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ABSTRACT

Research in the form of a case study explores the factors that influenced physics enrollment in year 11 of a group of students taught over three consecutive years, from year 8 to year 10 in a New South Wales country school. The findings reveal that students who enjoyed their learning experiences in junior science and achieved good results in science were confident in their ability and more likely to enroll in physics. Positive interpersonal; teacher behavior, together with an innovative curriculum, which includes fun and mentally challenging activities, contributed towards shaping positive attitudes to science and science careers. The role of strategic teaching was significant in increasing physics enrollment. Interview questionnaire is appended. (Contains 15 references.) (Author/YDS)

Increasing Physics Enrolment in Year 11

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Abstract

Research in the form of a case study explores the factors that influenced physics enrolment in Year 11 of a group of students taught by the teacher-researcher over three consecutive years, from Year 8 - Year 10 in a NSW country school. The findings reveal that students who enjoyed their learning experiences in junior science and achieved good results in science were confident in their ability and more likely to enrol in physics. Positive interpersonal teacher behaviour, together with an innovative curriculum, which includes fun and mentally challenging activities, contributed towards shaping positive attitudes to science and science careers. The role of strategic teaching was significant in increasing physics enrolment.

Introduction

Within Australia, physics enrolment has declined over the last 10 years. From 1991 to 1996, physics enrolment at my high school remained low, varying between six and eight students. However, in 1997, the enrolment more than doubled to nineteen students.

This paper outlines a case study that explored factors, which influenced physics enrolment in Year 11 for a class that I taught over 3 consecutive years. It highlights the significant role that 'strategic teaching' played in influencing physics enrolment in Year. 11. In keeping with qualitative research (Merriam, 1988), I have used the first person voice throughout this paper.

Background

As an experienced science teacher (Shulman, 1986), I believed that there were at least 20 students in any Year10 group (20% of average enrolment), who would have the ability to successfully study physics. But some teachers believed that students would choose physics only if they had to, that is, because university courses required it (Fensham, 1980; Toews, 1988).

As a physics teacher, I believed I could influence the subject choice of my students by targeting desired outcomes through 'strategic teaching'. My definition of *strategic teaching* is teaching to achieve a set goal. My goal was to increase physics enrolment in Year. 11.

While I did not sit down to formally plan my objectives, strategies, resources or the roles I had to play, I had set my goal and time frame. My everyday professional judgment in decision making and planning, based on an ongoing reflective process as an enthusiastic and experienced science teacher, enabled me to think on my feet and to plan and adjust plans when necessary.

My beliefs and strategic teaching objectives

One of my objectives was to request a top class in Year 8 because I believed that *early intervention* can assist in developing good learning habits, positive attitudes to science, and academic

achievement. My view of curriculum is similar to Kliebard's (1972) three root metaphors in curriculum image: *production* "...envisions the student as raw material to be transformed..."; *growth* "..perceives the teacher as an insightful gardener..." who carefully nurtures the students to full bloom; and *journey*, where "..the teacher is a tour guide who leads students through a terrain rich in knowledge, skills, ideas, appreciation and attitudes" (as cited in Schubert, 1986).

I also believed that an enjoyment of science learning through:

(i) an innovative yet mentally challenging curriculum, by
(ii) using desired outcomes-based teaching strategies, which are
(iii) enhanced by positive interpersonal teacher behaviour,

would result in positive attitudes and high achievement outcomes in science, which would in turn increase physics enrolment in Year 11. My beliefs/perceptions are based on ongoing critical reflection of my own teaching and observations of science teaching and learning.

I believe the starting point for 'grooming' potential physics students has to begin in Year 7 or Year 8 (Crawley & Black,1992). I also believe that this 'grooming' process has to be consistent and sustained for a period of three years. Metaphorically, I saw myself as a *strategist*, employing analysis, tactics, and calculated moves to combat low enrolment in senior physics (Shulman, 1986).

Purpose of the Study

The purpose of this study was to explore the factors that affected my students' decision to enrol in physics. These factors were based on my own perceptions and assumptions made known earlier.

The study assessed the efforts I made to foster positive attitudes to science, positive learning environment/classroom climate, and high achievement outcomes. It also assessed whether curriculum played a part in shaping the students' attitudes and achievement outcomes. It investigated why my students chose to study physics.

Significance of the Study

The findings of this study reveal whether and how a science teacher can positively influence students' subject choice, in particular physics. The implications of this study are of interest to science teachers, in particular physics teachers, teacher-educators and science educators in general.

Methodology

Based on my research focus and goals, I adopted an interpretive case study approach, based upon a paradigm that assumes there are multiple realities and beliefs, rather than facts, forming the basis of perception (Merriam, 1988). A case study does not claim any particular methods for data collection or data analysis (Merriam, 1988). Methodological triangulation, which combined dissimilar methods to study the same unit was employed, so that the weaknesses of one method can be compensated by the strengths of another (Denzin, 1970; in Merriam, 1988). My use of qualitative methods such as participant observation and interviews, and quantitative methods such as surveys and official documents enabled both subjective and objective dimensions to be compared.

Data collection included two questionnaires – a short version of the Questionnaire on Teacher Interaction (QTI) developed by Wubbels and Levy (1993) to assess teacher interpersonal behaviour in the classroom and a self-designed questionnaire referred to as Questionnaire 'B', to assess teaching strategies and reasons for enrolling in physics (this included open-ended questions and room for comments). These questionnaires are attached in the Appendix.

Student interviews were conducted to probe and crosscheck interpretations from participant observation of events that took place in the classroom. The sample came from 10 volunteers that made up four groups. Grouping was based on matching time schedules. Interview questions stemmed from Figure 1, which is based on my hypothesis about the possible outcomes of good science teaching. It developed as a result of my reflective teaching. Due to the nature non-directive group interviewing, the prepared questions were used only as a guide (a copy of the interview questions is attached in the Appendix). Despite the strengths of good rapport, a weakness of interviews is the danger of the teacher-researcher having a 'power' over the students to influence their perspectives of the situation. However, my students have always in the past been ready to argue their point, so therefore, I doubt my 'power' in such a situation is of significant influence. An advantage of informal group interviewing is the potential for discussions to develop thereby reducing bias. The interviewees checked the transcripts after the interviews.

