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Science Students' Perceptions of Engaging Pedagogy

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Abstract

During their years of schooling, students develop perceptions about learning and teaching, including the ways in which teachers impact on their learning experiences. This paper presents student perceptions of teacher pedagogy as interpreted from a study focusing on students' experience of Year 7 science. A single science class of 11 to 12 year old students and their teacher were monitored for the whole school year, employing participant observation, and interviews with focus groups of students, their teacher and other key members of the school. Analysis focused on how students perceived the role of the teacher's pedagogy in constructing a learning environment that they considered conducive to engagement with science learning. Two areas of the teacher's pedagogy are explored from the student perspective of how these affect their learning: instructional pedagogy and relational pedagogy. *Instructional pedagogy* captures the way the instructional dialogue developed by the teacher drew the students into the learning process and enabled them to "understand" science. How the teacher developed a relationship with the students is captured as *relational pedagogy*, where students said that they learned better when teachers were passionate in their approach to teaching, provided a supportive learning environment and made them feel comfortable. The ways in which the findings support the direction for the middle years and science education are considered.

Key Words: effective teaching, engagement, middle years of schooling, pedagogy, science in schools, student perceptions

Despite educational reform in science education over the past 30 years, the disparity between the science curriculum on offer and the needs and interests of students continues to be a growing concern (Goodrum, Hackling, & Rennie, 2001). During their first years of secondary schooling, students face restructuring of what to expect from a learning environment, including that of school science. Secondary science offers the promise of real science equipment in a proper laboratory and a teacher who knows science. The teacher and what the teacher presents as science is pivotal in maintaining student engagement in science.

As their first year of secondary science progresses, research has shown that an eager group of students can become less attentive, and negativity and apathy can dominate attitudes towards science (Biggs & Moore, 1993; Speering, 1995; Speering & Rennie, 1996). The quality and value of learning is diminished when students lose their motivation to be engaged. The benefits of learning are annulled by negative attitudes and behavioural patterns (Biggs & Moore, 1993). Consequently, current research and reform in both science education and the middle years of schooling have focused on this issue of student engagement.

The widespread disengagement from learning science is evident through the decreasing numbers of students choosing to continue with science beyond the post-compulsory years and who choose science as a vocation. A report on the status and quality of science teaching and learning in Australia prepared by Goodrum et al. (2001) verifies this "actual picture" of disengagement in science education: "When students move to high school, many experience disappointment, because the science they are taught is neither relevant nor engaging and does not connect with their interest and experiences" (p. viii).

This apparent disengagement is not restricted to the sciences, but is being experienced across the middle years of schooling. Concern about the direction of teaching and learning during the middle years has been sharpened with the recognition that these years should be considered an explicit stage within the schooling life of students (Barratt, 1998). Although all young adolescents have personal, intellectual and social needs, it has been acknowledged that the onset of puberty results in young adolescents having "particular physical, emotional and cultural needs that also need to be addressed" (Barratt, 1998, p. 55). In 1996, a national focus on the middle years through the National Middle Schooling Project (NMSP) was launched, managed by the Australian Curriculum Studies Association (ACSA) and funded by the Department for Employment, Education, Training and Youth Affairs (DEETYA). A primary purpose of this project was to provide a unified approach to reform in the middle years. The Middle Years Research and Development (MYRAD) Project[1] responded to these concerns facing the middle years of schooling. The findings of the project affirmed that students in the middle years were commonly under-achieving and disengaged from school.

The rationale for the research reported in this paper stemmed from my own experience of witnessing eager Year 7 science students become progressively disengaged from learning science. I became interested in investigating the relationship between student engagement, learning environments and the emergence of apathy and negativity towards science.

In order to respond to my own students' disenchantment with and disengagement from science I initiated the current study with the explicit aims of:

1. identifying the specific experiences that may contribute to how students perceive science;
2. exploring the change in expectations of and perceptions of school science over the school year regarding the teacher, themselves as learners, and other environmental, social and physical influences; and
3. observing how the meaning of their experiences of school science appeared to influence students' perceptions and expectations of science.

As the study progressed the teacher emerged from the data as being strongly represented in students' descriptions of what engaged them during science lessons. Speering (1995) found similarly that, during this time of transition, it was the teacher who had the potential to maintain student enthusiasm by providing a relevant, stimulating and hands-on subject.

This paper presents two dimensions of pedagogy that students identified as helping them engage with science.

Research Design

The study was conducted in 2001 and 2002. The participating school was a co-educational independent school in a provincial city in Victoria, Australia. One Year 7 class of 26 students and the science teacher, Miss Baker (a pseudonym), participated in the research. Miss Baker, who volunteered to be involved in the study, was in her third year of teaching and acted as both science teacher and Head of House for this class. In 2003, Miss Baker was promoted to Head of Science out of recognition of her exemplary organisational and teaching abilities. The class consisted of 15 girls and 11 boys entering the school from a range of feeder schools in the city and surrounding regional and rural areas.

Ethnography provided a methodological approach for investigating the culture of the classroom, with the emphasis on giving students the opportunity to explore for themselves and communicate to me the meaning of their experiences in school science.

I employed ethnographic qualitative methods (Carspecken, 1996) to follow the science class through the 2001 school year. As with any interpretive study, I constructed meaning from a number of data sources. Participant observation (Erickson, 1986) of one of two science lessons per week allowed me to observe the students and teacher to build the class context (38 observations from the 65 lessons for the year). Nineteen semi-structured interviews (Oppenheim, 1992) with focus-groups of two or three students conducted once during each school term allowed me to explore students' perceptions and expectations of science and the meanings of their experiences. Twelve students volunteered to be involved in the interviews, eight girls and four boys, with ten to twelve students being interviewed each round. Four informal interviews were conducted at various times throughout the year with the teacher and other key informants for the purpose of gathering contextual information about the curriculum and student progress. Five informal discussions with the teacher provided insight into her thinking. These were often reactive to particular current events or in the form of a relaxed chat about how things were going generally. A number of artifacts were collected from the lessons and the school. Member checks for validation of the developing interpretations occurred in a number of ways. During the focus-group interviews I asked the students to revisit themes in order to seek clarification of my interpretations from previous interviews. During the informal interviews and discussion with the teacher I sometimes shared interpretations and sought clarification of her intent. At the end of the year I shared with the students some of my interpretations and students were given the opportunity to make comment.

