Feminist Pedagogy in the Physical Sciences

by

Fran Davis
Arlene Steiger

Le ministère de l'Enseignement supérieur et de la Science
Programme d'aide à la recherche
sur l'enseignement et l'apprentissage
Code de diffusion: 1532 - 0419

FEMINIST PEDAGOGY IN THE PHYSICAL SCIENCES

By

Fran Davis

Arlene Steiger

June, 1993

Cette recherche a été subventionnée par le ministère de l'Enseignement supérieur et de la Science dans le cadre du Programme d'aide à la recherche sur l'enseignement et l'apprentissage

On peut obtenir des exemplaires supplémentaires de ce rapport de recherche auprès de la Direction des services pédagogiques du Collège Vanier ou en s'addressant à

Fran Davis/Arlene Steiger
Collège Vanier
821 Boul. St. Croix
St-Laurent
Québec, H4L 3X9

TABLE OF CONTENTS

LIST OF TABLES

LIST OF APPENDICES

ACKNOWLEDGEMENTS

We would like to thank the ministère de l'Enseignement supérieur et de la Science, Programme d'aide à la recherche sur l'enseignement et l'apprentissage, for the funding which has made this research possible. In particular, we thank Madame Hélène Lavoie and the evaluation committees for their support and encouragement.

We would also like to thank Vanier College for making so many of its resources available to us. We offer special thanks to Dr. Maurry Epstein, Director, Institutional Planning, Research and Professional Development. We are grateful for all the help we received from Maurry's assistants Nancy Brown, Dagmar Fehringer, Leona Hamel-McVetty, and Lise Hall. We thank Academic Dean Alex Potter and Associate Dean of Arts Fred Robinson for their interest and encouragement. We owe a particular debt of gratitude to Hans Speich and his staff at the Vanier College Printshop for excellent advice and friendly service on all our complex printing requirements.

We are certain that without our statistical consultant Jacques Lemaire this research would not have been possible. His help and advice in creating and running statistical programs for the analysis of our quantitative data has been invaluable. His empathy with our objectives also helped us develop a method of interweaving the qualitative and quantitative data in new ways, highly congruent with our feminist orientation and objectives.

We thank our student assistants Daniel Nemiroff, Lesia Prystupia and Greg Davis for the seemingly endless hours of entering data and coding interviews.

We offer particular and heartfelt thanks to all the teachers who have participated in this project, both those who introduced the strategies into their classrooms and those who acted as controls. All these teachers collected important data for us and allowed us access to their students in ways we could not have had without their generous cooperation. To the teachers who actually implemented the strategies, we owe an immense debt of gratitude. Their imagination, dedication and commitment have been an inspiration to us at every turn. They and their students have taught us much of what we know, and it is their good work which has generated the significant results of this research.

Finally and most gratefully we thank our wonderful supportive friends and families who always take an interest in our work, who support us in our convictions, and who always encourage us to press forward in our inquiries.

Fran Davis

Arlene Steiger

June 1993

ABSTRACT

The objective of this research has been to test feminist teaching strategies designed to improve women students' confidence and their commitment to and engagement with the physical sciences. The teaching strategies have been peer-support partnerships, writing in the learning process, and systematic self-disclosure by the teacher.

In each of four semesters, two experimental sections were matched with parallel sections in which the experiment was not in place. Effects have been assessed by attitude inventory, grades, failure and abandon rates, office appointments, teacher and student interviews, and student evaluation of and involvement with the strategies.

Feminist pedagogy is shown to effect significant positive change in student attitude both to the physics teacher and to physics as a subject of study. This is true for both women and men, although women show less enjoyment overall. When student rates of achievement are taken into account, almost significant effects on student anxiety are also noted, as low achieving students are less anxious in experimental classes. The partnership and writing assignments are positively evaluated by the majority of students, with low achieving and women students making significantly more positive evaluations and taking fuller advantage of the writing.

Feminist pedagogy appears to have a positive impact on engagement in and commitment to physics for all students. Gender differences on the attitude survey point to new research areas.

CHAPTER I

WOMEN AND EDUCATION IN THE PHYSICAL SCIENCES

Improving the educational experience for women at the college level in the physical sciences has been a fundamental objective in this research. This focus upon the classroom experience of women has grown out of our appreciation of the complex and contradictory relationship between women and post-secondary educational institutions, particularly at this juncture in history when women are entering these institutions in greater numbers than ever before.

That actual educational attainment is crucially important for women should be underlined at the outset. Education is, for women, more firmly linked to labour force participation and a chance to escape poverty than is the educational attainment of men (Statistics Canada, 1989). Nevertheless, the general educational pattern for women continues to be distinguished from that of men by women's tendency to drop out of the system in greater numbers at higher levels (Canada, 1991). This statistical path emerges much more dramatically in the sciences, even though women's achievement rates in science and math at the college level have been equal to those of their male counterparts (Lafortune, 1986). The registration of women in applied and physical sciences remains disproportionately low at both the undergraduate and graduate levels (Canada, 1991) and, at the present rate of increase, there is little reason for optimism concerning women's potential for gaining access to academic decision-making positions in these disciplines (Canada, 1991). Given this lack of educational preparation, modelling and control, women continue to miss opportunities to pursue employment in science and science-related fields, areas which are increasingly the most likely to offer them permanent earning power and which are an important means to access power and authority in our society (Lafortune, 1986).