The strengths of a case study are its ability to answer my research questions. Of crucial importance are the perspectives of the students that are unique in this case. But, as with any research approach, there are also limitations in its usage. ."Case studies can oversimplify or exaggerate a situation, leading the reader to erroneous conclusions about the actual state of affairs" (Guba & Lincoln, 1981, p.377; in Merriam, 1988, p.33). *Readers need to be aware that it is a study based on a particular case within a specific context.*

Strategic teaching for desired outcomes – some examples

1. The Teacher's roles

I believe that teachers can influence students' aspirations by constantly enthusing them in their learning of science and exposing them to the myriad of career options in science. The role of the teacher is significant (Sobolewski, 1993), because I could 'market' my product (science) to a captive audience (students). If I 'market' it well, over an extended period of time, I could see a rise in the number of 'consumers'. In other words, I, as the teacher could strategically plan my teaching in such a way as to make science, and in particular physics, attractive, fun and achievable to increase enrolment in physics in Year 11.

2. *Early Intervention*

In Australia, to be a high achiever in school is not a popular choice, but I have noticed that within a relatively homogenous group, such as in a class of high achievers, students do value achievement, especially when it is reinforced by peer approval, teacher approval and school approval (ie, a reward system). Because good habits can be inculcated through teaching, role modeling and peer reinforcement, I believed that students could be taught to value science learning and academic achievement from a young age (Kliebard, 1972; cited in Schubert, 1986).

Although it is easy to enthuse Year 7 students, it takes much more effort to sustain that enthusiasm in science up to Year 10. Studies reveal that the longer science is studied, the less popular it becomes (Fensham,1998; Crawley & Black,1992). It is important then that Year 10 students continue to enjoy their science lessons (Novak, 1981; White & Tisher, 1986; West & Pines,1983, in Fensham 1988) and in particular physics, because it is during this time that they start to think about subject choices for Year 11. Figure 1 portrays my perspective on the factors that influence good teaching and the types of learning outcomes that lead students to choose a career in science.

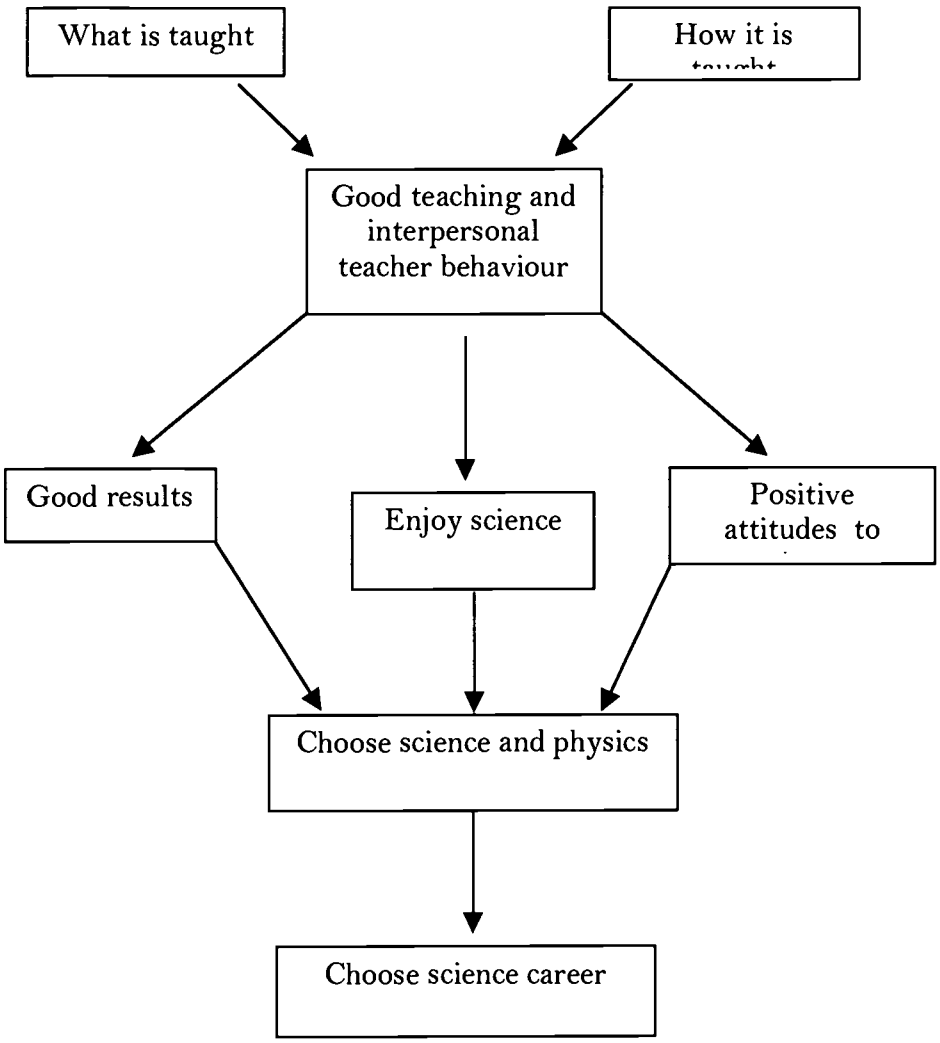
3. *Enthusiasm in teaching and high expectations*

Teaching strategies were aimed at enthusing challenging and encouraging students, as well as enabling them to enjoy science. I encouraged a high standard of work and high achievement by helping students to understand science concepts and by rewarding them with chocolate bars and merit certificates. Physics has tended to amaze students because of intriguing phenomena that can be observed, especially when the results of classroom experiments are contrary to students' expectations. If a teacher is enthusiastic about physics, it adds to the excitement of learning and students can be further challenged; but if a teacher is unenthusiastic, it can dampen the excitement and not encourage interest (Franz, Aldridge & Clarke, 1983; cited in Sobolewski, 1993).