The data analysis was generative for further lines of inquiry and occurred in three stages:

1. The first stage was a preliminary analysis of interview data, observational data and my analytical notes taken after observations; this stage provided for the development of a conceptual framework and helped to develop lines of inquiry for the remainder of the year (Miles & Huberman, 1984).
2. The second stage was an intensive analysis of the transcripts from the interviews, discussions and observations through categorical coding.
3. The third stage involved an intense thematic analysis (van Manen, 1990) at the micro level that led to the convergence of the various data sources and the construction of meaning for chosen experiences. This was principally an analysis of spoken data from the interview and observation transcripts led by the developing lines of inquiry.

These lines of inquiry evolved throughout the research, with three areas being the focus during the third stage of analysis: students' perceptions of learning, pedagogy and the nature of science. The inquiry into pedagogy, which is the subject of this paper, drew on students' perception of what they perceived a teacher can do to help them learn.

This study sought to contextualise the students' perceptions offered during interviews within the experiences that I observed occurring in the classroom. The students were considered experts of their own experiences and interpretations of their experiences. I have, therefore, found it imperative to maintain their voice throughout data production, analysis and synthesis of the exemplars represented here.[2]

In my research I worked on the assumption that perceptions of classroom phenomena from researcher and teacher perspectives cannot be expected to be representative of the way in which students see their classroom environment (cf. Fraser, 1990; Weinstein, 1983). This suggests that there is a need for a research approach that enables the student voice to be heard. Consequently my attempts to understand effective teaching, I believe, were enriched by listening to the students' experience of teaching and learning. Student perceptions were the vehicle for developing examples of engaging teaching practice based on a recurring question: "What can the teacher do to help you learn?"

The Teacher as Pivotal to Engagement

The teacher emerged from the data as determining the level of student enjoyment in science. In particular, the analysis was situating what students were saying about how the teacher helped them learn within two distinct dimensions of pedagogy. During a preliminary analysis I labeled these two dimensions as "instructional pedagogy," which related to the teaching methods that assisted in student understanding; and "relational pedagogy," which pertained to how the teacher nurtured a relationship with the students. While no clear distinction or relationship was necessarily made directly by the students, it became evident as I spent time in the classroom and talked with the students that there was an implied relationship between these two dimensions. During observations I sensitised myself to both these dimensions, and

in particular, to how the teacher's interactions with the students fostered a caring, responsive environment focused on providing students with a stimulating, challenging and fun experience of science.

In order to understand further what students were saying about the teacher I perused pedagogy-based theory and research literature to ascertain whether the theoretical notion of pedagogy was representative of the snapshots of pedagogy that were being identified by the preliminary analysis. Two particular spheres of pedagogical theory seemed to distinguish between the two dimensions of pedagogy that were being constructed through the analysis: Shulman's (1986, 1987) pedagogical content knowledge that focuses on instructing for understanding, and van Manen's (1999) relational emphasis.

Shulman's notion of pedagogical content knowledge

Students often referred to the way the teacher presented the content of science in a way that had meaning for them. Shulman's (1986, 1987) notion of *pedagogical content knowledge* (PCK) appeared to capture the essence of these actions of the teacher. PCK is less about teachers simply having the content knowledge, and more about teachers knowing how to deliver the content in ways that are sensitive to the needs and requirements of the learners. In comparison, *content knowledge* is defined by Shulman (1986) as having understanding of the content that is appropriate for teaching. PCK adds to this dimension of subject matter the knowledge required for teaching it to students, and includes the "ways of representing and formulating the subject that make it comprehensible to others" (p. 10). In this way, teachers understand that something is so and "why it is so, on what grounds its warrants can be asserted, and under what circumstances our belief in its justification can be weakened and even denied" (Shulman, 1986, p. 9).

The presumption of PCK is that students do not walk into the classroom as "blank slates" (p. 10), but bring with them previous conceptions, and sometimes "misconceptions" about the knowledge under instruction. Accessing these previous conceptions is paramount (Carr et al., 1994). Constructivist learning theories, therefore, become central as they promote the acknowledgment that students come to science with ideas about their world, and that learning is then enhanced when students are able to place the unfamiliar knowledge into an existing framework of the familiar. The teacher is seen as playing a pivotal role in identifying for the students familiar experiences that will help them to understand the unfamiliar. In order for this to be effective, the teacher must be able to respond to the needs of the audience and know which experiences will be most appropriate to make the explanation have meaning:

> Explanatory legitimacy in the classroom depends upon the students' interest and prior knowledge, the subject level, the teacher's knowledge and the science content. (Treagust & Harrison, 1999, p. 32)

For this research, PCK in concert with constructivist theory became the window through which I viewed the "Instructional Pedagogy" described here, where students

identify how teachers use various teaching methods to allow them to talk and think about what they already know, and to allow the teacher to share valuable skills and knowledge in an understandable way.

Van Manen's relational emphasis

The other important aspect of the teacher that predominated students' descriptions of how the teacher helped them learn related to the teacher's personality and the nature of the teacher's interactions with the students. How the teacher developed relationships with them was important to the students. Van Manen (1999) highlighted this relational dimension of pedagogy and how pedagogy is ultimately and foremost "the study and practice of actively distinguishing what is appropriate from what is less appropriate for young people" (p. 25). In terms of the classroom, van Manen considers pedagogy as the way we are "attentive to the manner that students experience their lives in the classroom" (p. 26). Van Manen is adamant that every action carried out or not carried out by teachers has significance for students "[b]ecause as teachers we stand in relations of influence to our students" (p. 19). It is through relating with the students that we influence them in the way they view teaching, learning and themselves. His exploration of how students experience the interactive or relational dimension of teaching was influential in the analysis and formation of the "relational pedagogy" represented in this paper.

