blended one, the research methods included those used in action research and in ethnographic case studies. For example, action planning and review meetings with the teacher and other staff or students, whether in-depth interviews, shorter group interviews, or informal conversations, also served as my data gathering for the ethnography.

Procedure

To strengthen the rigour of the research, I tried to see the situation from a variety of perspectives, by observing in the classroom as a participant, by conducting interviews with both the teacher and the students, by reading the students' writing, by writing up analytic memoranda after the event, and by replaying electronic recordings of classes and interviews. However, I do not believe it is possible, even when an account is based on such "triangulation," for a researcher-writer to represent faithfully the perspectives of the other participants; it will always remain her interpretation of events, even when their words are used as evidence of assertions. Therefore a more appropriate term for this would be Richardson's (1994) *crystallization*, which suggests the gradual distillation and emergence of substance and significance in what has been observed, without implying that an objective truth is being confirmed.

The study took place over most of a school year, between late February and mid-November, with some interruptions caused by examination periods, school holidays, and short absences for personal reasons. There was also one visit to negotiate entry to the

school at the end of the previous year. During the school year, I attended all four periods per week (two single and one double), with few exceptions, acting as an observer while the teacher was conducting whole-class sessions, but assisting students during seat-work or practical work. For the first school term (of four), I mainly acted as an observer and assistant, to familiarize myself with the cultural context. However, at the end of the term, I led an introductory exercise related to the journal writing. Later in the year, as well as participating in journal-writing activities, discussions with the teacher led to my producing occasional worksheets and leading the class from time to time. I also used two further double-period classes to withdraw groups of students and conduct group interviews with them while the rest of the class continued with investigations.

After classes I spent one or two hours writing detailed analytic memoranda about each class observed. I interviewed the teacher at length twice near the beginning of the study and again at the end of the second and third school terms, though these interviews should be seen more as conversations in which the researcher and the respondent shared experiences and views about science education, rather than as prompted monologues which the term "interviews" may suggest. I conducted small group interviews with all the students in friendship groups, once at the end of the second term, and once during the fourth term, as well as conducting stimulated recall sessions with several pairs of students at the end of the study. My focus was particularly on the students' attitudes towards Science as a school subject and the journal writing activities they had done. At the suggestion of the host teacher, I also had several meetings with the resource teacher, one including the classroom teacher. I audiotaped and videotaped several classes and listened to or watched for anything of significance that I may have missed in the first instance. I gathered data from students' journal writing, students' examination papers, other school artefacts such as newsletters, from teacher and school meetings, and from conversations with other school staff.

I also audiotaped all interviews and transcribed them, but mainly after the action research had finished, for my own purposes of analysis, for which I used a grounded theory approach (Strauss & Corbin, 1990) and NUD*IST software. While the research was still in progress, the interviews with the teacher served more as critical reflection sessions to review the last action, discuss theory, and plan the next. In a similar manner, the progressive reports by the teacher on his experience of the research acted as a form of review, as did the posters on the study I presented at a conference and also within the school.

Student Journal Writing

The most obvious change we made to the curriculum was to make affirmational dialogue journal writing a part of it, and it is to this change that I want to draw attention in this article. I believe the journal writing was crucial in this study to the creation of the kind of learning environment in which the students could have more ownership of their own learning and hence could become more personally engaged in learning Science. The students wrote individually and I or the teacher wrote affirming replies.

I believed that for students to begin to trust their own thinking and writing, three features would be essential, at least in the beginning: (a) students could say what they liked; (b) answers would not to be judged for scientific orthodoxy nor for orthographical or grammatical correctness, and (c) all answers would be welcomed in the spirit that the students had the right to make sense of their own experience. The teacher contributed a fourth feature which turned out to be an important one in ensuring that the first three could be achieved: (d) making such student writing anonymous by having students choose code-names to identify themselves in their writing. Although I would not have chosen to do this myself, it may have been necessary in this case to reassure the students that a teacher who

appeared to be authoritarian would not react in typically authoritarian mode to their expression of negative feelings or opinions. More importantly, perhaps, it protected them from possible fear of ridicule from class-mates when responses were read out in class. In any case, previous research had shown me that students liked the fun aspect of having a codename, and it probably gave them implicit permission to play a different and more personal role from the one they assumed was normally expected in this class.

We also had students vote on their own suggestions for a name for their journals. They came up with the name BLAST (Book of Learning About Science and Technology) and a logo of an arrow resembling a rocket taking off. These small events had extra significance in being rare occasions when students--even those not "good at Science"-- could contribute to decisions about what went on in their Science class. This support for autonomy in thinking, and hence for active participation in learning activities, became an important feature of all the journal writing activities which followed and also of other activities. Another activity which I believe gave similar encouragement to student autonomy in thinking, although it was originally intended only for data gathering purposes, was the group interviews I conducted with students, with the full cooperation of the teacher. These activities could be seen to convey implicit messages that what students thought and felt was considered important in this context, and that sharing their thoughts was a legitimate exercise.