4. *Enthusing my students in physics – some examples*

Machines was taught in Year 8. In one of the practicals, the challenge was for students to find out whose arm could lift the heaviest load. Students were taught to calculate force using the Principle of Moments. The competition was keen, to find out who would be the champion and what each one's personal best might be. I was teacher, participant, cheerleader, challenger, judge and encourager (Wubbels, 1993). To encourage creativity, students had to make a model of a movable arm, using elastic bands for muscles and then to explain how their model worked. There were some excellent creative designs submitted. Year 8 culminated with a visit to the Science Centre in Canberra, to immerse students in and expose them to the wonders of science.

Figure 1 A Flow Chart on Good ScienceTeaching and its Outcomes



Electricity was introduced in Year 9. The Van de Graff generator produced lots of fun time, where only the brave got to light the Bunsen burner with the touch of a finger or experience the flow of electricity by holding hands in a row. Electrostatics experiments continued to amaze by bending water, making bits of paper dance and causing hair to stand on end. Group discussions on what to do in the event of a lightning strike while out on a picnic proved to be valuable. Investigations were carried out to test if an insulator was really an insulator, by employing meters of different sensitivities. Investigative pracs studied the effect of series and parallel connections of resistors, and the heating, chemical and magnetic effects of electricity were well received by students.

In *Light and Sight*, students experimented with pin-hole cameras, ray boxes and lenses, mirrors, and colour filters. The students were very impressed with their pin-hole cameras and were thrilled with the clear coloured images of the different parts of their school in view. They were equally thrilled with the dispersion of light using a prism. Straight paths for light changed to non-linear paths when a laser beam entered a bent glass tube, and reflection began to take on a new meaning. There was a challenge to see how many mirrors could be used to keep on reflecting a laser

beam. Students' knowledge of colour mixing with pigments in art class caused some arguments when it came to colour mixing with light. They were adamant that their prior knowledge in art was correct!

Motion is usually the final topic in Year 10, and therefore crucial in promoting interest in physics for Year 11. I introduced the topic with outdoor activities: running, walking and wheelbarrow races, checking the speed of cars and dropping objects from the third floor balcony. This relaxed approach was appreciated by all, especially after the school certificate exams. After that, they were quite ready to carry out some serious investigations with trolleys and ticker timers. Dummy car crashes were used to investigate inertia and seat belt safety, and static and sliding friction in anti-brake locking systems. I even inspired them to do the table-cloth trick. Some introductory Year 11 physics was incorporated to give them a taste of things to come.

5 Challenges in physics

I began to slowly introduce to my students physics concepts not normally taught until Year 11 or 12, to whet their appetite for senior physics. To present physics as an interesting and challenging subject in itself was important because students' cognitive preferences plays an important role in subject choices in science and mathematics (Malone & Cavanagh, 1997, Teows, 1988).

Solenoids and magnets were used in activities to demonstrate the conservation of energy in producing electricity, and what happens when a solenoid becomes a magnet – the nature of its polarity and magnetic strength. Demonstrations were conducted, such as electrical conduction in conductors other than metal wires, as in low-pressure gases (which produce our neon lights), the spectacular Maltese cross tube and in liquid metal such as in mercury.

6 Extra curricular activities

I believe that quizzes, debates excursions and enrichment classes are good strategies for encouraging interest in science. The end of Year 10 culminated in a quiz which I named, 'The Revenge of the Nerds'. My motto for this class had been 'Dare to be a Nerd' - in other words, stand tall, tall poppy. I wanted to impart the feeling that it was alright to be a 'nerd' and to have fun learning challenging subjects, even though I knew that students hated to be associated with the term 'nerd'. I think I succeeded, because we laughed about the term, and they took pride in being a smart class. We were proud of our buzzer system that we had made for the quiz. There were quarter-finals, semis and finals. Questions came from the CSIRO Helix quiz book and I acted as the quiz-master. Amid the cheers, laughter, thumping of desks, the sounds of buzzes ringing and lights flashing, the quiz was an exciting finish to the year. The students and I really enjoyed those moments.

7. *Exam techniques*

I believe that exam marks play an important part in influencing physics enrolment (Crawley & Black, 1992). However, I was disappointed with my students' Year 10 trial exam results. My analysis revealed an unnecessary loss of marks due to poorly explained answers in the free response sections. I began to stress the correct usage of scientific terms in their explanations and in expressing answers clearly and concisely. These exam techniques were practiced diligently and the result was an increased number of 'A' and 'B grades'.

Results and Discussion

Only a summary of the results is presented in this paper due to space. Quantitative results are presented in the form of tables and figures, while qualitative results are presented as vignettes or descriptions.

1. *Results from Questionnaire 'B'*

Table 1: Responses to Question 1

1.This teacher treats boys and girls equally in terms of:	True (%)	False (%)
equipment in practicals	89	11
help in practicals	100	
help with a problem in your work	100	
taking a personal interest in students	89	11
showing care and concern	94	6
encouragement and praise or rewards	89	11
discipline or punishment	83	17
not showing favouritism	89	11

Table 2: Responses to Question 2

2. This teacher encourages you to	True(%)	False(%)
work hard and not waste time	100	
Be honest in all your work and in your practical results	100	

strive to do your best, to reach your potential	100	
Be considerate to each other	100	
cooperate with each other	100	
think of solutions to problems	100	
Be thoughtful and creative about your work	89	11
ask questions in class	100	

Table 3: Responses to Question 3

3. The practical work you do in class: (Figures are actual numbers for n = 18)	Never 0	1	2	3	Always 4
reinforces what is being taught in class	0	1	0	11	6
is helpful in understanding the theory taught	0	0	3	5	10
is carried out to investigate a problem	0	0	0	8	10
is to explore what happens (controls and variables)	0	0	0	8	10
is to help me learn practical skills	0	0	1	5	12
is to help me think about evidence to draw conclusions	0	0	2	8	8
is used to teach me something new	0	0	6	9	3
is based on a reward /punishment system	4	10	4	0	0
is sufficient in quantity for its purposes	0	1	5	8	4
is just for the fun of it	2	11	4	1	0

These results showed that students perceived me as being fair in class, encouraging and providing positive learning experiences in practical lessons. They seem to indicate that my strategic teaching for desired outcomes such as instilling good learning habits through role modeling and encouragement has been successful.