Within the framework of these dimensions of pedagogy ("PCK" and "relations of influence"), the remainder of this paper explores what the students say about how the teacher presents the curriculum and what the teacher can do to maximise interest in learning.

Instructional Pedagogy

Students acknowledged the tendency of Miss Baker to use students' ideas in constructing conceptual understanding. Students also acknowledged a desire to take an active role in what they were learning. Some students were appreciative of being able to contribute what they knew in order to build up a concept, and not have the teacher dictate what was going to be learned:

Kerry: Yeah, it's good how she doesn't just write the things up, ... like get other people to tell. She's good .... [Interview 4]

Through analysis of the student interviews and observation transcripts, three contexts were identified where the teacher allowed students to contribute to the construction of knowledge: explanation, class discussion and clarification. These contexts appeared to capture the various elements that the students identified as helping them learn. Each context is distinguished by its purpose. A key characteristic of all three contexts is the use of a "language of responsive teaching" (Hogan & Pressley, 1997,

pp. 89–90) that uses teacher statements and questions to prompt student thinking and draw them into the thinking and learning process. Exemplars of the discourse between the teacher and students during these teaching acts have been constructed from the observation transcripts. Each exemplar illustrates the role the teacher and students play in creating an engaging learning environment.

Explanation

The first exemplar relates to the teacher's efforts to explain the relevant scientific concepts, referred to as important by many students. The efficacy of teacher's explanations was identified as being important for helping students learn: "It's good 'cause she explains everything well, more than other people do" [Interview 4]. The following exemplar typifies the discourse occurring during an explanation that I commonly encountered in this classroom.

Miss Baker takes the students through each of the features of a microscope. She has got down to the mirror. She asks the students, "What about the mirror, what's the mirror for, Betty?" Betty responds, "To reflect the object so it goes up, and when you look through this (indicating the lens) it makes it bigger." Miss Baker thinks for a second. "OK," she says, "these are the magnifying lenses, so those make the object look bigger, so you're right, it does go up through here, but what about this bit here, what is this mirror actually doing there?" Daniel calls out, "It makes the light go around, or up through the lenses." "OK," says Miss Baker again. "If we want to reflect the light, where is the light coming from?" Sam looks around him and then calls out "The room." "But look at mine," responds the teacher. "Where's my light coming from?" Lyle indicates his globe. The teacher points out the box of microscope lamps sitting on the bench and says, "The mirror's turnable, so you can make sure that you've got the maximum amount of light going through, up through the specimen on your slide, like Betty said, and into your eyepiece" [Classroom observation].

The teacher is attempting to draw certain information from the students. The teacher develops an explanation of the purpose and use of the microscope mirror by directing the thoughts of the students through questioning and prompting rather than providing the details for them.

Of particular interest is how Miss Baker refocuses Betty's incorrect answer and includes the ideas of this student in the explanation so that the response is made correct. This was a typical discursive strategy used by Miss Baker during the observed science lessons, and was usually evident when she was attempting to draw certain information from the students. Student engagement with the learning was maintained by inviting students into the process of constructing knowledge, in this case, in defining the components of the microscope, through probing questions such as, "What do you think?" "What happens if?" "So if it's that, then what if, or what does…?"

Class Discussion

A number of students identified class discussions as valuable in drawing them into the learning process. This strategy was observed to be a major feature of the classroom. The teacher assumes mainly a facilitatory role during these class discussions, using primarily open questions to allow the students to share their ideas, then directive questions to focus and summarise the ideas presented by the students. One student admitted that "[c]lass discussions are OK when we are included" [Interview 2]. They are more effective for sharing knowledge and a more attractive alternative compared to the teacher simply "telling" them, as the members of the class are "more involved."

Following is an exemplar of the discourse used by students and teacher when the class was engaged in a discussion.

Fay:	(*Reading from the textbook*) "You leave your phone card sitting on the stereo for a long period of time. When you try to use it you find that the money has totally disappeared. And since no members of your family have been making secret calls, what do you think has happened to your card?"
Miss Baker:	What do you think?
Ken:	It's been near a magnet and it's drawn all the credit out of it.
Miss Baker:	You think that?
Ken:	Yeah, 'cause if it's been near a floppy disk.
Joan:	Yeah, I think that too.
Miss Baker:	So, it's been near a magnet and drawn all the credit out. How does the magnet draw the credit out? (*A number of students yell out answers.*)... I'm glad to see we've got lots of hand up 'cause I want to hear what you have to say. Daniel.
Daniel:	Part of the floppy disk is magnetic and when you put something on it it writes it in binary code, like positives and negatives and stuff and it... and it puts the little bits in the right spot and then when you put a magnet over it it puts, it just reorganises everything so that it doesn't recognise it any more.
Lorraine:	It mucks it up.
Miss Baker:	That's good Daniel.
Betty:	Ok. I know what the phone card is. It's like when a magnet touches metal it goes up, well it's sort of like, the card has a bit of metal in it and like it sort of drags it all out.
Miss Baker:	Right. Mitchell.
Mitchell:	Well, the same thing happens with a mobile phone.
Miss Baker:	It draws the credit out of a mobile phone?
Mitchell:	No, no, not, I had my SIM card, the magnetic strip at the back, near my phone and you're not supposed to.
Miss Baker:	Yep, ohh, the mobile phone draws the amount of money out of the card.

(*Some students respond to this idea*.)

Fred: It normally does that, when you make phone calls, no, no, the key card, when you make calls.

Miss Baker: Oh, that's interesting. I didn't know that. . . . Lorraine.

Lorraine: Because, are these the cards you put in and pull out straight away? They have a copper thingy in it to tell how much money you've got on. And um, the magnets in the machine thingy draw it out.

Joan: When Dad wants to erase floppy disks he just runs a magnet over it.