An intricate web of social factors must certainly be recognized here. However, we have been concerned with that aspect of the problem which might reflect a failure of the educational system to capture the interest and commitment of women students and we have sought to explore the impact of pedagogical intervention in these areas.

That young women do, in fact, experience disaffection and even alienation in the traditional educational system is suggested by several different bodies of research. Although much work remains to be done in exploring the relationship between gender and class in education, it is clear that working class women may be disadvantaged in particular ways. In her study of Canadian teenage girls, No kidding, Myrna Kostash (1987) writes of the interweaving of gender and class with respect to young working-class women:

> Such students, said one of their teachers, "don't feel they have any control over their lives, nor that anything they do matters."... In defiance of an institution that separates their destiny from that of their middle-class

> peers, they create a kind of sub-institution and culture all their own...By indulging in rude behaviour in the classroom and refusing to be instructed in such "boring" and "useless" subjects as math and English, and by quitting school altogether to go out and work, working-class girls only reinforce their class disadvantage - illiteracy, inarticulateness, and indecorous behaviour - and their vulnerablity to the crises of the labour market, where the well-paid trades, such as carpentry and plumbing, are still male preserves (p.84).

However, even among women who persist in education, there is evidence to suggest that these women must invent the means by which they come to survive an experience which is essentially alien to them. Carol Gilligan, in her study of adolescent women, <u>Making connections</u> (1990) introduces us to twelve-year old girls in a large mid-western American city who, "when asked to describe a powerful learning experience, were as likely to describe an experience that took place inside as outside of school. By fifteen, more than twice as many girls located powerful learning experiences outside of school than inside" (p.14). Even priviledged girls of upper middle-class backgrounds are seen in her study as girls at risk, "in danger of drowning or disappearing" (p.4). She documents their sense of being disconfirmed by the knowledge, the discourse, and the social structures of schools, and she shows how, unless they are rescued by institutions sensitive to their needs, their learning "goes underground", and they "become divided from their own knowledge, regularly prefacing their observations by saying 'I don't know'" (p.14).

The young women who struggle through this period remember it with pain. In a journal assignment on Robin Morgan's essay on growing up female, called "Barbarous Rituals" (1977), two students in a Cegep Humanities course describe the gendered nature of their own experiences:

> I quickly learned in High School like Robin Morgan did, that boys did not like smart girls. Instead of "unconsciously dropping back", I resorted to becoming friendly with smart boys instead of more popular boys. However, these boys made me feel inferior and made me believe that I could never be as smart as they were. I never could seem to beat them in subjects like Mathematics or Science but I enjoyed learning that I received higher marks than they did in subjects such as English and Moral Education (even though they believed that these subjects were not important).

> The article said that men are turned off by smart girls. Through out high school I found that this was true. That's where I discovered my love for math and science so I would always do great in these courses. In grade 11

physics the teacher would tell us our grade out loud and when he said 96% a lot of boys didn't like me anymore, especially popular and fun boys. It was as if I murdered someone.

Clearly, for these young women, the message of the peer group in high school is that boys, not girls, ought to succeed, particularly in the important so-called male-identified subjects. Certainly the gendered nature of classroom dialogue provides women students with reminders of their relative unimportance and powerlessness, as male voices take over, affirm one another, and nudge students and teachers of both sexes to collude in the sexual politics of this process.

The outstanding fact about talk is that in mixed groups, men do more of it. They speak more frequently and assertively and they are more likely to interrupt when a woman is talking (Spender, 1980). Female students may raise their hands, but it is a verbal intervention that is more likely to attract our attention, and it is male students who are more likely to make such interventions (Laforce, 1987). Eventually, discouraged by lack of serious attention, some women students sink entirely into silence (Rich, 1979).

Support for this view is found in the fact that almost all teachers appear to play an unconsciously complicit role in perpetuating this inequality (Serbin and O'Leary, 1975). Helene Laforce (1987) reports that American researchers have found that teachers identify females as speaking more frequently than males when these teachers are asked to view taped classroom interactions in which males are, in fact, speaking several times more freqently than the average. It is impossible to resist suggesting that the teachers' attentions are drawn by the simple fact of women speaking at all. However, while the suggestion does highlight one aspect of the problem, it obscures the most perplexing finding of this piece of research: the teachers who identified themselves as feminists were as likely to misjudge the relative frequency of "girl-talk" as any other teachers.

Furthermore, that science continues to be viewed by students as a male domain stands out quite clearly in the journal responses quoted above. In fairness, it must be said that the students whom we have interviewed in this project were almost universally agreed in insisting that women have every right to lay claim to places for themselves in the sciences. However, an examination of the way in which language is commonly used to define and describe the scientific enterprise illustrates most clearly the extent to which the discipline is shaped by values and behaviours that continue to be exclusive of and discouraging to women. Both the experts and those who aspire to enter the domain employ this language. It is significant, therefore, that the relative absence of women among degree holders and practitioners in science corresponds to a remarkable feminization of the object of scientific enquiry.

Carolyn Merchant has observed that Nature as female is the most powerful image in Western science (Eslea, 1987). From Francis

Bacon's conception of "the new science" as a force that can hound, conquer and subdue nature (Keller, 1985, p.36) to the seduction envisioned by the twentieth century high-energy physicist Frank Close, whose Nature "hides her secrets in subtle ways" (Easlea, 1987, p.205), the language of science reflects a gendered point of view.