Table 4 : Response to Question 4

Students' reasons for choosing physics	Percentage	Rank
You think you have the ability to do it	89	1
You have done well in science in your junior years	83	2
You found it challenging	83	2
You are naturally interested in the subject	78	3
You have to, because of university requirements	72	4
You enjoyed studying it in your junior years	56	4
Your teacher encouraged you to do it	56	4

Note: 'ability to do it' denotes confidence in handling the rigour of physics. 'enjoyed studying it' was later found (cross-checking from interviews) to be a negative connotation because the word *study*, implied hard work and thus not enjoyable.

The results showed that students' reasons for choosing physics were valid reasons (Toew, 1988). The surprising outcome was that the reason 'ability to do it' had the highest frequency (89 %), which agreed with the findings in Crawley and Black's study (1992). I was also surprised by the results that students' perceptions, that 'physics is challenging', and their 'natural interest in physics' both rated more highly than 'university requirements'(Malone & Cavanagh, 1977). The impact of such personal beliefs on physics enrolment (Crawley & Black, 1992) indicated that the students were much more in control of their subject choice than I thought.

Question 5. *If your university entry did not require you to study physics, would you still have chosen it?*

In fact, 89% of the students indicated that they would choose physics even if it was not required for university entry, which coincided with 'ability to do it'(89%) in Table 4. Could it be that my early intervention strategies (Crawley & Black, 1992) had been successful in shaping some of their beliefs?

Question 6. *Physics students' reasons for choosing to do more than one science subject in Year 11.*

83% (15/18) had chosen one or more science subject apart from physics. Of these 18 students, 50% (9/18) selected Chemistry , 17% (3/18) selected Biology and 17% selected Engineering science. Reasons given were: enjoyed science in junior years, prefer science to other subjects, like science and want to pursue science career, science is challenging, related to interests/ future study, it was recommended, more options later. Enjoyment was not just 'fun' learning experiences, but also the satisfaction of the mental challenges and rewards of achievement as supported by the responses in the interview as well. (Note: No student had selected three science subjects.)

Question 7. *What factors helped you to decide on doing science in Year 11?*

The factors have been categorized and ranked in decreasing order:.

1. Good results in Year 10
2. Enjoyed science and University related requirements
3. Ambition related

(Note: 'university' and 'enjoyment' ranked equally, closely followed by 'ambition'.)

Question 8. *If you have chosen to do a science subject in Year 11, does that mean that you are interested in a career based on science?*

To the question 44% (including all the girls) indicated a definite interest in a science career. In this case the girls seemed more definite once they knew where their interests lay. Choosing a science career is a result of enjoying science as mentioned in the interview.

Question.9. *What factors have helped you to become interested in a career based on science?*

The factors were categorized and ranked in decreasing order:

1. Positive experiences in junior science
2. Personal interests or ambition
3. Results in science
4. Teachers
5. Good teaching

These results tend to support my hypothesis in Figure 1 about the possible outcomes of good science teaching, one of which is choosing a science career.

Table 5: Responses to Question 10.

How students rated the teaching/learning strategies in terms of being helpful to their enjoyment of science in years 8 to 10.

Teaching/learning strategy	Enjoyed (%)	Helpful (%) value (%)
Science quizzes	83	67
Practical demonstrations	78	61
Outdoor activities	72	78
Debates	72	78
Excursions	72	56
Practical lessons	72	89
Group work	61	89
Video lessons	33	83
Library research	28	83
Science projects	28	44
Australian Science Competition (past papers)	22	50
Worksheets	17	89
Chalk and Talk	17	94
Questioning	17	78
Oral presentations	17	67
Exam technique/preparation	6	94

The findings revealed that the students have two sets of values when it comes to teaching/learning strategies. The least enjoyed strategies such as chalk and talk and exam techniques, which are designed to improve understanding of concepts and maximize test scores, were found to be the most helpful towards their enjoyment of science in the junior years. This can be understood by their remarks in the interviews when students equated success and achievement to enjoyment of science. Most students also found their worksheets contributed highly to their enjoyment in science. This again can be attributed to the mental challenge that well chosen worksheets can provide and the sense of achievement that results from doing well in them. Library research and videos contributed

to their enjoyment of science even though they did not enjoy these strategies perhaps because they were a change from 'hard work'. Library research provided a choice in learning, a more relaxed environment and chance for informal interaction.

2. *Exam Results*

Table 6: Results of the Year 10 School Certificate exams

Year/ Grade	A	B	C	D	E	Number enrolled in physics the following year
1993	7	16	38	28	12	6
1994	5	15	27	21	14	8
1995	7	19	35	29	10	6
1996	12	17	41	26	7	19

All grade 'A' students enrolled in physics in 1997, including 5 girls. This supports the results from Questionnaire 'B' and the interview responses, that science results do influence physics enrolment (Crawley & Black, 1992). Good results reinforced that confidence in their ability to handle the rigor of physics.

3. *Results from interviews*

The following is a summary of responses which provided a rich description of the classroom situation, to further assess students' values, beliefs, and preferences, and to fill in gaps left by questionnaires or to identify new variables or relationships, which I might have missed. It was also used to follow-up unexpected results to the questionnaires.

Question: What do you think good teaching means?

'You are able to learn easily, is fun and you like the subject';
'Where the teacher teaches at your level, not above or below you,
'Lots of activities, practicals'; 'Not a lot of writing'; 'Good discipline';
' Got to be interesting ....'; 'Good communication with students';
'And in the senior years, there's got to be mutual respect, teachers have to give it too'.