Miss Baker: Does he? That's quick isn't it! I didn't know it had anything to do with that. [Classroom observation]

What is unique about a discussion, compared to the other methods used by the teacher, was how the students listened to each other as they responded and built on each other's ideas. As illustrated here, the purpose of a discussion was to allow the students to share what they knew about something and not to necessarily arrive at a predetermined answer. The spread of ideas was of greater significance. Discussions were often used as a means of brainstorming, especially at the beginning of a unit to elicit students' current level of understanding and to expose preconceptions, but not always so. In the scenario above, with very little input from Miss Baker, seven students (plus others who were not picked up by the tape recorder) provided an introduction to what magnets can do and how they are used in everyday life.

Clarification

The third major feature of Instructional Pedagogy was the repetition needed to clarify for students previously covered ideas. Many of the students valued the teacher's efforts to clarify what had already been covered by "going over and over [it] again for those who don't understand" [Interview 2]. Such clarification appeared to serve a number of purposes, including allowing the students to realign themselves at the beginning of each class with what had occurred in the previous lesson, to reinforce protocol such as homework responsibilities, and in confirming student understanding of concepts and instructions. Also, this tendency to clarify related closely to the way the teacher used explanations. Clarification commonly occurred during explanations where the teacher confirmed students' understanding. Kerry stated that the teacher "explains things more than other people do. She makes sure you understand before she goes on" [Interview 4]. Explanation with clarification of understanding appears to be considered optimal for this student in helping her feel confident about what she is learning.

Repeating previous lessons and concepts through revision at the beginning of each lesson was a common practice for Miss Baker. There was mixed reaction from the students to this revision as to whether this was done adequately or too much. Nicole called for more "going over" what was done in the previous lesson, while *at the same time* felt that there was *too much* revision at the beginning of some lessons, making science boring at times. The exemplar below referred to activities performed

in the previous lesson and clarification of "electricity" in readiness for preparing the practical report.

Miss Baker:	. . . Who can remember what electricity is? Fred?
Fred:	It flows atoms and electrons.
Miss Baker:	Flows atoms and electrons? Would you like to refine that a bit for us?
Fred:	Well, electrons are atoms.
Miss Baker:	Are the word atom and electrons exactly the same, or how do they fit together?
Fred:	Well, aren't they a different name for, well, one's more basic than the other one.
Miss Baker:	Is it?
Fred:	Yeah. I think so.
Miss Baker:	I think you're on the right track there Fred, you're basically on the right track. We just need a little more confirmation of what's going on.
Roydon:	Right, in a wire, there's positive electrons and negative electrons.
Miss Baker:	Positive electrons!
Roydon:	Oh, protons. And the positive are really big and they attract the negative. The negatives are really small ones and they move along to the bigger protons.
Miss Baker:	Right. So the definition of electricity would be the flow of. . .
Roydon:	Negatives.
Miss Baker:	Electrons. And how does an atom differ from an electron? Maree, do you know?
Maree:	They're, the protons don't move, do they?
Miss Baker:	Mm hmm. They're kind of stuck aren't they.
Maree:	And then the electrons they attract to the big proton.
Fay:	I don't get why the electrons don't go to positives in the middle there.
Miss Baker:	Because this (the battery positive) is much much stronger. Say if you had one magnet that was quite weak and next to it you had another magnet that was quite strong and you put a nail in between the two mains, which way would it go to do you think? The big or the little.
Students:	Big.
Miss Baker:	So that's like the big plus. And that one's not so big. . . So, if you remember we did all of these things. . . and we did two experiments. And if you could take out your text book please and turn to the first experiment that we did. . . [Classroom observation]

The exemplar illustrates how little students retain from one lesson to the next, and how important it is to not assume that students will bring with them their thoughts and learnings from the previous lesson. Through the use of prompting and probing questions Miss Baker exposes an alternative conception from Fred, that electrons and atoms are basically the same, just one is more basic than the other. Miss Baker asks for further "clarification" and other students work together to build a description that

is aligned with the teacher's definition. Therefore, Miss Baker's attempt to clarify understanding was not a simple transmission of previously constructed meanings, but allowed students to engage with the process of revision through probing questions aimed to identify and deal with alternative conceptions.

From Instructional Pedagogy to Relational Pedagogy

Students acknowledged that the teacher employed a discourse that drew them into the learning process. Some students indicated that they were positive about being able to contribute to their learning in this way, especially when it involved interaction with their peers, such as through class discussions. Other empirical studies support this attitude, showing that students appreciate the opportunity to use their own ideas and knowledge, and through such social interaction students felt more valued (Hand, Treagust, & Vance, 1997). Tobin, Tippins, and Gallard (1994) state that:

> Group discussions can play a significant role in students' learning by providing time for interaction with peers to answer student-generated questions, clarify understandings of specific science content, identify and resolve differences in understanding, raise new questions, design investigations, and solve problems. (p. 49)

Promoting an atmosphere of social interaction can enable students to negotiate difference of opinion and seek consensus and further foster students' ability to voice their opinion. These social contexts of teaching and learning "provide the impetus for a vision of science teaching and learning that is grounded in the search for meaningful experiences" (Tobin et al. 1994, p. 49). Roehler and Cantlon (1997) refer to this type of discourse as conversation. They make the distinction between instructional conversation and learning conversation. Instructional conversations can be likened to the explanation and clarification exemplars described above; they are "discussion-based lessons geared toward creating opportunities for students' conceptual and linguistic development" (p. 10), where the teacher builds on students' ideas using a structure to guide the discussion. Learning conversations have a similar process, but differ in that the teacher does not merely teach, but also learns, such that they co-construct information with the students, and all ideas, comments and questions are valued. The class discussion exemplar above has evidence of this co-construction occurring.

In terms of contributing in such a social arena, in a study by Varelas, Luster, and Wenzel (1999), the teacher successfully developed a learning community with a social–organisational dimension where students felt safe to contribute and voice their thinking and ideas, where there was cross-dialogue between students during lively, respectful discussion, where the teacher revoiced ideas to add value, and the students were given opportunity to think and share ideas orally and in writing. Similarly for the exemplars presented here from the current study, the teacher adopted a discourse that promoted and encouraged students to be risk-takers when sharing their ideas as part of a communal process in meaning making (cf. Tytler, 2002). The involvement of the teacher depended on the purpose of the situation. Freedom to participate in the

social acts has appeared to contribute to the establishment of the discourse used by students and teacher as presented here.