Indeed, it is this language, sexualized and territorial, which has served as a sign post for researchers interested in tracing the structural and institutional roots of the various scientific disciplines. Brian Easlea and Sally Hacker have explored the connections between the military, on the one hand, and physics and engineering, on the other. They have pointed out that education in these fields has traditionally been achieved by performance in an environment which emphasizes disipline, rigour, and control and which, it could be argued, is therefore well-suited to a particular kind of masculinity.

That the classroom should become the microcosm of a gendered society should not surprise us. What should capture our attention, however, is the irony of our expectation that women should fare well in such an atmosphere. Indeed, if we think through the sexual politics around which the content, ideology and pedagogy of post-secondary science education are structured, we cannot but conclude that this educational experience is poorly suited to women. There is, nevertheless, a further contradictory factor here. Unsuitable as it may be, this educational experience, in some important ways, may be more crucial for women than it is for men. This gender difference appears to be connected to career goals and the way in which such goals operate as incentives for persistence in the sciences.

When asked in interviews or informal surveys why they are continuing their study of science, Cegep students offer a variety of replies. Frequently, students discuss issues that appear to have little to do with interests or careers. In response to the question "Why are you taking science at Cegep?" one young woman student in her first semester of Pure and Applied Science wrote as follows:

> Well, I feel like I have to. It's sort of at the top of things (like the most difficult program), and if I cannot handle it, I can work my way down to other programs. At least, that is what I thought in High school. But now, I could never quit it. It's sort of like I have too much pride, and maybe I'm embarrassed....My friends (who are mostly in sciences themselves) find it normal to be in science. They sometimes look down on anyone from Social who brags about how hard it is for them - they laugh.

This is not an atypical answer from students, both men and women, who are not yet certain of what career they wish to pursue. The prestige factor and, as dozens of students have told us, the chance to keep their options open by collecting all the necessary pre-requisites for a variety of university programs, operate as important reasons for staying in science.

When interests or career aspirations do figure in these accounts of program choice, gender differences emerge and tend to follow those outlined by other researchers in the field. Women students are much more likely to cite a desire for a medical career than for a career in engineering or architecture. This general trend rejoins such research as that conducted by Lunneborg and Lunneborg (1985) which indicates that women favour service rather than technical interests. However, limiting their career aspirations to medicine is also more likely to present these women students with obstacles, as many of them fail to attain the high grade point averages for entrance to medical faculties.

Men students are more likely to be actively considering a variety of technical careers. Interviews with a class of Electrotechnology students in the course of our research revealed that every one of the men in the class had spent his childhood tinkering with a range of electronic gadgetry and had made his program and career choice accordingly; the only two women in the course had not spent such childhoods and were there on the advice of guidance counsellors and teachers. In short, it seems likely that there are gender differences in the way that career goals operate as incentives to continue in the sciences, in general, but certainly in the physical sciences.

Sheila Tobias (1990) argues that it is career goals, much more than the actual content of science courses and programs, which have traditionally motivated students to complete their science training. However, if women are less committed than their male counterparts to careers in the physical sciences, they are perhaps, as a result, more sensitive to educational experiences which they (and frequently the men as well) qualify as negative. This line of reasoning would suggest that for a variety of historical reasons, educational experience has greater impact upon women's persistence in the sciences than it has, heretofore, exercised upon that of men. And it is precisely this educational experience which the research, described and analysed in the pages which follow, seeks to address.

CHAPTER II

FEMINIST PEDAGOGY: ORIGINS, CHARACTERISTICS AND STRATEGIES

We have proposed that a feminist pedagogy, grounded in feminist theory, might offer women an education which is more in their image. Our over-all hypothesis has been that by increasing student engagement with learning processes and course content, this feminist pedagogy can produce more active, confident, and committed women learners.

Other libratory pedagogies have most certainly contributed toward the formulation of the principles and strategies of this feminist education. In its insistence upon the centrality of affect, for instance, feminist pedagogy resembles humanist pedagogy; in its confrontation with and challenge to the reproduction of traditional knowledge, it resembles critical pedagogy. The uniqueness of feminist pedagogy, however, lies in the space which it insists upon for the voicing of diversity, and in the way in which it privileges those characteristics which research has suggested are most likely to be found among women. As it foregrounds the recognition of diversity, and the uncovering of those forces which would seek to hide this diversity, feminist pedagogy can be understood as a conceptual framework responsive to the experiences of students who may suffer other forms of marginality. Although some features of this latter terrain are tentatively charted in the present study, it has been the experience of women students which has been the central focus of our attention.

From the beginning, the challenge has been to elaborate a set of pedagogical strategies which would reasonably address the issues central to a discussion of the education of women and which could, at the same time, be used by teachers who face the exigencies of college workloads and curricula. Affect, collaboration, and personal engagement appear to us to be the key characteristics of such a pedagogy. We have come, finally, to propose that classrooms which are structured by peer support partnerships, which privilege specific kinds of writing in the learning process, and which encourage self-disclosure from both teacher and students, are classrooms where important feminist principles are being applied.