In their journals, students were asked to be metacognitive about their own processes of learning, and to write about how they felt emotionally and motivationally. I had been strongly influenced by Baird's studies (e.g., Baird, 1986), where students were helped to be more metacognitive, but was more concerned to produce in students an empowered state in which goals might be formulated and reflection might take place more spontaneously than to provide training in metacognitive practices which the majority of students might not be motivated enough to employ fruitfully. I was particularly concerned, both from cognitive science and critical theory points of view, that, as well as addressing conscious thinking processes, less conscious underlying emotional and motivational aspects should also be openly addressed.

The first activity I introduced was a worksheet at the end of the first school term inviting students to free associate with the word "science," state what subject they were most looking forward to studying at the beginning of the year and circle adjectives which best described how they felt about studying Science, recount a life incident which may have led to such feelings, and state one thing which they hoped to do in Science. The classroom teacher thought these provided useful feedback about prior knowledge--or, rather, evidence of lack of it, as few students seemed to have much prior experience of school Science. For me, the main goal of this exercise was to make the point that everyone was coming to Science with different prior experiences, feelings, fears and hopes, and that such differences were legitimate. The activity, and the feedback I gave to the class about what I had learnt from it, was necessary, I believe, to set up and reinforce an expectation that each person's experience and thinking would be different, and that there would be no right or wrong answers for such writing, no shame or blame.

As we could not assume that students would know what kind of writing was expected in such a novel situation as personal writing in a Science class, and as I did not want to disadvantage students from less literate backgrounds, the teacher and I decided to structure the tasks to give students some guidance as to what to write in their journals. For example, students were asked on different occasions to write about their first investigation using a microscope, to give their understanding of the meaning of technical terms such as *focus* and *lens*, to write what they had remembered about a chemistry demonstration the previous day, to state how they felt and what they would do to prepare for an upcoming test, to write

down the most important topics in a chapter on forces, and to tell what was the best and worst thing about Science in a particular school term. Overall, the tasks were reflections about six aspects of their experience (a) their feelings about particular aspects of the curriculum, such as tests, the overall curriculum, and writing; (b) what they saw, wanted to ask about, did, or learnt in practical investigations; (c) the topic of study and the meaning of key words, (d) how they went about learning Science in class or for tests, (e) their feelings about the subject and school, and (f) what they thought of the journal writing activities, and having the researcher in the class.

I set up the task and responded to what students wrote on the first two occasions that we used personal writing in class, to set the tone I wanted. The teacher and I decided to take turns at setting the tasks, though we usually discussed them together and modified them before a class. However, for much of the time, although he read all the students' entries, it was I who responded to the students. This was partly because it was more time-consuming so I did not like to ask the teacher to do it very often, partly because I sensed that he did not see the responses as a high priority, and partly because I wanted to keep control of this part of the journal writing. I thought it was crucial that the responses be warmly affirming, and I wanted to model this. As it turned out, many of the students, because of their literacy problems, tended to write very short entries, rarely more than one or two sentences, and I did not find it very time-consuming to read these and write short replies.

Journal writing activities generally took up about 10 minutes weekly, during terms II, III, and IV. However, we had three in the first two weeks of Term II, missed some weeks when the teacher wanted to catch up on "content," and, from time to time, the teacher would give me a major part of a class period for my own purposes. There were about 20 occasions for writing over the three terms but I used several of these for giving oral feedback and having discussion. There were another dozen classes which I took all or part of but these were dedicated to other activities.

I or the teacher would introduce the questions or topics briefly, write prompts on the board and then let the students write until the books were collected, though some finished well before this. When I was given time, I would later give collective feedback to the class about what students had said, using the code-names when quoting from a particular journal. This was partly to model a range of types of writing for students who were still unsure of what or how to write, but also to show that we valued what was written. As well, it probably helped establish a feeling of being in a learning community in which everyone's learning counted. Once I gave such collective samples of the journal entries as a photocopied handout to the students, which delighted those who had been quoted and interested everyone.

Analysis

Because the main point of the journal writing for me was the effect of the intervention on the learning environment as students saw it, the main data analysed to judge its success was the student interview data, and not what students wrote in their journals. To a lesser extent the journals did provide some feedback on how they affected the students, but tended only to repeat what students had already said in interviews. I also analysed teacher reports, both written and spoken, to investigate whether the students' journal writing had changed the teacher's perceptions of them and how they learnt in his class.

In terms of action research, most of the broad-brush analysis of the data took place in on-going meetings I had with the teacher. Because he had many commitments, whereas I was constantly on site and had more flexibility, I was willing and able to adapt my arrangements to have interviews with him when it best suited him, which was not always

predictable far in advance. Consequently meetings and discussions did not take place in a highly regulated fashion, and cycles of research were more visible in retrospect that in advance planning or at the time events occurred.