For such risk-taking to occur when engaging in active, constructivist learning practices there needs to be a caring, supportive environment (Noddings, 1993; Watts & Bentley, 1987) so that learners can feel empowered when sharing in the classroom setting. For example, Miss Baker's dealings with Betty's incorrect answer during the explanation of the purpose of the microscope mirror required being able to respond to Betty in a personal way, implying a relational dimension to Miss Baker's pedagogy. A closer look at how students recognised this follows as "relational pedagogy."

Relational Pedagogy

Along with the instructional approach of the teacher as described above, some students were able to articulate the way in which a teacher related to them as having an impact on their learning. The emphasis on relationship in teaching is not new. Research by Speering and Rennie (1996) argues that the decrease in students engagement in the first year of secondary school may be a function of a change in student–teacher relationships experienced at the primary and secondary levels. However, what are the characteristics of a teacher that enables positive relationships with his or her students?

Students in the current study drew on their experiences of Miss Baker and other teachers to articulate what they perceived as being valuable teacher characteristics.

Through analysis, six "characteristics of relation" emerged pertaining to participants' perceptions of how a teacher should be: enthusiastic, friendly, non-threatening, encouraging, understandable, and attentive. Further analysis revealed that these six characteristics could be grouped into three "spheres of relational influence" – passion, comfort and support – inspired by van Manen's (1999) notion of "relations of influence" (p. 19). These spheres are presented here as the "relational pedagogy" of the teacher, and represent what the students identified as teachers' interpersonal interaction with them (Figure 1).

These "spheres of relational influence" are distinct, but are also interrelated as represented by the clockwork mechanism, where if one is activated they are all activated. This representation is a compilation of the characteristics that different students perceived as being important for a teacher to possess in order to create a secure and productive learning environment.

Sphere 1: Passion

Some students acknowledged that Miss Baker was passionate about both teaching and science: " 'Cause she's enthusiastic about it and she like enjoys doing it and so she tries" [Interview 3]. This was referred to as "enthusiasm," which was considered to be essential for the following student as keeping him interested and enthusiastic:

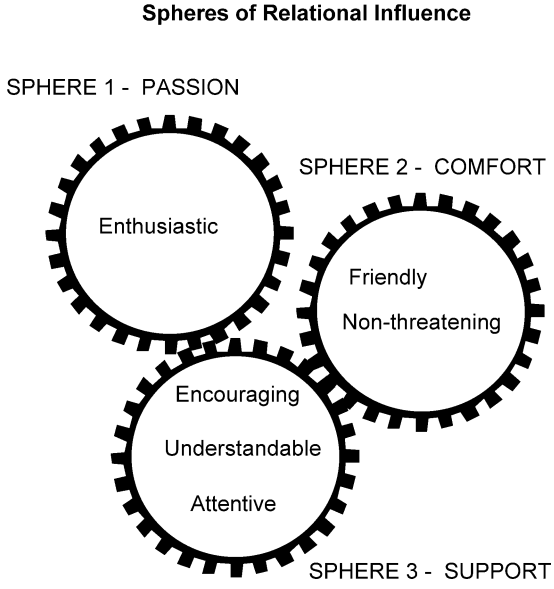

Figure 1: "Spheres of relational influence." Year 7 students' reflections of teachers' relational pedagogy are identified as occurring within six categories, then organised within three spheres of relational influence: passion, comfort and support.

"They need to be enthusiastic about the subject" [Interview 4]. Enthusiasm represents a sense of care on the part of the teacher; that the teacher cares about what she does and wants to share this with the students. In fact, there appeared be to an expectation from some students that teachers will be enthusiastic about their subject areas. For example, with Miss Baker, Lyle noted that "she's motivated by science... There's no point teaching a subject if you're not enthusiastic about it" [Interview 3]. This expectation becomes important for teachers when the level of a teacher's enthusiasm is easily interpreted by students: "You subconsciously interpret their body language and stuff" [Interview 3]. This judgement by Lyle about the teacher's attitude towards science and of its manifestation is reflected by van Manen (1999), who asserts that every action carried out or not carried out by teachers has significance for students.

Sphere 2: Comfort

The second sphere of influence incorporates the friendly and non-threatening characteristics of the teacher in providing a comfortable environment. Students like to have a friendly teacher, one who will talk with them: "Can have a chat to you about not particularly school all the time, they can talk about other stuff... in science and out of science" [Interview 4]. The teacher shows that they see the student as

a worthwhile individual, and that they can enjoy being "friends" with the student. Friendliness contributes to students being able to enjoy a subject. A non-friendly teacher is considered to be more threatening, as represented by the non-threatening element of the teacher: "I reckon you've got to have a friendly teacher if you want to enjoy it because you don't want to be sitting there and have someone growl at you or something" [Interview 2].

The sense of humour was a common element of the *friendly* teacher: "they have to be able to have a joke" [Interview 4] and, specifically about Miss Baker with the non-threatening element, "She's pretty good, 'cause you can have a joke with her and stuff and she doesn't get mad at you" [Interview 4].

A friendly teacher led to a feeling of comfort for some students. Friendliness contributed to them being able to enjoy a subject as it appeared to provide a positive learning environment. The following response came from a student who was questioned whether she would prefer to have a different teacher for science next year: "No way, no way. I'm sort of more comfortable with a teacher that, well not coaxes but you're sort of friends with instead of another teacher" [Interview 4]. The student appears to find comfort in having this feeling of familiarity about a teacher, somebody she is friends with. This response highlights also the concerns pertaining to transition from primary to secondary school, where students come from a supportive environment with few teachers, to a school culture that has less support, and different teachers for each subject providing constantly changing learning environments. Nola commented about how difficult this transition was for her:

> Like in our primary school you always had the one teacher for most subjects and when you get here you have a different teacher for every subject so, it's kind of confusing at the start, like maybe they should have, like in primary school, when you get up into the higher years you should start to get used to it, they should do something so you can get used to it .... [Interview 4]

The need for familiarity and consistency emerges as an issue during Year 7 and has been recognised through middle years research (Centre for Applied Educational Research, 2002) and research into students' transition from primary to secondary school science (Ferguson & Fraser, 1998; Speering, 1995; Speering & Rennie, 1996).