A. THE CENTRALITY OF AFFECT

Both research and common sense tell us that women's experiences, shaped by socialization and mediated by the social structure, are different from those of men. If we are to offer women a genuine place in the classroom, we must face the challenge of finding effective strategies for validating these experiences. In this sense, teachers must allow access for a student sub-culture which may be as alien to their own personal and professional lives as the culture of the school is to the students: what emerges so clearly in Myrna Kostash's study of the world of teenage girls (1987) is that the educators experiencing the greatest difficulty dealing with these girls neither understand nor wish to know about the lives they are leading: it is teacher disapproval as well as student resistance that ensures that the connection between the cultures is never made. We see this situation as a parallel to the situation which Freire (1973) dealt with among the oppressed illiterates in Latin America, and we see it as requiring an equal amount of effort and imagination to validate and incorporate the real lives which female students live.

In their study Women of academe: Outsiders in the sacred grove, Nadya Aisenberg and Mona Harrington (1988) demonstrate how women pursuing higher education are seeking fundamentally transformative experiences, and how often they are deflected from their educational goals by personal and affective concerns which the structure of the academy does not give them opportunities to integrate with their learning. Some balance between the rational and the intuitive, the objective and the affective, will have to be found if we are to seriously address women's learning needs. In fact, the rejection of the dichotomy between the subjective and the objective is a cornerstone of feminist thinking, developed perhaps most tellingly by scientist Evelyn Fox Keller (1985). Students themselves declare the need to overcome the dichotomy: we are thinking here of Marie Josée Desrivières' 1982 study of Quebec university women in which she found that "elles aiment les approches globales associant approche rationelle et intuitive" (p. 27).

However, all of this must be done in educational settings which are becoming larger and increasingly impersonal. In science disciplines, we face the further challenge of nurturing affective connections in spite of the apparent absence of affective content, in the face of a pedagogical tradition which has fairly consistently emphasized objectivity and rationality. These latter have been defined, as Keller (1985) and Bordo (1987) point out, in terms of separation and distance, involving, above all, the denial of affective connections between the knower and the known. Evelyn Fox Keller (1985) suggests that such distancing of the self serves the interest of what we identify as a masculine personality type, that is, an identity forged and maintained through separation from the (feminine) mother. In this sense, she says, objectivity is better understood as an objectivist ideology - a construction which protects the masculine knower who remains hidden in a disguise of neutrality. That such an ideology excludes both women and important approaches to knowledge deserves the serious attention of educators.

B. THE IMPORTANCE OF COLLABORATION

A second feature of the feminist pedagogy we wish to develop is a collaborative rather than a competitive, hierarchical classroom structure. The importance of peer relationships has already been underlined in Chapter I by the students whose journal writing has been quoted. In her work on the development of moral reasoning in males and females, Carol Gilligan (1982) has found that females value human relationships over abstract principles and that in this respect their psychological development appears to differ from that of males. Her more recent work on adolescents emphasizes the importance of connectedness in the learning processes of young women (1990). This theme of human relationships surfaces again and again in the work of researchers exploring the experience of women in the so-called non-traditional programs. Informal discussion among Quebec researchers has suggested that women entering these programs identify fear of isolation as one of their greatest concerns.

In our current work in the sciences, the student interview material underlines these realities to an almost frightening degree. Students who drop out of science programs at Cegep cite loneliness as one of their major reasons. In their interviews with us, they sometimes complain about the emphasis not only on silent listening to teachers, but on solitary work doing calculations of problems set by someone whose mind-set they do not understand, and who appears not to understand or care about theirs.

Many of these interviews describe an atmosphere of competition in which successful students become less and less willing to talk about their work with others except insofar as they compare good marks and vie with each other for the surprised and delighted attention from the teacher who, according to these marginalized students, really seems only to want to talk to the top achievers. An ideology that is, in Quebec at least, quite openly elitist, begins to operate from about ninth grade, encouraging top achievers to enter the sciences, not to collude with "cheaters" by sharing their work, and to struggle to outdo each other in the process of eliminating the unsuitable. These are the experiences which elicit from science dropouts statements such as "science students have no fun", and which brand such drop-outs as lazy, when, in fact, they are perfectly willing to work in subject areas where the ideology of study is more humane. "There's science, and then there's life," said one drop-out, focusing an attitude expressed by many others, both by those continuing in the subject and by those who do not.

It has been our contention that the maintenance of such elitism through an emphasis on competitive individualism is related to the fact that women are under-represented in the sciences. For decades now, researchers have observed that women's performance tends to decline as the level of competition increases. Many theories have been put forward to explain this phenomenon: role conflict and discouragement (Epstein, 1984), anxiety about failure and, of course, anxiety about success (Horner, 1969). For us, however, the important fact is that competition itself seems to be experienced negatively by women.

In fact, women seem to prefer situations which favour collaboration. Dale Spender traces gender differences with respect to speech patterns (1980) and shows that women are more inclined to collaborative modes of expression and problem solving. Carol Gilligan (1982) stresses the premium placed upon collaboration in the psychological development she describes for women; and this is one of the clear gender differences revealed in the research evaluated in the TV Ontario documentary The pinks and the blues (1983). When writing about some of the difficulties women have in the traditional math class in which the teacher stands at the blackboard, delivers a stunning lecture, and then challenges the class to ask worthy questions, Léonie Burton (1986) explains the women's reticence as follows: "(c)eci n'est pas seulement une question de confiance mais une préférence pour un style d'interaction qui ne soit pas empreint de confrontation et de compétition" (Lafortune, p.40). Women even appear to learn different things than men because of this orientation: Evelyn Fox Keller (1985) has shown that women doing research in science often have a more relational and interactive vision of the behaviour of matter, and she contrasts this orientation with the notions of master molecules and other hierarchical systems theories developed by those who work within the dominant masculinist paradigms.