Good teaching according to students was a balance of good discipline with mutual respect, where there is variety in learning and pitched at the right level.

Question: Which is more important for learning: teacher behaviour, what is taught, or how it is taught ?

'How it is taught, if you can understand, it is more important than teacher behaviour, like combining theory, prac, explanation, demonstration';
'What is taught is most important,...if you don't get the right material, you're not going to learn anything - followed by how it is taught and lastly teacher behaviour';
'Teacher behaviour is pretty important, they are all probably the same';
'If a teacher likes the subject, ... the material is better, she knows what she's teaching, teaches it better, easier to understand'
'..but some students can't put up with the teacher, so they won't listen to the teacher'; '.. so they don't try'

'What is taught' was perceived as excellent and challenging content and 'how it is taught' was perceived as students achieving understanding, promoting interest and fun. 'Good teacher behaviour' was perceived as teacher being friendly, helpful and understanding, and offering mutual respect. The thought that the three factors are closely linked cropped up many times as they discussed the factors. How it is taught seemed to win the majority vote, however, most believed that all three factors are important and interrelated. Getting on with the teacher was a prime concern among the students.

Question: Do you think enjoyment is more important than good results?

'You've got to be enjoying it to get good results'
'If you don't enjoy it, you're not going to be bothered working hard'
'Positive attitude relates to enjoyment'
'Positive attitude relates more to teacher behaviour, if a teacher keeps putting you down, always asking a question he knows you can't answer to make a fool out of you....'.
'..you might really enjoy it, but you might be really pathetic at it, so then you won't get good marks, then it would be pointless doing it'. 'Then again, if you enjoy it, you are going to study hard to get better marks.
'But if you don't enjoy science, why are you choosing science for a career, got to enjoy it too otherwise you're not going to get much out of the uni course'
'Good marks make you enjoy it more, if you are good at it, even if you don't like how it's taught, you enjoy it if you can see your achievements more'.

They all agreed that positive attitude and enjoying science are similarly related to teacher behaviour. These results are related not only to good teaching but teacher behaviour as well. While enjoyment is related to teacher behaviour, positive attitude is also related to good results and therefore, is affected by both good teaching and teacher behaviour. *Attitude*, according to the students, is explained in terms of 'feeling good about yourself'; and they feel good if they have good results and 'if the teacher does not put you down or makes a fool of you by asking you questions he knows you can't answer'. All agreed that attitude and enjoyment would suffer with poor teacher behaviour, and some said that results might be affected due to not wanting to learn.

Question: Can you describe your class?

'Noisy, bright people, if it was a prac, every one is happy and talking'; 'Content'; 'Cheerful', 'Well behaved, listening or talking when they are working, and happy';
'Everybody probably understands what's going on and not stressed out, and can learn easily so they are happy'; 'If a lot of other people can understand what's been taught and then they can't, then they think they are dumb, they might be stressed';
'We can get along with you better than the other teachers';
'...like you sort of took an interest in what you're teaching and whether we were learning or not';
'You covered all the angles - for those who were smart and those who were not so smart, you took it from different perspectives, different ways of attacking problems so we can pick which is easier';

Question: Do you think that as a group you had an effect on each other?

'Grouping affects the environment and enjoyment of the class'; 'We were all friends and on the same level, the odd people (or odd bods) put you off the work'
' our year has a whole heap of smarter people always doing well...'
'If you've got competition, you have to work harder, and the other person works harder';

The 'group' factor affects group dynamics within a class. It can affect the learning environment by reinforcing or hindering effective learning and quality time during a lesson. However, it would be naïve not to include the teacher as a key person in the 'group'.

Question: Why were these most enjoyed strategies: debates, excursions, group work, pracs and quizzes?

'Fun!'; 'More willing to do something if fun', 'competition'; 'It got everyone going'.
'... you get to interact with each other', 'They are a change from theory all the time, we're getting out of the classroom, like debates, you're getting other people's ideas'.
'It is a fun break from work, ...made it more interesting in science, and therefore you worked harder on the written work'.
'I liked the practicals, seeing it happen, like reactions, not just writing about chemical reactions'., 'Pracs are really good, helped with understanding'.

The results of the QTI were sent to Curtin University for analysis and plotted as sector profiles as shown in Figure 3. Figure 2 shows the Model for Interpersonal Teacher Behaviour (Wubbels, 1993)