Beyond these discussions, I saw my writing of analytic memoranda as my principal research method. Through my writing, I developed ideas and theories from reflection on previous action and then tested them with new observations during the next action. As far as the action research went, these reflections served the purpose of helping me clarify the ideas I would then feed back into the discussion with my host teacher. My thinking was also modified by critical friends with whom I shared my experience of the study, in person or on action research email lists, and by collaboratively editing a book composed of accounts of action research projects written by this group of critical friends (see Hanrahan, 1998a, for more on this process).

Because my interest was on the learning environment as a whole, observations were focused on all the activities of the class and not just on the journal writing activities. Similarly, my theories were based on the overall effect of the whole enacted Science curriculum of which the journal writing was only one part. Consequently, both the topics of my discussions with the teacher and the direction of subsequent modifications to action plans changed over time, though the journal writing, partly because it proved very popular with the students, continued throughout the period of the study. As time went on, we focused more of our attention on other class activities, since it became obvious that adding one practice without changing practices which were conveying. contrary messages would not be likely to have much effect on the students in the long. Briefly, these other activities involved demystifying the genres of the Science textbook and the Science examination, as well as addressing differences between technical terms used in Science and the meaning of the same words in everyday usage. (For more detail see Hanrahan, 1997, December). Nevertheless, I believe that the journal writing activities were the agent resulting in change in the nature of the learning environment, and hence want to evaluate their use separately here.

Findings

The findings are presented in two parts: the particular findings relating to the journal writing activities; and general findings which applied to the whole class and the research process as a whole. The overall finding was that the journal writing allowed a dialogue to develop between the teacher and the students. This in turn moved the curriculum from being a teacher-and-text-centered one which most students found they could not keep up with, to being one in which the both the teacher and students thought the students' needs were being better understood and accommodated.

Before I report on students' comments made during the group interviews, I should give some idea of the type of dialogue which took place in the journals by indicating the kind of entries students wrote and the kind of replies we wrote. In general I tried to adopt an active listening stance, reflecting back to students what I heard them saying they felt or thought.

Among the more articulate student entries for a task which involved commenting on the BLAST activities themselves, was:

I think the BLAST books where [sic] a good idea because we can wright [sic] about how we feel about science and what troubles we are having in science. I like it best

when we had a little bit of time every lesson. I also like it when we when we got to write how we felt and could write our feelings about science." (Sandy, 28/8)

My reply to this was "Thanks for the feedback & the suggestion of writing a little bit every class." Another articulate student commented:

I think we should keep the BLAST books because it helps us because Mis [sic] H & Mr Y give us advise [sic] on how to study & it helps us a lot. Sometimes we write interesting things but sometimes we write things that are non-interesting and don't really help us. I like writing about exams because they help us and we get way better marks. I think we should have these books next year for the students in your next science class. (Snoopy, 28/8)

In reply, I wrote, "Well, thankyou for all the feedback. It is interesting about studying for the exams. I would like to know which activities are less interesting. Can you let me know above (on opposite page)?" The reply came back. "I think that subjects that are less interesting are the ones where we have to write a lot" to which I simply wrote, "OK. Thanks."

Interestingly, the help we had given students in relation to studying for exams was little more than to ask them questions before and after a test, about how they felt both, what they would do to prepare and why they got the grade they did. The following student entry illustrates this. "How I feel about the coming test I feel confident because I have done good in the past. How am I going to pass I am going to read the whole of Chapter 1, 2, 13. What do I need to do I need to learn and listen more" (Jordan, 24/5). The previous entry for this student had only consisted of "Yesterday Mr Y" and the date "23/5" to which I replied. "Well, at least you got your book ruled up so next time you'll have more time for writing. I look forward to that. P.S. Good on you for getting yourself a book. Well done." On the same occasion, three students had written almost identical entries to each other's, to which I replied in a way which made the most of their point of departure from the others. After that they wrote individual answers. This indicated to me that they recognised that real dialogue would be appreciated and that it was safe to write down their own ideas, whatever they were.

As I commented above, my host teacher was not someone who subscribed to constructivist beliefs. Early in the research, in both interviews and in informal conversations, he talked about the necessity of covering the content and keeping the class strictly disciplined, and about the tendency for students to be lazy and to need talking to sternly from time to time to make them work harder. For example, at one stage, when I was particularly despondent about his ever sharing my emancipatory concerns for his students, I wrote in my notes after a class,

T seems more and more fixed on the notion that students are naturally lazy and that the way to combat that is to be stricter and stricter with them, to give them demerit points, and lecture them about working harder, about school being not about having fun but about knuckling down and getting their work done." (Analytic memoranda, 23/7)

Later in the research he commented that my being there meant that he desisted from his usual practice of berating the students about "becoming slack."