C. ENGAGING WOMEN STUDENTS

Some special effort seems to us to be necessary to bring about the engagement of female students, so alienated by the impersonal and hierarchical educational structures described above. And so we have asked ourselves how, in fact, post- secondary learning can be brought into meaningful connection with the personal and affective life of the student. And how, in fact, can a truly collaborative experience be generated at this level? For we see this engagement as the process required to satisfy these other needs.

The answer, for us, has been to explore what might be called a new literacy for women, one which would permit them to define their developing lives and to create meaningful and empowering links with their educational environment (Neilsen, 1990). The use of language is, as most of us now recognize, a critical step in the process by which students come to know, and lay claim to that knowledge as their own. Not only has language been shown to be essential in the learning processes of young children (Britton, 1970), but the importance of informal "student talk" has been emphasized by educational researchers in literacy across the curriculum (Fulwiler, 1980; Martin, 1976; Shor, 1987) as well as in specific disciplines like biological and physical science (Brooke and Driver, 1986; White, 1988) and mathematics (Baruk, 1985). The new language fluency which we wish to provide for women has, as we see it, both oral and written components, and we see it as essential in every subject area.

1. The Role of Talk

The problem here, as discussed in Chapter I, is that the politics of the classroom do not provide women students with an equal access to the discourse. Clearly, if we are to successfully create a space for women, we have to devise a means for overcoming these difficulties. Here we have used the classroom behaviour of students as a guide in devising appropriate pedagogy. On a recent questionnaire sent out to Cegep teachers asking them to comment on gender differences in their students' response to their courses, 20% of the teachers surveyed complained that they had trouble with the girls, "who persist in chattering together, despite repeated warnings" (Davis and Nemiroff, 1993). Asked what they are talking about, the girls are deeply embarrassed, but this research of Davis et al suggests that they are often discussing the course material; however, both because of the gender dynamics and because their orientation towards the material is often a little different from traditional approaches, they cannot find entry into the larger classroom discourse. The obvious answer is to provide them with legitimate opportunities to talk to each other.

2. The Role of Writing

Another way to provide space for women is to integrate spontaneous and informal writing into high content subject areas. We look to this writing in order to cut across the habits and expectations of inferiority and silence which we have been describing above. Asking a student to write what she thinks validates her as a significant individual with an inner life that is worthy of recognition in the educational process. Such writing is active, not passive; writing is one of those skills which some young girls appear to learn more quickly and develop earlier than boys and in which they often develop more confidence than they do in their other scholastic skills (Laforce, 1987); writing gives voice to silence; writing forces a verbal confrontation of the self with the subject and can thus be used to generate thought; writing integrates learned material into existing thought processes. We see this kind of writing as providing the space for women students which has not been afforded them in the traditional classroom, and we look to it as providing the other half of our new literacy for women, of which the informal student talk provides the first.

D. FEMINIST PEDAGOGICAL STRATEGIES

Taking into account the specific needs and learning styles which appear to characterize large numbers of women students, we have devised three different pedagogical strategies. Each strategy can be implemented by teachers in almost any subject area. Each strategy has been selected and developed to empower women, and to afford them opportunities which traditional pedagogy, particularly in the sciences, does not provide.

1. Strategy One: Peer Support Partnerships

The need to include appropriate and comfortable talk space for women students lies at the heart of one of the strategies which we ask teachers to experiment with: peer support partnerships. This strategy attempts to validate and incorporate women's preference for collaborative learning behaviour. To the teachers involved in our study, we have suggested permanent term-length dyads or triads who will work together inside and outside the classroom so that no student needs to experience the course in isolation. Our objectives here are to humanize the classroom by creating structures which offer students the opportunity to build relationships of mutual respect, trust, and support with other students, and to enhance the autonomy and self-sufficiency of each student by placing value upon student-centred learning. Peer partnerships are designed to deal directly with those feelings of alienation and marginalization which female learners describe as part of their experience of large post-secondary institutions. The essential behaviour of students within these support units is talk.

Our hypothesis has been that partnerships are most useful for women if they are permanent, on-going, integrated into classroom activities, given specific tasks, and rewarded with marks. We have suggested that some small percentage of the student's total grade be set aside for partnership work, and that the marks be awarded for actual participation, not for quality of performance. We have also suggested that teachers ensure that the dyads or triads be formed by the second or third week of class and that the first tasks be carefully monitored.

It is our emphasis on positive and supportive learning experience as an end in itself that distinguishes our work from most cooperative learning theory. We share with researchers such as Slavin (1987) and Johnson and Johnson (1990) the recognition of the social contexts of learning and the way in which competitive individualism disempowers a large proportion of all learners. The emphasis, however, of such theorists upon the effective mastery of skills and material as the goal of cooperative learning is quite different from our much greater concern with the affective aspects of the process. Furthermore, the methodology of cooperative learning is based on concepts such as team-building, games, and strategies for winning in competition with other teams: these are the activities which young men are encouraged to involve themselves in, but they do not appear to be the way in which young women interact together, nor do they represent any significant portion of the fabric of many girls' daily lives. Though all the theorists recognize that cooperative learning behaviours must be taught, it is our belief that the outcome, the co-operative learning situation, may not be significantly more comfortable for women than is the conventional classroom.