The non-threatening teacher provides students with a safe environment within which they can learn. As would be expected, students did not like teachers who "growl" at them or "get mad or yell." According to van Manen (1999), management of student behaviour has the potential to expose a threatening side of the teacher, so how a teacher handles those "testing" times has the potential to damage the feeling of comfort. Students' responses and classroom observation have portrayed Miss Baker as being fair, tactful and thought-provoking, logical and controlled, rather than domineering, demanding and unfair. In the classroom I observed Miss Baker dealing with situations constructively so as to reduce damaging her relationship with the students.

Sphere 3: Support

The third sphere relates to the provision of "help," or support, from their teachers: "Sam: [The most important thing about a teacher is] that they understand how you like, what you're like, and they help you and talk to you and stuff" [Interview 4]. This issue of knowing that a teacher is willing to give help was common amongst the interviewees and related to the teacher's ability to encourage, be attentive to their needs, and help them to understand, all of which were achievable only if the teacher was understandable.

Students appeared to respond positively to a teacher that encouraged them, both personally and with their work. This encouragement helped students with feeling confident about their work and about themselves as people, thereby also being closely linked to the comfort sphere.

Students identified that a teacher who listened and was attentive to the learning needs of their students was seen to be responsive, fair and acknowledged all students. Such qualities add a relational dimension to class discussions and being able to contribute to what they learn. In relation students being able to discuss and share their views, Caleb stated that "you don't have to be nervous about it when you talk about it" [Interview 4].

To bring students to a point of understanding requires instilling confidence in the student through encouragement and being attentive to what the student needs in order to understand. This is an acknowledgment of the individual and requires being able to read, respond to, and relate to an individual, so being able to elucidate what will make the matter of concern have meaning. This idea was captured by Nola who spoke of a science teacher that visited her primary school:

> . . . I think maybe our science teacher could have, like talked to us a bit more and like about school things, because we didn't really know her well enough to know what she wanted. So you got a bit confused so that's why half the things didn't work. [Interview 1]

Although Nola's account of her teacher may not represent a true account of events but an interpretation of events (van Manen, 1999), in this situation, the teacher's ability to relate to the student was the determinant. Without that relationship, there was limited understanding between the student and the teacher, resulting in reduced understanding for the student.

In the literature, this issue of "support" often comes under the guise of "teacher support" (Campbell et al., 2001) or "supportive learning environment" (Fraser, 1990, 1994) and has been found to be pivotal in building learning environments that are conducive to learning (Fraser, 1990, 1994). Hanrahan (1998) asserts that interpersonal factors such as the extent to which students feel affirmed by the teacher and perceive support for autonomy in thinking can increase or decrease emotional constraints on reflection of current and prior learning. Deep engagement in learning is dependent on the emotional aspects involved, such as feelings of self-worth and autonomy.

Discussion

The students in this study appeared to be aware of the teacher's role in providing a learning environment that assisted their engagement with learning in science. It was identified that many students liked teachers who provided opportunities to draw on previously understood conceptions when attempting to introduce new concepts and clarify previously encountered understandings. Such teaching approaches acknowledge constructivist learning theory, and draw also on social constructivist theories by allowing students to share and construct within the context of classroom discourse. Constructivist practices that access the prior knowledge and understanding of students are generally well accepted within science education (see Harlen, 1999, and Bennett, 2003, for recent reviews of research relating to constructivist learning theories in science education).

The relational dimension of the teacher's role was also profoundly represented in what students identified as helping them learn. Van Manen (1999) emphasises the relational influence teachers have on their students and that it is important to listen to how students experience the interactive dimension of teaching. He asserts that teaching is often seen by students in terms of style, personality and qualities such as fairness, patience, commitment, and kindness. When students in this study were asked what they felt as being important characteristics for a teacher, snapshots of both the teacher's style and how she related with the students emerged. Three spheres of relational influence in the spirit of van Manen's "relations of influence" conceptualised how students gave preference to teachers who were passionate, and provided a comfortable and supportive classroom environment. I am particularly disposed to van Manen's view of pedagogy as referring to the way people are "attentive to the manner that students experience their lives in classrooms" (Oldfather, 1994, p. 26). Creating caring classroom environments where students' opinions are heard and valued involves teachers having an empathic understanding of and response to children's thinking and feeling (Oldfather, 1994). The value of listening to students in order to understand how they want to be engaged becomes clear. "Learning in science," says Hanrahan (1999), "may be facilitated by paying attention to students' needs to be treated with dignity… and be heard and answered in their difficulties" (p. 714). Hanrahan argues that students need to feel empowered before they will be motivated to construct their own understanding of science, and to feel that they have the permission to take risks when exposing their naïve concepts. One of the needs of young adolescents expressed by Barratt (1998) is to experience success, which involves "having multiple opportunities to learn valued knowledge and skills as well as opportunities to use talents and expertise that students bring to the learning environment" (p. 55). Students in this study were interested in having the opportunity to both share their ideas and to listen to ideas of others. Perhaps what contributed to the willingness and desire for students to contribute was that Miss Baker often granted students explicit permission to present their naïve concepts during class discussions. Students were able to contribute relevant and valuable snapshots of their realities allowing them in this

social setting to engage in active construction of their own knowledge and achieve success.

This intrinsic link between engagement, student success, and how the teacher relates with the students has been strongly represented in other research into learning environments and pedagogy for the middle years (Australian Curriculum Studies Association, 1996; Department of Education, Employment & Training, 1999). Barratt (1998) identified seven specific needs of Australian middle years students: identity, relationships, purpose, empowerment, success, rigor, and safety (p. 55). These needs have pedagogical implications for the way teachers construct the classroom learning environment, such as, how the teacher provides opportunities for students to develop productive and affirming relationships with adults and peers in an environment that respects difference and diversity, and acknowledging that success requires allowing students to use their talents and expertise when learning valued knowledge and skills.