In spite of my wish for participatory research, I was concerned about how he would participate in the affirmational dialogue journal writing activities, thinking he might use them as an opportunity to pass moral judgements on the standard of the work, and destroy the trust I had been building up with students in both their journal writing activities and in the group interviews, and which I thought was so necessary for them to feel somewhat free

to express their own ideas and opinions. On the other hand, he had invited me into his classroom, even after hearing me enthuse about non-threatening learning environments, and had not undermined the journal writing activities but had in fact supported them, regularly giving me short bursts of time to explain my view of the activities, give students positive feedback, or introduce new activities and allow time for writing, and he had not taken advantage of what he could have learnt about students' opinions in their journal entries to criticise them. He seemed to be as aware as I was that trust was crucial to their success. It was as though he thought my methods were appropriate for me, and perhaps complemented his, but were not the kind of thing which would be useful to him as a Science teacher.

Consequently, I was apprehensive the first time he set a journal writing exercise himself and also wrote responses to the students' entries. I need not have worried, however, as he responded with empathy to student concerns, even when students wrote such things as "I dislike science." For example, one student wrote:

> My mark of c3 test Biology was poor, it sucks. My marks are all failers. I try, god knows I try. I study, read and write, nothing works. I dislike science. I know for a fact that in Chapter 4 test my mark will be low. Mr Y works too fast and I dot [sic] have time to catch up. I am scared. My parents say I am the brain the most intellegent [sic] of all. but I'm just letting them down. ("Pan-Pacific," 14 August)

and Mr Y replied,

> I believe you are very intelligent. You may find that the answer to your problem is quite simple. One main reason why people fail is because they cannot work out what the question is asking. One way would be to show me your answers to questions from the exercise. It is a start. TY.

His replies to other students were also empathetic and contained suggestions about how they could do better, and invitations for them to ask him more questions, both of which showed some confidence in their capacity to learn Science if they improved their methods.

Students' and the Teacher's Responses to the Journal Writing Activities

Firstly, in spite of general enthusiasm for the journals there was some student criticism of their use. A few students said that they generally had difficulty thinking of what to write. I had expected this since many students prefer questions with an obvious right answer (and such students may even flourish most in Science classes). As well, the majority of the class were boys with poor writing skills, students who have typically had few good experiences with writing and have learnt to avoid it as much as possible. In retrospect, I believe all students would have benefited if I had allowed students some time to discuss the task among themselves before writing. One or two students in one group, although they did not object strongly to the journals, made comments such as that the journals "didn't *do* much." These tended to be students who were "star performers" during whole class discussion when the teacher asked factual questions.

In general, however, the students expressed appreciation for the two-way communication involved in the journal-writing. Support for the journals was particularly evident in the mini focus group interviews. In these, the students contributed many reasons why they liked the them, saying that the journal writing activities meant that they had (a) permission to express their own opinions and feelings; (b) a safe place to make mistakes, take risks, and criticize the teacher; (c) increased ownership of their contribution to the class; (d) a chance to reflect on their own learning/thinking processes; (e) relevant and personally meaningful learning; and (f) a situation in which everyone's ideas were

considered worthy of consideration.

Students seemed to look forward to the activity and to see it as a meaningful activity. At the beginning of the Term III, when my host teacher had a medical leave of absence for two weeks, the temporary replacement teacher agreed to my attending a class and having the students do some writing in their journals for the last 10 minutes. In my analytic memorandum for that day I noted that I had not explained the task very well to the students and thought they would not have anything to write, yet found that they wanted to keep their books longer:

> [W]hen I asked them if they wanted to start handing in their books after five minutes, I got no takers, they all wanted to keep them a bit longer, and so obviously wanted to write something, or a bit more than they had written. (Analytic Memorandum, 5 July)

Earlier in the same entry I had noted, "Mrs E was curious and asked could she see one of the books, and, almost as a single voice, the class chorused, `No, they're for Miss Hanrahan,' and quite surprised me with the conviction with which they said it." The teacher seemed to be on good terms with the class otherwise; they seemed to be enjoying what they were doing and later I discovered that almost all of them had written highly positive comments about the investigation they had just completed. When I explained to the class that Mrs E. simply wanted to know more about how the journal writing worked, one or two of the more obliging girls let her look at their journals. The incident highlighted, however, the extent to which the students saw their journal writing as a personal communication.

The students' preferences were expressed with considerable enthusiasm in the interviews. They made such comments as "We can tell you how we really feel about Science and we should have that more in every subject that we're having trouble with" (AR). That this gave them more ownership of what happened in Science was shown by comments such as and "[We can] write our own opinions... Like, he's got something to do with it, but not as much as we do." (HA). That it was normally not considered safe to be so honest is shown by what this student goes on to say, "And he can't, we can't get in trouble for something that we're saying. Because if we want to say our own thing and we say it, like, we might get into trouble, but if we write it down, it's easier....like if a student complains, the teachers go, `Oh, yeah!'" (HA). As I saw it, this student was implying that teachers usually interpret such criticism given orally as rebelliousness.