2. Strategy Two: Writing in the Learning Process

We emphasize to the teachers who work with us that we are calling here upon a very particular kind of writing, a different kind of writing from that which they normally associate with post-secondary education. Much of the writing required of students in post-secondary studies appears to test what Mary Belenky calls "received knowledge" (1986). This is particularly true of the physical sciences, where writing for post-secondary students is normally limited to reproducing learned definitions and to writing lab reports on assigned experiments which they have conducted. Student exposure to writing models in these courses is generally limited to the textbook and lab manual. These writing tasks and samples tend to reinforce the objectivist ideology, discussed earlier in this chapter, that stands behind the subject matter. The passive voice, in which the identity of the knower disappears, is the accepted mode of communication, and doubts and ambiguities are not admitted to the discourse.

Much has been written on the various discourse communities of the academy, and how important it is for post-secondary instructors to introduce students to the principles, forms and vocabulary of their particular disciplines (Bazerman and Paradis 1990; McLeod 1988). Indeed, much of the energy now focused on Writing-Across-the-Curriculum programs is spent encouraging subject-area instructors to take an active part in such instruction, and to make explicit the requirements which students will have to fulfil. However, the emphasis on the process of discourse mastery begs the question of how women are to situate themselves vis à vis a discourse which many believe is related to the exclusion of women from the sciences. It is our contention that other forms of writing, which allow greater room for self-reflection, may serve a useful function here, in helping women to build more comfortable relationships with the physical sciences.

The writing tasks which we ask our participating teachers to try are more spontaneous forms of expression, such as five minutes of free writing at important moments of reflection during the lecture period itself, or detailed accounts of students' difficulties with theories, processes or problems, or journals written either for their own reflection or to share with the other students in the class. Like some of the recent theorists in composition theory (Atwell, 1990; Murray 1990), we stress that we are using writing to learn, not learning to write. We consider the task its own reward and that the process is more important than the product. We ask the teachers not to correct or intervene in any way which might make the students overly self-critical and subsequently write to please the instructor rather than to discover new ideas and voices within themselves. We are thus making a very particular use of this composition theory: helping female learners to begin to find a language with which they feel comfortable, and to build confidence in their own thought processes. We ask teachers to set aside a small percentage of the student's total grade for a writing-to-learn component in their courses, and to award these marks for participation rather than for the quality of the work.

Specifically, in the physics courses of the Cegeps, we have experimented with what we have called Collective Class Logs and Question/Answer Boxes.

For the Collective Class Log, students are asked to write a page once a week or every two weeks on some topic of their own choice, whether it is a problem they have, a new idea they have discovered, or something from the media. They are asked to insert their writing in a class loose leaf binder which has a space for each student. This loose leaf binder is kept on reserve in the library. Students are encouraged to read each other's work, and teachers may read and register a response to this writing on their own schedule, taking care to respond individually to each student in some appropriate way.

For the Question/Answer Box, students are asked to write a page once a week or every two weeks explaining their difficulty with a particular problem or concept or else outlining some discovery they have made. The teacher responds briefly and individually, using the writing as a route to understanding both individual and class difficulties. Keeping the actual Question/Answer Box visible in specific classes is also advised.

3. Strategy Three: Self-Disclosure

Another of the strategies which we have tested is something we have called systematic self-disclosure. We have developed a methodology to help teachers bring personal, affective experience into the classroom in ways which democratize the atmosphere, reveal the teachers themselves as participants in learning processes, and show students how knowledge is constructed by the thought processes of individuals, not found fully formed (Belenky, 1986). This is of particular importance in the science classroom, where the teacher stands as the representative of the elitist discipline, whose distance from the novice is evident at every moment of the lecture and problem solving process, and where the individuality of the science professor tends to be denied by the language and structure of the discipline.

These particularly impersonal and distancing features of science education have made it imperative to us that we help teachers develop systematic and self-conscious strategies for humanizing their teaching. Ideally once a week, but at least every two weeks, the teacher is asked to choose a few moments of class time in which s/he can reveal her/himself engaged in a learning and working process, rather than as an accomplished master of skills and content. In making this self-disclosure, the teacher creates an atmosphere in which students may feel more free to examine their own states of process, reveal their confusion, ask questions, and see the learning process as universal and desirable rather than either the temporary state of the young and powerless or the uncomfortable state of the impossibly ignorant. The point is to engage the student as a colleague, albeit a junior one, in a discussion of material which is of interest and importance to all. The goal is to enhance the student's capacity to see her/himself as a serious learner, one who is responsible for her/his thought processes.

What we have suggested to the teachers of physics is, first of all, that they refer sometimes to their own educational experiences with the concepts and processes they are teaching. They might talk about the difficulties they have had, or the helpful or enlightening nature of some concept or problem-solving device. If they are able to share some disclosure of a learning experience which they are presently undergoing, this discussion too will democratize the learning process. Teachers have also been asked to call attention in self-reflective terms to their own occasional moments of fallibility in the classroom. Calling upon personal, outside-the-classroom experiences which reveal the teacher's interests for the illustration of problems has constituted another layer of self-disclosure activity.

As we have worked with science teachers, we have been struck by how foreign this kind of an approach is to traditional science teaching. The identification of the science teacher as an affective human being who operates from the perspective of her/his own place in the world finds little support within the context of a pedagogy which continues to equate fairness in the teacher role with neutrality and distance. However, the point is precisely that the identification of the teacher as a person is an important step toward allowing women students to make the kind of connections they may need for furthering their learning.