Similarly, the MYRAD project (Centre for Applied Educational Research, 2002) identifies relationship development as being important for student well-being and engagement, particularly teacher–student relationship. In particular, messages from the project acknowledge that for these students, how a teacher teaches and relates with his or her students has a strong bearing on student engagement with learning. Consequently, the report states that "[t]here is a need to move right inside the classroom, to illustrate the actual teaching–learning approaches and practices that are successfully directed to the learning outcomes for the knowledge society" (Centre for Applied Educational Research, 2002, executive summary). Capturing the essence of these pedagogies as exemplars or case studies can inform practicing teachers and teacher educators.

In Victoria, the Science in Schools (SIS) Research Project has assisted in understanding the nature of effective teaching and learning in science (see, for example, SIS Project Team, 2003; Tytler, 2003). The research has shown that changed teaching practices at the participating schools have resulted in more positive student attitudes towards science (SIS Project Team, 2003). Elements used by the SIS Project to measure students' attitudes highlight two aspects of the students' science experience: engagement with learning (and could include the SIS elements of "enjoyment of science," "motivation to succeed in science," "usefulness of science"), and teacher pedagogy (including the SIS elements of "teacher enthusiasm," "teacher responsiveness," "quality of feedback," "openness of the teacher and classroom"). Represented in these elements of what is considered to be effective are instructional and relational aspects of pedagogy as identified in the current research.

While directions for both middle years and science education clearly acknowledge the intrinsic relationship between a teacher's pedagogy and the level of engagement that his or her students have with learning, explification of the relationship between the relational and instructional dimensions of pedagogy may be important to help understand exactly what students are talking about when they refer to how the teacher can assist them in learning.

Conclusion

In attempting to understand how the teacher can help students engage with learning, two distinct dimensions to the teacher's pedagogy were identified by the analysis: instructional and relational. While no clear distinction was made by the students, my analysis drew on the interview data and evidence from the classroom to construct these two pedagogical dimensions. In doing this, my intentions were twofold: firstly, to highlight the various components of a teacher's pedagogy that can impact on student learning; and secondly, to highlight that the relational dimension of teaching was as important to many of these students in getting them to the point of understanding as was the depth of the teacher's ability to present concepts in an understandable way.

There is growing evidence in research of the fundamental nature of the student–teacher relationship in engaging student learning, not only in the science education context. The findings reported in this paper add to this body of literature practical descriptions of what students identified as drawing them into the act of learning: instructional methods founded on students constructing their own knowledge; and the nature of the personal interaction between teacher and student that lies at the heart of the teaching act. These examples have the potential to enhance teacher education and the way science is taught in schools. They provide *real* examples of how a "language of responsive teaching" (Hogan & Pressley, 1997, pp. 89–90) can be used to scaffold student learning, emphasising the social nature of this particular classroom in the construction of conceptual understanding.

While I acknowledge that both relational and instructional dimensions are part of the same teaching act, by dichotomising the pedagogy of the middle years teacher into relational and instructional I hope to highlight that, for these students entering secondary school science, how the teacher related to them on a personal level had as much effect on how they perceived the teacher's involvement in their learning as did the way the teacher instructed the science content. Students and teachers are in a constant state of interaction, where teachers always have some influence on students, whether it is the teacher's intent or not (van Manen, 1999). Fraser (1994) asserts that the teacher and the environment affect each other. Through this interaction, the teacher and the students expose something of themselves, whether intended or not. What is also fundamental is that "students tend to experience instructional relations as personal relations" (van Manen, 1999, p. 23), suggesting that instructional pedagogy cannot be isolated from the relational pedagogy. With this in mind, the interpretations of this study support the recommendation that a teacher of the middle years be aware of how their relations with students during instruction, whether intended or not, affect opportunities for learning.

Notes

1. A project by the Centre for Applied Educational Research (2002), a Victorian project funded by the Department of Education and Training.

2. Throughout the remainder of the paper the student voice will be labeled in the following way: [Interview #] for voices from interviews, with the # indicating in which of the four school terms the interview took place; and [Class observation] indicating an excerpt or construction from an observation.

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References

Australian Curriculum Studies Association. (1996). *From alienation to engagement: Opportunities for reform in the middle years of schooling*. A three-volume report of a national research project. Canberra, ACT: ACSA.

Barratt, R. (Ed.). (1998). Point and counterpoint. The future: The shape of middle schooling in Australia. *Curriculum Perspectives, 18*(1), 53–75.

Bennett, J. (2003). *Teaching and learning science*. London: Continuum.

Biggs, J. B., & Moore, P. J. (1993). *The process of learning* (3rd ed.). Sydney: Prentice Hall.

Campbell, J., Smith, D., Boulton-Lewis, G., Brownlee, J., Burnett, P. C., Carrington, S., et al. (2001). Students' perceptions of teaching and learning: The influence of students' approaches to learning and teachers' approaches to teaching. *Teachers and Teaching: Theory and Practice, 7*(2), 173–187.

Carr, M., Barker, M., Bell, B., Biddulph, F., Jones, A., Kirkwood, V., et al. (1994). The constructivist paradigm and some implications for science content and pedagogy. In R. F. Gunstone & R. T. White (Eds.), *The content of science* (pp. 147–160). London: The Falmer Press.

Carspecken, P. F. (1996). *Critical ethnography in educational research: A theoretical and practical guide*. New York: Routledge.

Centre for Applied Educational Research. (2002). *Middle Years Research and Development (MYRAD) Project. Executive summary. February–December 2001*. (Report to the Learning & Teaching Innovation Division, Department of Education & Training by the Centre for Applied Educational Research, The University of Melbourne.) Retrieved June, 2003, from Victorian Department of Education and Training, SOFWeb Web site: `http://www.sofweb.vic.edu.au/mys/docs/research/MYRADExecSummary.doc`

Department of Education, Employment & Training. (1999). *The middle years: A guide for strategic action in Years 5–9*. Melbourne, Victoria: DEET.