They also explained why they let the teacher talk uninterrupted when they did not see or did not understand what he had said or demonstrated. I asked one group of students who said the teacher went too fast for them why they did not ask questions about aspects they had not understood or wanted repeated. They replied that the typical reaction to such a question from most teachers was `Haven't you listened?.... Or `Are you stupid or something?' (AY & AT). Two girls in a different interview said that they were put off asking questions by boys behind them whispering such things in tones not loud enough for the teacher to hear. Some students also complained that leaving their hand raised for a long time to have a question answered left them feeling stupid and/or rejected. It was obvious that students appreciated the journal-writing where such feelings of fear at being shamed or accused of inattention or laziness were not a feature, but rather where it was safe to admit to problems with learning in Science.

Most students reported preferring to write in their journals to doing "normal" work, and I think the vignette involving the short-term contract teacher illustrates this. They tended to see the writing as "getting out of work." Many students asked for more frequent opportunities to do such writing. Some students wanted wider access to their journals. They commented that they sometimes did not have their journals when they wanted to write but then could think of little to say when they were asked to write. One commented that having

the journal made Science less boring, "Then we don't get bored of science." One of the more competent boys commented that what they wrote was useful feedback to the teacher, "Well, the advantages of it, um, like, you, the teachers, know what they have to pick up in and what they don't have to pick up in." (TA)

It was not only the students who appreciated the two-way communication. My host teacher said that he knew much more about what students were thinking than he ever had before. At first he found this disheartening, as students expressed their difficulties, but then he found that it allowed him to adapt his teaching to better match his students' needs. This process, in turn, allowed the students to feel that they had more influence over the curriculum; which may explain, at least in part, why they remained engaged and on task for the whole year, whereas they had become a significant behavior management problem for most of their other teachers, who found their literacy level to be a serious obstacle to learning. In the teacher's own words:

> For me, it was probably the valuable feedback that I was getting from the students that I may not have gotten normally. Because communication is unimpeded....I was able to adjust more easily to suit their learning needs. Although the journals were designed primarily for writing down their understanding of scientific concepts we did tend to ask more general emotive questions. Students did prefer this and much useful information came out of it. Because students did have a firmer input into classroom proceedings there tended to be a better learning atmosphere than there may have otherwise been. In fact, this particular class had developed a reputation for being fairly slow, from a literacy angle, and behavioral problems were evident. This had surprised me when I had heard this as my comment would have been `noisy on occasions but very pleasant to teach.' (TY, Report to colleagues, 6/11)

Students' Wider Responses

A finding I thought significant was the students' amazement at the frankness being allowed in the interviews, and by implication, the journals. One even asked for the audiocassette recorder to be stopped and the tape to be rewound after what she perceived to be an unacceptable opinion offered by one of her fellow students, and was astonished to be told that what he had said was `OK' to say; students obviously expected to be discouraged from expressing negative feelings or opinions about the subject. This supported my suspicion that students learn to discount their own feelings and ideas in favour of what they think the teacher wants, a situation which is unlikely to encourage students to reflect honestly about their own concepts and learning processes.

Most of the students said that they had rarely done any Science in previous years. Significantly, students who did speak of considerable experience of Science in primary school were those who were gaining the top marks in the tests, which supports theories which stress the importance of prior related knowledge in new learning.

In general, students were better behaved in this Science class than they were in their other classes. The less academically oriented students had gained a reputation across the year as "trouble-makers" in their other classes, but this behavior did not emerge in Science.

Discussion and Reflections

This study was designed to address problems such as feelings of disempowerment for many students in Science classrooms, and a lack of deep engagement with scientific concepts. The findings suggest that it went some way towards achieving our goals. In spite

of the small proportion of time given to them--an average of 10 minutes weekly--the affirmational dialogue journal writing activities appeared to have a significant impact on students' engagement with learning in this classroom. Their impact may have been extended, it is true, by the fact that such affirmational activities were associated with me and hence my mere presence, since it was obviously supported by the teacher, may have became a potent symbol of the affirming character of the learning environment.

Although it is difficult to measure their impact on improving students' understanding of scientific concepts, these journal writing activities did seem to encourage students to participate more actively in their own learning, and to give them a safe place as well as implicit permission to begin expressing their own thoughts and feelings about learning science. In this way they provided an opportunity, which the students embraced, to become more personally engaged with learning in Science, in spite of the generally low literacy level of the students involved. I believe that it was the implicit messages of affirmation, in an attempt to empower, or perhaps to word this more tellingly, to "undisempower" (Kemmis, 1995) the students, which were an important factor in the improved learning environment.

As well, the dialogue journal writing gave the students a chance to participate in the curriculum by providing feedback to the teacher (and me) about their experience of the Science class. The teacher admitted seeing problems of which he had not been sufficiently aware before and of changing his teaching to better meet the needs of these students. It has to be remembered that this was a teacher who generally used transmissive, teacher-and-text centered methods, and who generally continued to do so throughout the period of the research. However, with feedback about how the students were experiencing learning in his class, although his general style of teaching did not change, in small ways it was as though he had begun a dialogue with the students, empathising with their personal concerns and endeavouring to make the learning experience more meaningful for them. The culture did not change to the extent that students would interrupt the flow of the class to voice their concerns, but the fact that they had been seriously listened to in the journals seemed to make them more attentive and give them a calmness and dignity which they reportedly did not have in their other classes. Curiously, this seemed to work even though the journal writing was anonymous. Even though students' contributions counted in a cumulative, general way rather than as identified, individual contributions, the effect was as though each student felt validated by the way that everyone was treated non-judgmentally. The ethos had changed to some degree from an individualistic, competitive (in which many were bound to fail) to more of a community ethic in which everyone's learning counted, regardless of how much it differed from current scientific orthodoxy.