The correction of student work is another area where we have asked teachers to engage in a variation on the self-disclosure strategy. Instead of adopting an authoritative and judgemental stance, teachers have been encouraged, wherever possible, to interact in a more encouraging and collaborative manner with their students. Helping the student to identify where he/she is in the learning process with comments such as "I see you aren't quite ready for this" rather than "Why don't you know this?" are oral interventions which can make a great difference to how students feel in the science classroom. Responding to the needs of individual students in their writing about science can also be a crucial part of this supportive self-disclosure. The science teacher should assess where each student's needs might be and offer the kind of encouragement that might be appropriate at that point in time. If, instead of "This was taught for three weeks in succession in class," the teacher responds by saying "Perhaps this is a good time for you to make an office appointment," the student is given permission to come forward at her precise point in the learning process and to ask for the individual, connected learning experience which she may at this point most require. Long corrective or informative responses to student writing are discouraged as 'paternalistic,' even where the teacher might feel inclined to provide them: empowerment is often a simple recognition of individual need, difficulty or distinction, and this can be given in a very unauthoritative fashion by the careful teacher.

CHAPTER III

METHODOLOGY

In this chapter, we include in our discussion of what was done some consideration of the problems encountered and the accomodations made along the way. Since pedagogical research must, of necessity, take place in a somewhat untidy laboratory, it is our hope that such an approach will prove useful to other researchers.

A. RESEARCH DESIGN

The underlying structure of the research design grew out of our focus on the testing of a specific set of pedagogical strategies. This problem lent itself to a quasi-experimental design, in which students in a control group could be compared to students in the experimental group who had experienced the strategies in a semester-long physics course. We began by recruiting physics teachers who would be willing to undergo some training in the use of the feminist strategies and who would then be willing to systematically implement these strategies in one of their courses. We therefore allowed our volunteer system to completely determine the courses into which the strategies would be introduced. As it turned out, all of the courses were on the introductory level and the vast majority of them were aimed at students with partial or inadequate science requirements. In retrospect, it appears clear that this was not entirely coincidental. These are precisely the students with whom science teachers feel the most ill-equipped; furthermore, the pressure to "cover material" exercises considerably less constraint here than it does at upper level courses, where teachers readily admit that they are unwilling to tamper with the established regimen. *Given* our agenda, these were precisely the students with whom we were most concerned.

From the outset, the plan was to restrict the number of physics teachers who would be implementing the strategies in any given semester to two. This decision reflected our commitment to creating a "clinical" setting which would maximize our ability to supervise the implementation of the strategies and allow us to make continuous and detailed assessments of the outcomes. Thus, in each semester, there would be two experimental groups compared to two control groups; however, the size of the student population in the sample would be increased by repeating the experiment over a period of four semesters from H91 to A92.

The problematic of distinguishing the effects of a specific pedagogy from the impact of a particular teacher haunts such a research endeavour. In spite of our concerns about the problem of "contamination" of the control group by a teacher already working with the strategies in an experimental class, we opted initially to have the same teacher teach both control and experimental groups. However, by the first semester of the research, the vagaries of course allocation and workload assignments had already compromised the original plan. Furthermore, by the end of the first semester's orientation period, the participating teachers themselves began to express concern over their capacity to keep the feminist strategies out of their control group classes. Their concerns were vindicated by our experience with the one participating teacher who did teach both control and experimental groups in A91 and who had so much difficulty in distinguishing the two classes that the students with whom he worked had ultimately to be dropped from the sample.

In the final design, control group classes were matched to experimental group classes by course level and content but they were taught by different teachers. In an attempt to minimize the impact of personal style as a variable, the control group teachers were chosen from among a group of colleagues who, in addition to sharing a willingness to allow us access to their students, were identified as sharing, in a broad and general way, a personal style with the teacher participants. Ultimately, of course, the issue of the teacher as a confounding variable in this study is never fully resolved. It is, however, an issue which is repeatedly addressed in our work, beginning with the way in which we have chosen to treat the data. Thus all of our data recordings include identification of the teacher. As well, each experimental class, with matched control, is treated as a separate "cell" for the purposes of statistical analysis. Thus, as part of the global analysis of the effects of the experimental strategies, we have been able to explore the similarities and differences in the pattern between cells. The organization of control and experimental groups into cells was as follows:

Cell #1: Experimental group A vs Control group A (H91)

Cell #2: Experimental group B vs Control group B (H91)

Cell #3: Experimental group C vs Control group C (A91)

Cell #4: Experimental group D&E vs Control group D/E (H92)

Cell #5: Experimental group F vs Control group F (H92)

Cell #6: Experimental group G&H vs Control group G/H (A92)

Plus two deleted cells:

Cell #7: Experimental group J vs Control group J (A91)

Cell #8: Experimental group K vs Control group K (A92)

As the reader can see from this list, two of the original eight cells in the research design were deleted from the final analysis. Cell seven was eliminated because of the problems encountered when a single teacher acted as his own control. Cell eight was deleted because the control group teacher was forced to take an emergency medical leave at a point well into the semester. In the chaos that ensued, the anxiety levels of the students rose so high that it hardly seemed fair to continue to use them as a basis for comparison. We briefly explored the possibilty of re-using data from another control group in this cell, but then abandoned the idea on the grounds that it would unfairly weight the data which had emerged from a single, relatively small control class. These two cells do, however, stand as reminders of the value, particularly in this domain, of research designs which allow for the replication of results. Pedagogical research which takes place in the real world and is based on a single semester of intervention, is a risky business indeed.