Department of Education, Science & Training. (2003). *Australia's teachers: Australia's future. Advancing innovation, science, technology and mathematics. Main report*. Canberra, ACT: Australian Government.

Erickson, F. (1986). Qualitative methods in research on teaching. In M. C. Wittrock (Ed.), *Handbook of research on science teaching* (pp. 119–159). New York: Macmillan.

Ferguson, P. D., & Fraser, B. J. (1998). Student gender, school size and changing perceptions of science learning environments during the transition from primary to secondary school. *Research in Science Education, 28*, 387–397.

Fraser, B. J. (1990). Students' perceptions of their classroom environments. In K. Tobin, J. B. Kahle, & B. J. Fraser (Eds.), *Windows into science classrooms: Problems associated with higher-level cognitive learning* (pp. 199–221). London: The Falmer Press.

Fraser, B. J. (1994). Research on classroom and school climate. In D. Gabel (Ed.), *Handbook of research on science teaching and learning* (pp. 493–541). New York: Macmillan.

Fraser, B. J., & Tobin, K. (1990). *Environments for learning science and mathematics* (Key Centre Monograph Number 2). Perth, WA: Key Centre for School Science and Mathematics.

Goetz, J. P., & LeCompte, M. D. (1984). *Ethnography and qualitative education research*. Sydney: Academic Press.

Goodrum, D., Hackling, H., & Rennie, L. (2001). *The status and quality of teaching and learning of science in Australian schools*. Canberra, ACT: Department of Education, Training and Youth Affairs.

Hand, B., Treagust, D., & Vance, K. (1997). Student perceptions of the social constructivist classroom. *Science Education, 81*, 561–575.

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

Hanrahan, M. (1999). Rethinking science literacy: Enhancing communication and participation in school science through affirmational dialogue journal writing. *Journal of Research in Science Teaching, 36*(6), 699–717.

Harlen, W. (1999). *Effective teaching of science*. Edinburgh, Scotland: Scottish Council for Research in Education.

Henderson, D., Fisher, D. L., & Fraser, B. J. (2000). Interpersonal behaviour, laboratory learning environments, and student outcomes in senior biology classes. *Journal of Research in Science Teaching, 37*(1), 26–43.

Hogan, K., & Pressley, M. (1997). Scaffolding scientific competencies within classroom communities of inquiry. In K. Hogan & M. Pressley (Eds.), *Scaffolding student learning: Instructional approaches and issues* (pp. 74–107). Cambridge, MA: Brookline Books.

Miles, M. B., & Huberman, A. M. (1984). *Qualitative data analysis: A sourcebook of new methods*. Newbury Park, CA: Sage Publications.

Noddings, N. (1993). Constructivism and caring. In R. B. Davis & C. A. Maher (Eds.), *Schools, mathematics and the world of reality* (pp. 35–50). Boston: Allyn and Bacon.

Oldfather, P. (1994). *When students do not feel motivated for literacy learning: How a responsive classroom culture helps* (Reading Report No. 8). Athens, GA: National Reading Research Centre, Universities of Georgia and Maryland.

Oppenheim, A. N. (1992). *Questionnaire design, interviewing, and attitude measurement*. London: Pinter Publishers.

Roehler, R., & Cantlon, D. J. (1997). Scaffolding: A powerful tool in social constructivist classrooms. In K. Hogan & M. Pressley (Eds.), *Scaffolding student learning: Instructional approaches and issues* (pp. 6–42). Cambridge, MA: Brookline Books.

Shulman, L. S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher, 15*, 4–14.

Shulman, L. S. (1987). Knowledge and teaching: Foundations of the new reform. *Harvard Educational Review, 57*(1), 1–22.

SIS Project Team. (2003). *The science in schools research project: Report on phase 3*. Melbourne, Victoria: Deakin University Consultancy and Development Unit.

Speering, W. (1995). Great expectations: Science in the secondary school. In M. W. Hackling (Ed.), *Proceedings of the 20th annual conference of the Western Australian Science Education Association* (pp. 99–104). Mount Lawley, WA: Edith Cowan University Department of Science Education.

Speering, W., & Rennie, L. (1996). Students' perceptions about science: The impact of transition from primary to secondary school. *Research in Science Education, 26*(3), 283–298.

Taylor, P. C., Fraser, B. J., & Fisher, D. L. (1997). Monitoring constructivist classroom learning environments. *International Journal of Educational Research, 27*, 293–302.

Tobin, K., Tippins, D. J., & Gallard, A. J. (1994). Research on instructional strategies for teaching science. In D. Gabel (Ed.), *Handbook of research on science teaching and learning* (pp. 45–93). New York: Macmillan Publishing Company.

Treagust, D., & Harrison, A. (1999). The genesis of effective scientific explanations for the classroom. In J. Loughran (Ed.), *Researching teaching: Methodologies and practices for undertaking pedagogy* (pp. 28–43). London: Falmer Press.

Tytler, R. (2002, October). *Effective science teaching and learning: A value position?* Paper presented at the Values Conference, Monash University, Clayton, Victoria.

Tytler, R. (2003). A window for a purpose: Developing a framework for describing effective science teaching and learning. *Research in Science Education, 33*, 273–298.

van Manen, M. (1990). *Researching lived experience: Human science for an action sensitive pedagogy*. London: The Althouse Press.

van Manen, M. (1999). The language of pedagogy and the primacy of student experience. In J. Loughran (Ed.), *Researching teaching: Methodologies and practices for understanding pedagogy* (pp. 13–27). London: Falmer Press.

Varelas, M., Luster, B., & Wenzel, S. (1999). Meaning making in a community of learners: Struggles and possibilities in an urban science class. *Research in Science Education, 29*(2), 227–245.

Watts, M., & Bentley, D. (1987). Constructivism in the classroom: Enabling conceptual change by words and deeds. *British Educational Research Journal, 13*(2), 121–135.

Weinstein, R. S. (1983). Student perceptions of schooling. *Elementary School Journal, 83*(4), 286–312.