Throughout this research report the psychosocial learning environment has been suggested as a crucial factor in the development of student autonomy in thinking, with the journal writing activities being seen as a way of giving students implicit messages about the importance of their own thinking in the learning process, to encourage them to try out ideas and develop ways of expressing their understanding. My choice of personal writing as a way to change the learning environment had been reinforced by my reading about research done by Roth and her colleagues (K. Roth, 1992), which emphasized the importance of a "learning community of science inquiry" in a primary school Science classroom. Significantly, Roth had pointed out that her conceptual change learning model (e.g., Roth, 1990) could be counter-productive, and even lead to harmful epistemological beliefs if not supported by such a learning community, in which improvement in understanding (rather than correct answers) was clearly seen as the main goal.

At the high school level, Lloyd (1990) found that literacy was developed very differently in two Year 9 Biology classes with teachers who had very different beliefs

about science literacy. Where the teacher taught in a way which invited students to contribute their own experience, ideas and questions, students participated readily in classroom discussions. In contrast, in the class where the teacher believed literacy teaching consisted almost exclusively of getting students to reproduce the content of the text book under many guises and with many repetitions of the same material, much passive resistance was observed during classes.

In the present study, although the teacher's methods resembled in some ways those of the more authoritarian of the teachers Lloyd (1990) observed, the journal writing provided an alternative avenue for student expression which was potentially available to all students. In contrast to the alternative in many Science classes of only being able to contribute successfully if one was able to "talk science" (Lemke, 1990), there was always the chance in the research class for even the least scientifically literate to contribute and to have this contribution acknowledged as worthwhile. This may have been an important factor in preventing the less successful students from giving up on the subject and resorting to the resistant behaviors which they reputedly exhibited in most of their other classes.

My interpretation of this is that the affirmational and dialogical nature of the journal writing had allowed a more democratic and collaborative classroom ethos seemed to develop. The students, perhaps because they felt heard, were more inclined to respect the needs of the teacher. In his turn, with more data than usual about them and their difficulties, he was more inclined to take their human needs into consideration, and to focus more on language and literacy aspects of science learning, and to be less concerned about "covering the content." He became more concerned with eliciting the students' questions and helping them with problems as they saw them, and they repaid him by remaining interested and cooperative, a "pleasant class to teach," and eventually performing as well as the other Science classes at the Year 8 level, in spite of their learning difficulties and the time spent writing in the BLAST books. Part of this could be explained by the novelty and extra attention that the research project (and my presence in the classroom) provided, but, as the resource teacher pointed out, the effect lasted even when the novelty should have worn off, eight months into the study.

This is a significant finding by itself. As alluded to above, unbeknownst to the Science teacher until later in the year, the students in the study class were notorious for being badly behaved and almost absurdly incompetent in other classes (and they became almost unmanageable for a different teacher the following year). Thus, the teaching approaches used in the study class do begin to suggest one answer to the problems of poor performance and alienation from schooling, particularly among boys, problems which the resource teacher pointed out to me were significant in schools such as this one servicing lower socioeconomic areas, particularly when teachers felt obliged to deliver a predetermined curriculum, regardless of its inappropriateness for the majority of their students.

The findings from this research thus support one of the assumptions found in the androgogy, humanistic and critical pedagogy literature: that feelings of self-worth are crucial factors in motivation and learning, and that an affirming teacher-student relationship is important for student engagement in learning. This seems to contrast with current practice in many Science classrooms where observations have revealed that unwritten rules, often supported by student expectations, seem to discourage the introduction of personal factors into learning and teaching (Lemke, 1990). Lemke reported, however, that student engagement in Science classroom activities was highest when teachers broke such unwritten rules about scientific language. Personal writing as it was used in this study would therefore seem a likely contributor to a positive learning environment in Science.

Finally, with regard to the research methodology, in contrast to my previous attempts at classroom research, where my participation had been more limited, I found that both I and the teacher had changed over the course of the research. I accepted the limitations that practical reality put on my sometimes idealistic theories, and the teacher accepted that a *non-threatening learning environment* did not mean having more behavior management problems, or less productive students. I also found that discussion with the teacher was enhanced when I made myself vulnerable to criticism by taking some classes. We both found that we had an important role to play in curriculum change through classroom research in this particular case, and that action research, by being flexible and responsive to the way things happen in classrooms and schools, was a practical and productive way to do classroom research.