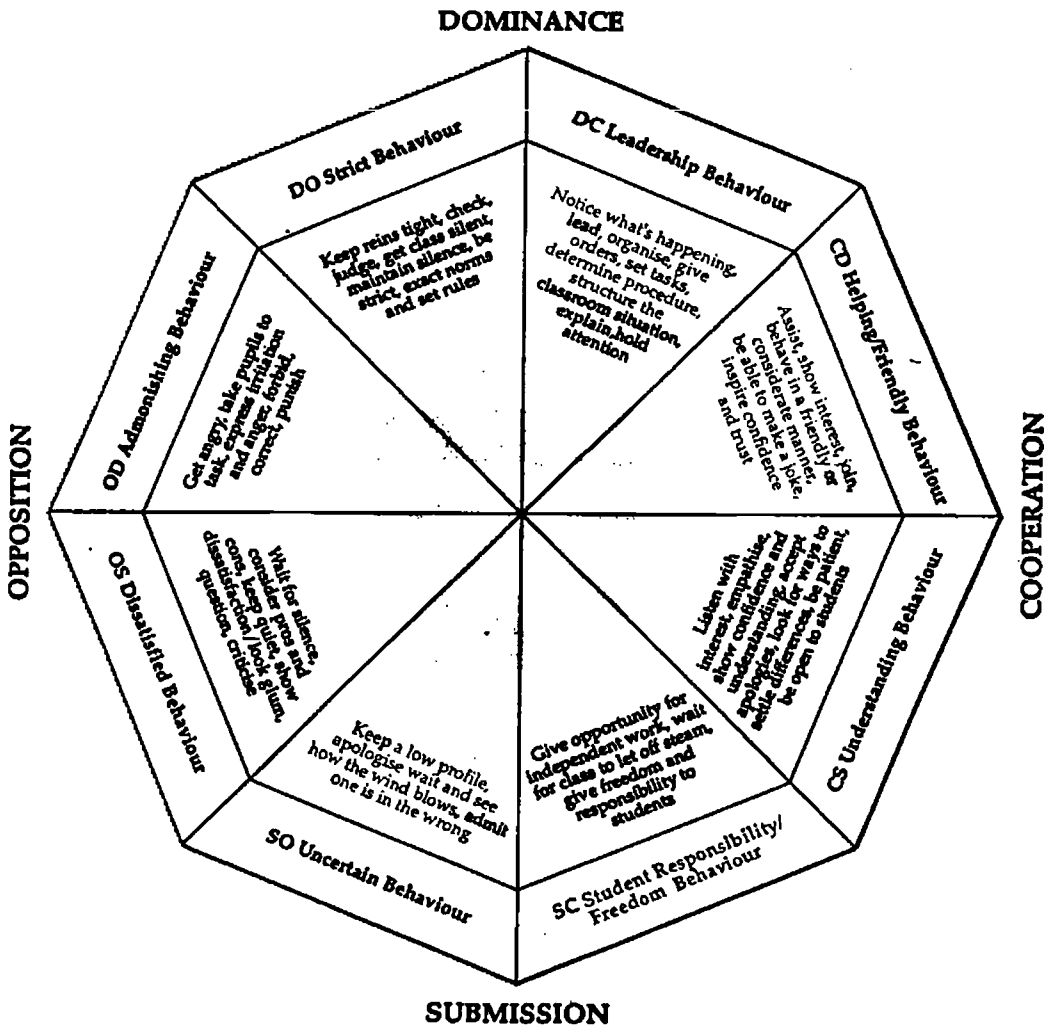
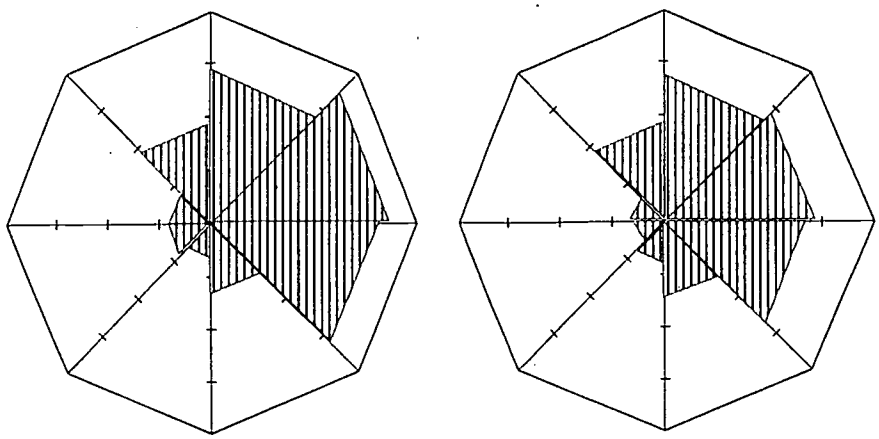


Figure 2: Model of Interpersonal Teacher Behaviour (Wubbels, 1993)

How the average teacher sees themselves and how their students see their teacher



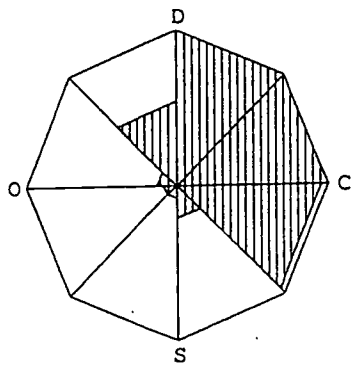
Average Teacher (Self Perceptions)

Average Teacher (Student Perceptions)

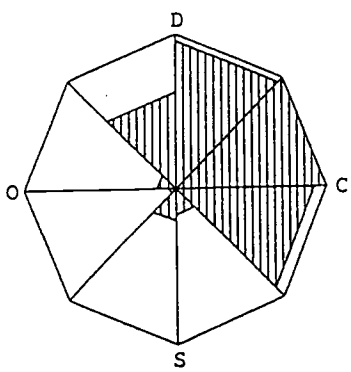
An Australian sample of 792 students and their 46 science and mathematics teachers.

Figure 3: Comparison Profiles (Wubbels, 1993)

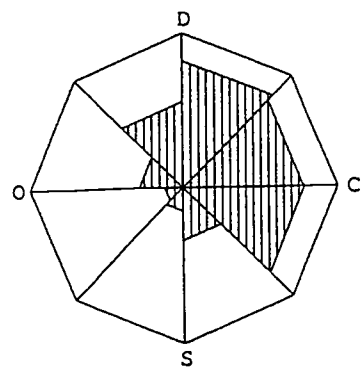
'Best teachers, according to their students, are stronger leaders, more friendly and understanding and less uncertain, dissatisfied and admonishing than teachers on average. Best teachers also give students a little bit more responsibility', (Wubbels, 1993, p.5).



My Ideal Teacher Profile



How I see Myself



How my students see me

My students' perception of me fits the 'best teacher' profile, and this is supported by results from Questionnaire 'B' and their interview responses. My perception of an 'ideal teacher' profile and how I actually saw myself as a teacher coincided quite closely with the 'best teachers' profile. It showed that I understood my students' needs and that I am closer toward being a 'best teacher'.

Wubbels (1993) suggests that, in terms of this model, students taught by teachers who show

more than the 'average teacher' behaviour in the sectors on the right of the D-S axis and less in the sectors on the left of this axis, *on average viewed their physics lessons more positively* (see Fig. 4.2). In my students' perceptions of me, the profile shows more than the 'average teacher' behaviour in three of the four sectors on the right of the D-S axis, with the last sector only slightly below. This could mean that my students, on average, viewed their physics lessons more positively. This result was also supported by the results from Questionnaire 'B', and the interview responses.