A Caveat

This study indicates that the affirmational dialogue journal writing we introduced made teaching and learning more fruitful for both the students and the teacher. However, I do not wish to imply that the activity of journal writing in itself is guaranteed to make a difference and should be adopted by all Science teachers. Used by a teacher with a different philosophy and *without* genuine affirmation of the students' worth, it might not have the effect that it had in this class; it might even cause harm.

I believe that what made journal writing work in this case, especially since it was backed up in other curriculum activities, was the message it gave students that someone cared what they thought and how they felt about their learning, no matter how unsuccessful they were academically. This took place in what to some extent, in spite of the individual nature of the writing activities, turned out to be a *learning community* ethos, where sharing in a caring environment was encouraged, and this was probably another factor in its success. However, these implicit messages could probably have been conveyed to the students in other ways. The following year the teacher had similar results when he used a "mail-box" for students to post anonymous feedback written on coloured slips of paper which he supplied. My more general finding from this study is that learning in Science may be facilitated by paying attention to students' personal needs to be treated with dignity (cf. Worsley, 1989), and to be heard and answered in their difficulties.

Although this would seem to go against general expectations that communication in Science classrooms should be impersonal and content-oriented and that learning science is mainly an intellectual matter, it supports findings that learning of any kind, including that in Science classrooms, is a much more complex sociocultural process involving the interpersonal relationship between teacher and students and, as such, is likely to be enhanced by genuine dialogue (Lemke, 1990; Lloyd, 1990; O'Loughlin; Roth, 1992). In conclusion, I would like to suggest that science literacy has less to do with producing correct technical terms and a particular kind of rationality, and more to do with teachers and students engaging each other in ways which are personally meaningful and which promote not only better communication in the short term, but also better personal understanding of the interaction between humans and their environment in the long term.

References

Baird, J.R. (1986). Improving learning through enhanced metacognition: A classroom study. <u>European Journal of Science Education, 8</u>, 263-282.

Baird, J.R., & Northfield, J.R. (Eds.). (1992). <u>Learning from the PEEL experience</u>. Melbourne, Australia: Self-published.

Boud, D. (1987). A facilitator's view of adult learning. In D. Boud & V. Griffin (Eds.), <u>Appreciating adult learning: From the learners' perspective</u> (pp. 222-237). London: Kogan Page.

Carr, W., & Kemmis, S. (1986). <u>Becoming critical: Education, knowledge and action research</u> (Revised ed.). Victoria, Australia: Deakin University.

Claxton, G. (1989). Cognition doesn't matter if you're scared, depressed or bored. In P. Adey (Ed.), <u>Adolescent development and school science</u> (pp. 155-161). London: Falmer.

Collins, A., Brown, J., & Newman, S. (1989). Cognitive apprenticeship: Teaching the crafts of reading, writing and mathematics. In L. Resnick (Ed.), <u>Knowing, Learning and Instruction: Essays in honour of Robert Glaser</u> (pp. 453-493). Hillsdale, NJ: Erlbaum.

Collins, C. (1985). The power of expressive writing in reading comprehension. <u>Language Arts, 62</u>, 48-54.

Cosgrove, M., & Osborne, R. (1985). Lesson frameworks for changing children's ideas. In R. Osborne & P. Freyberg (Eds.), <u>Learning in science: the implications of children's science</u> (pp. 101-111). Auckland, NZ: Heinemann.

Dick, B. (1996). <u>Session 2: The change process and action research</u>. AREOL 4: Action research and evaluation on-line: Archived resources. URL: ftp://psy.uq.au/lists/arlist/areol402. (Accessed 2 August, 1996).

Driver, R. (1988). Theory into practice II: A constructivist approach to curriculum development. In P. Fensham (Ed.), <u>Development and dilemmas in science education</u>. London: Falmer.

Erickson, F. (1986). Qualitative methods in research on teaching. In M.C. Wittrock (Ed.), <u>Handbook of research on teaching</u> (3rd ed.) (pp. 119-161). New York: Macmillan.

Fensham, P. (1985). Science for all. <u>Journal of Curriculum Studies, 17</u>, 415-435.

Fensham, P.J., Corrigan, D.J., & Malcolm, C. (1989). <u>Science for everybody? A summary of research findings</u>. Canberra: Curriculum Development Centre.

Fensham, P., Gunstone, R., & White, R. (Eds.). (1994). <u>The content of science: A constructivist approach to its teaching and learning</u>. London: Falmer.

Fulwiler, T. (Ed.). (1987). <u>The journal book</u>. Portsmouth, NH: Boynton/Cook, Heinemann.

Guba, E.G., & Lincoln, Y.S. (1989). <u>Fourth generation evaluation</u>. London: Sage.

Hanrahan, M.U. (1994). Student beliefs and learning environments: Developing a survey of factors related to conceptual change. <u>Research in Science Education, 24</u>, 156-165.

Hanrahan, M. (1995, September). <u>"Investigating is fun but I'm no good at science."</u> <u>Preventing loss of motivation in middle school science students by focusing on language</u>

learning. Paper presented at CONASTA44, the Annual Conference of the Australian Science Teachers Association, Brisbane. URL: http://owl.qut.edu.au/staq/conasta/papers/papers.html.

Hanrahan, M. (1997, December). Science literacy: Demystifying texts in science classrooms. Paper presented at the Australian Association for Research in Education Annual Conference, 30 November - 4 December, Brisbane. URL: http://www.swin.edu.au/aare/ 97pap/RUSSA97416.html.

Hanrahan, M.U. (1998a). Academic growth through action research: A doctoral student's narrative. In B. Atweh, S. Kemmis, & P. Weeks (Eds.), Action research in practice: Partnerships for social justice in education (pp. 302-325). London: Routledge.

Hanrahan, M. (1998b). The effect of learning environment factors on students' motivation and learning. International Journal of Science Education, 20 (6), 737-753.

Hanrahan, M.U., Cooper, T.J., & Russell, A.L. (1997, June). Science literacy for all: Action researching literacy difficulties. Paper prepared for the "Convergence in Knowledge, Space and Time" World Congresses, the 4th on Action Learning, Action Research and Process Management, and the 8th on Participatory Action Research, Cartagena, Colombia, 1-5 June.

Head, J. (1989). The affective constraints on learning science. In P. Adey (Ed.), Adolescent development and school science (pp. 162-167). London: Falmer.

Kemmis, S. (1995). Teaching that makes a difference: Curriculum with intrinsic value. Paper prepared for the Key Learning Area Consultants' Conference, NSW Department of School Education, Sydney, February 6, 1995.

Kemmis, S., & McTaggart, R. (1988). The action research planner (3rd ed.). Wauru Ponds, Australia: Deakin University Press.

Lankshear, C. (1994, May-a). Critical literacy. Occasional Paper No. 3. Australian Curriculum Studies Association.

Lankshear, C. (1994b). Literacy and empowerment: Discourse, power, critique. New Zealand Journal of Educational Studies, 29, 59-72.

Lemke, J.L. (1990). Talking science: Language, learning, and values. Norwood, New Jersey: Ablex.

Lloyd, C.V. (1990). The enactment of literacy in high school biology classrooms: Two case studies. Paper presented at the Annual Meeting of the national Reading Conference, Miami, FL. (ERIC Reproduction Service No. ED 337 747)

Marshall, H.H. (1992). Seeing, redefining, and supporting student learning. In H.H. Marshall (Ed.), Redefining student learning: Roots of educational change (pp. 1-32). Norwood, NJ: Ablex.

O'Loughlin, M. (1992). Rethinking science education: Beyond Piagetian constructivism toward a sociocultural model of teaching and learning. Journal of Research in Science Teaching, 29, 791-820.

Pintrich, P.R., Marx, R.W., & Boyle, R.A. (1993). Beyond cold conceptual change: The role of motivational beliefs and classroom contextual factors in the process of conceptual change. Review of Educational Research, 63, 167-199.

Posner, G.J., Strike, K.A., Hewson, P.W., & Gertzog, W.A. (1982). Accommodation of a scientific conception: Toward a theory of conceptual change. Science Education, 66, 211-227.

Prain, V., & Hand, B. (1996). Writing for learning in secondary science: Rethinking practices. Teaching and Teacher Education, 12, 609-626.

Richardson, L. (1994). Writing: A method of inquiry. In N.K. Denzin & Y.S. Lincoln (Eds.), <u>Handbook of qualitative research</u> (pp. 516-529). London: Sage Publications.

Roth, K.J. (1990). Developing Meaningful Conceptual Understanding in Science. In B.F. Jones & L. Idol (Eds.), <u>Dimensions of thinking and cognitive instruction</u> (pp. 139-175). Hillsdale, NJ: Erlbaum.

Roth, K.J. (1992). <u>The role of writing in creating a science learning community</u> Elementary Subjects Center Series No. 56. East Lansing, MI: Michigan State University. (ERIC Reproduction Service No. ED 352 259)

Strauss, A., & Corbin, J. (1990). <u>Basics of qualitative research: Grounded theory procedures and techniques</u>. London: Sage.

Taylor, P.C.S., Fraser, B.J., & White, L. (1994, April). <u>CLES: An instrument for monitoring the development of constructivist learning environments</u>. Paper presented at the annual meeting of the American Educational Research Association, New Orleans.

Tobin, K. (Ed.). (1993). <u>The practice of constructivism in science education</u>. Washington, DC: AAAS Press.

Tobin, K., & McRobbie, C. (1996). Cultural myths as constraints to the enacted science curriculum. <u>Science Education</u>, <u>80(2)</u>, 223-241.

Worsley, D. (1989). The dignity quotient. In P.N. Connolly & T. Vilardi (Eds.), <u>Writing to learn mathematics and science</u> (pp. 276-282). London: Teachers College Press.

Wubbels, T. (1993). Teacher-student relationships in science and mathematics classes. In B.J. Fraser (Ed.), <u>Research implications for science and mathematics teachers</u> (Vol. 1) (pp. 65-72). Perth, Australia: Curtin University of Technology.

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