In Figure 3, my students saw me as less strict, and allowing more student responsibility and freedom than I saw myself. They perceived me as frequently exhibiting leadership, friendly and understanding behaviours, but not as frequently as I saw myself. They also perceived me exhibiting admonishing and dissatisfied behaviour a little more frequently than I saw myself. They saw me as less uncertain in my behaviour.

Conclusion

The findings of this case study showed that there was close agreement between students' perceptions and my own with regard to interpersonal teacher behaviour. The students' attitude to science was very positive, and their reasons for these positive attitudes consisted of a combination of good results and an enjoyment of junior science. The students found the quality of the curriculum, regarding what was taught and how it was taught, had suitably met their needs as a 'top' class. The classroom climate was found to be highly conducive for learning, which encouraged students to reach toward their potential.

In this study, students' reasons for enrolling in physics were related to a positive attitude to science, including physics. Positive attitude was related to good results and an enjoyment of science, which could have resulted from a combination of good teaching plus good interpersonal teacher behaviour. Early intervention, which incorporated good teacher behaviour plus good teaching in science was a contributing factor in shaping students' positive attitudes to science *including* physics, which could have contributed to an increase in physics enrolment. The results of the case study supported my perceptions that students who enjoy their learning experiences in junior science, *and* achieve good results, are more likely to enroll in science *including* physics. The role of *strategic teaching* over a period of three years seemed to have enabled me to achieve my goal of increasing physics enrolment in Year 11.

Finally, a reminder that the question of external validity lies with the user and reader of the study because "generalizability is ultimately related to what the reader is trying to learn from the case study" (Wilson, 1979 p.454; in Merriam, 1988, p.177).

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APPENDIX

Interview questions

1. What do you think is good teaching?
2. What do you think of this flow chart – do you agree or disagree with it, or is there anything to add?
3. Which is more important among the factors for learning: teacher behaviour, what is taught, how it is taught – how would you rank them?

4. If you had good teaching but poor teacher behaviour, which will suffer – results, enjoyment, or attitude?
5. Give me a picture of your class – describe what is going on?
6. Why do you think there is a high enrollment in physics this year?
7. The strategies most enjoyed are debates, excursions, group work, pracs and quizzes – why?
8. What metaphor would you use for me as your teacher?

Student Questionnaire

This questionnaire asks for your honest opinions on the learning environment of your class.

Please circle the appropriate response:

Gender: Male Female
Years taught by Mrs George: Year 7 8 9 10
Science subjects in Year 11: Physics Chemistry Biology

Questions refer to the time you were in Mrs George's class only.

This teacher treats boys and girls equally?	True	False
(i) in terms of equipment in practicals?	T	F
(ii) in terms of help in practicals?	T	F
(iii) in terms of help with a problem in your work?	T	F
(iv) in terms of taking a personal interest in students?	T	F
(v) in terms of showing care and concern?	T	F
(vi) in terms of encouragement and praise or rewards?	T	F
(vii) in terms of discipline or punishment?	T	F
(viii) in terms of not showing favouritism?	T	F

comments:

2. This teacher encourages you to:	True	False
(i) work hard and not waste time?	T	F
(ii) be honest in all your work and in your practical results?	T	F
(iii) strive to do your best, to reach your potential?	T	F
(iv) be considerate to each other?	T	F
(v) cooperate with each other?	T	F
(vi) think of solutions to problems?	T	F
(vii) be thoughtful and creative about your work?	T	F
(viii) ask questions in class?	T	F

comments:

3. The practical work that you do in class	Never			Always
(i) reinforces what is being taught in class	0	2	3	4
(ii) is helpful in understanding the theory that has been taught	0	2	3	4
(iii) is carried out to investigate a problem	0	2	3	4
(iv) is to explore what happens (controls and variables)	0	2	3	4
(v) is to help me learn practical skills	0	2	3	4
(vi) is to help me think about evidence to draw conclusions	0	2	3	4
(vii) is used to teach you something new	0	2	3	4
(viii) is based on a reward/ punishment system	0	2	3	4
(ix) is sufficient in quantity for its purposes	0	2	3	4
(x) is just for the fun of it	0	2	3	4

Any further comments:.....

4. Did you choose to study physics in Year 1, because	True	False
(i) you enjoyed studying it in your junior years	T	F
(ii) you are naturally interested in the subject	T	F
(iii) you have done well in science in your junior years	T	F
(iv) you found it challenging	T	F
(v) you think you have the ability to do it	T	F
(vi) your teacher encouraged you to do it	T	F
(vii) you have to, because of university requirements	T	F

Any other reasons?

* If you did not choose physics, why not?

5. If your university entry did not require you to study physics, would you still have chosen to do it? Yes No
Why? .....

6. If you have chosen to do more than one science subject in Year 1, state what they are and the reasons for choosing to do them.

7. What factors have helped you to decide on doing science in Year 1?

8. If you have chosen to do a science subject in Year , does that mean that you are interested in a career based on science?

9. If your answer to Q. 8 is Yes, what factors have helped you to become interested in a career based on science?

10.Below is a list of teaching strategies used to teach you. Have any of these been helpful or not helpful to your enjoyment of science in Years 8 to 10? Tick the correct space next to the strategy.

Tick the 'enjoyed' column also, if you enjoyed learning science through that strategy.

Teaching strategies	Helpful	Not Helpful	Enjoyed
science quizzes - class topic quizzes, moon quiz, revenge of the nerds science quiz			
practical lessons - including electives and after school science extension programs			
science projects - rock collection, geology models, arm / lever model, extension program			
group work - discussions, projects, debates, quizzes			
oral presentation of work in class - individual presentation for an audience, team presentation of practical report			
library research - teacher given topic, own choice topic			
videos - to supplement class work, to show that physics is fun			
worksheets - to practise what you learned, to stretch your mind			
science competitions- to practise problem solving, thinking skills			
science excursion- to stimulate interest about the wonders of science, to build friendships			
debates- to express opinions, to think about issues, to learn to listen			
exam techniques and preparation- to help you get the marks you are capable of			
chalk and talk- for notes, diagrams, teaching			
outdoor activities-speed of cars, wheelbarrows, races, quadrat sampling techniques			
practical demonstrations- dangerous experiments			
questioning- oral and written			

11. Did any of your science projects, debates, discussions or any lessons

* bring out your creative hidden talents?	Yes	No
* help to improve your communication skills?	Yes	No
* help to overcome fear of public speaking?	Yes	No
* help to create a more cohesive group as a class?	Yes	No
* help spark interest in a topic?	Yes	No
* help you to get along better with others?	Yes	No
* encourage you to think for yourselves?	Yes	No
* encourage you to ask questions?	Yes	No

12. What are some of the times you have enjoyed most in this science class?

13.What are some of the times you disliked most in this science class?

14. What are some of the things you are most proud of that you have done or achieved in your junior science?

15. Do you think this teacher tried to use new and different ways to teach?

.....

16. What do you consider to be the weak points of this teacher? (something you would like to see happen in future lessons)

Thank you very much and have a nice day!

SUPPLEMENT

STUDENT QUESTIONNAIRE

This questionnaire asks you to describe the behaviour of your teacher. This is NOT a test. Your opinion is what is wanted.

This questionnaire has 48 sentences about the teacher. For each sentence, circle the number corresponding to your response. For example:

	Never				Always
This teacher expresses himself/herself clearly.	0	1	2	3	4

If you think that your teacher always expresses himself/herself clearly, circle the 4. If you think your teacher never expresses himself/herself clearly, circle the 0. You also can choose the numbers 1, 2 and 3 which are in between. If you want to change your answer, cross it out and circle a new number. Thank you for your cooperation.

Don't forget to write the name of the teacher and other details at the top of the reverse side of this page.

This page is a supplement to a publication entitled *Teacher and Student Relationships in Science and Mathematics Classes* authored by Theo Wubbels and published by the national Key Centre for School Science and Mathematics at Curtin University of Technology.

Teacher's Name _____ Class _____ School _____

	Never Always	Teacher Use
1. This teacher talks enthusiastically about her/his subject.	0 1 2 3 4	Lea
2. This teacher trusts us.	0 1 2 3 4	Und
3. This teacher seems uncertain.	0 1 2 3 4	Unc
4. This teacher gets angry unexpectedly.	0 1 2 3 4	Adm
5. This teacher explains things clearly.	0 1 2 3 4	Lea
6. If we don't agree with this teacher, we can talk about it.	0 1 2 3 4	Und
7. This teacher is hesitant.	0 1 2 3 4	Unc
8. This teacher gets angry quickly.	0 1 2 3 4	Adm
9. This teacher holds our attention.	0 1 2 3 4	Lea
10. This teacher is willing to explain things again.	0 1 2 3 4	Und
11. This teacher acts as if she/he does not know what to do.	0 1 2 3 4	Unc
12. This teacher is too quick to correct us when we break a rule.	0 1 2 3 4	Adm
13. This teacher knows everything that goes on in the classroom.	0 1 2 3 4	Lea
14. If we have something to say, this teacher will listen.	0 1 2 3 4	Und
15. This teacher lets us boss her/him around.	0 1 2 3 4	Unc
16. This teacher is impatient.	0 1 2 3 4	Adm
17. This teacher is a good leader.	0 1 2 3 4	Lea
18. This teacher realises when we don't understand.	0 1 2 3 4	Und
19. This teacher is not sure what to do when we fool around.	0 1 2 3 4	Unc
20. It is easy to pick a fight with this teacher.	0 1 2 3 4	Adm
21. This teacher acts confidently.	0 1 2 3 4	Lea
22. This teacher is patient.	0 1 2 3 4	Und
23. It's easy to make a fool out of this teacher	0 1 2 3 4	Unc
24. This teacher is sarcastic.	0 1 2 3 4	Adm
25. This teacher helps us with our work.	0 1 2 3 4	HFr
26. We can decide some things in this teacher's class.	0 1 2 3 4	SRe
27. This teacher thinks that we cheat.	0 1 2 3 4	Dis
28. This teacher is strict.	0 1 2 3 4	Str
29. This teacher is friendly.	0 1 2 3 4	HFr
30. We can influence this teacher.	0 1 2 3 4	SRe
31. This teacher thinks that we don't know anything.	0 1 2 3 4	Dis
32. We have to be silent in this teacher's class.	0 1 2 3 4	Str
33. This teacher is someone we can depend on.	0 1 2 3 4	HFr
34. This teacher lets us fool around in class.	0 1 2 3 4	SRe
35. This teacher puts us down.	0 1 2 3 4	Dis
36. This teacher's tests are hard.	0 1 2 3 4	Str
37. This teacher has a sense of humour.	0 1 2 3 4	HFr
38. This teacher lets us get away with a lot in class.	0 1 2 3 4	SRe
39. This teacher thinks that we can't do things well.	0 1 2 3 4	Dis
40. This teacher's standards are very high.	0 1 2 3 4	Str
41. This teacher can take a joke.	0 1 2 3 4	HFr
42. This teacher gives us a lot of free time in class.	0 1 2 3 4	SRe
43. This teacher seems dissatisfied.	0 1 2 3 4	Dis
44. This teacher is severe when marking papers.	0 1 2 3 4	Str
45. This teacher's class is pleasant.	0 1 2 3 4	HFr
46. This teacher is lenient.	0 1 2 3 4	SRe
47. This teacher is suspicious.	0 1 2 3 4	Dis
48. We are afraid of this teacher	0 1 2 3 4	Str

For Teacher's Use Only: Lea Und Unc Adm HFr___ SRe___ Dis Str

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