As the reader will also see from this list, cells four and six represent variations on the original model of restricting the number of experimental sections to two per semester. The teachers who volunteered to work with us in exploring the efficacy of these strategies undertook added workload and the burden of taking risks under the watchful eye of outsiders, however well-intentioned. We were repeatedly astounded by their commitment to this work and we willingly adjusted ourselves to their availabilities. In H92 and again in A92, we had one more teacher volunteer than we needed to maintain the original design. Because so little work has been done with feminist pedagogy in the area of physics, we opted for inclusion. We therefore merged two experimental classes and compared them with a single control group in each of these two cells. Although we remain conscious of the possibility that there may be differences between these two experimental groups, we opted to sustain our focus on the pedagogical strategies in this way.

Because it was impossible to predict which physics teachers would volunteer and persist through the experiment, we quite self-consciously abandoned the idea of exploring the impact of the gender of the teacher in this domain. It is clear to us, nonetheless, that this is an area to be explored. However, in the interests of protecting the anonymity of the teachers, we do not identify the teacher as to gender or college of origin throughout this report. For present purposes, suffice to say that two of the experimental classes and one control class were taught by women and both anglophone and francophone colleges are represented in the sample.

The participating experimental teachers all experienced orientation sessions exploring the pedagogical strategies with the researchers. Given that two of the teachers had participated in a previous research project which drew upon related strategies, it is accurate to say that all of the teachers had had at least two semesters of experience with the strategies by the end of their participation in the project. When a teacher was forced to leave the project he or she was replaced and a new control group was identified. The resulting variety of teachers and courses, albeit somewhat randomly generated, did afford us the opportunity to assess the impact of feminist pedagogy in a range of situations and to continue to problematize the interaction between teacher and pedagogy.

B. THE INSTRUMENTS

Our primary goal has been to assess the impact of the feminist strategies on student attitudes toward the study of physics. We began by broadly categorising these attitudes as bearing upon issues of self-confidence with respect to one's capacity to do physics, involvement with the subject matter, and commitment to continue studies in the area. The process of elaborating a series of instruments for measuring these attitudes has been an on-going one, but its central dynamic is given by an initial commitment to frame as many aspects of these attitudes as possible in the final portrait. In methodological terms, this has meant that we have attempted to work systematically on two fronts, the one quantitative and the other qualitative, and to allow data from one to inform the findings of the other.

Because we sought to measure the impact of relatively short-term pedagogical strategies, we rejected the use of broad-based tests of self-esteem in favour of a more focused, subject- oriented attitude survey. However,a careful review of the available surveys uncovered no such instrument for physics and so we opted to adapt an existing inventory of attitudes toward mathematics which appeared well-suited to our purposes. The Mathematics Attitude Inventory (MAI) was developed by Richard Sandman in 1979 for the Minnesota Research and Evaluation Centre as part of a large scale evaluation project supported by the National Science Foundation. The inventory itself was validated on a randomly selected sample of more than 5000 eighth and eleventh grade students. It consists of 48 items, 38 of which are included in six sub-scales, five of which bear upon self-confidence and commitment with respect to the material (self-concept with respect to mathematics, enjoyment of the subject, motivation to work on the subject, perceived value of the subject, and anxiety with respect to the subject). There is also a scale which explores attitudes toward the mathematics teacher. Published reliability statistics for these scales have been promising and there is favourable evidence concerning its validity. The survey is easy to administer, relatively simple to score and readily available from the testing centre.

We adapted this inventory to the particular context of the physics class by simply substituting the subject of physics for the subject of mathematics in 47 of the 48 items. The result was an instrument which appeared to have good content validity. It was pre-tested in a Secondary V physics class in December,1990 and the results were meaningful in terms of assessing group attitudes (see appendix 1).

This attitude inventory was administered to all students in both control and experimental groups within the first week of class, in each semester of experimentation. It was then re-administered at the end of each semester. Inventory scores were recorded on computer and calculated for each student on an on-going basis. It should be mentioned that, because of our system for recording and analysing the scores on the Inventory, students were asked to identify themselves on the survey. Although we wrestled with the theoretical problems posed by this loss of anonymity, in practice they did not appear to disturb the students. It seemed to us that most students were satisfied with assurances that the teachers would not see their responses. The confidentiality of the survey material was underlined by sealing the group's completed forms in a large brown envelope. In the final semester of the project, we adopted the practice of having each student seal his or her own completed Inventory in an envelope specifically provided for this purpose.

We also undertook to collect data related to course and classroom behaviour. Thus, we had teachers in both control and experimental classes maintain records of student visits to their offices. We also kept records of the marks which teachers assigned to the work which students did as part of their participation in the experimental strategies. Data on student drop-outs from the courses were also collected, however, in the end, and for a variety of reasons, they were not useful for analysis. The actual number of students who disappeared from physics courses at this level was so small as to render comparison between control and experimental groups statistically difficult. Moreover, because we dealt with each group of students for only one semester, we could not use this data to make accurate predictions about their persistence in their programmes, and as a final blow, the administrative system for recording drops from all courses changed mid-way into the project and left us with no consistent basis for comparing across semesters.

We asked teachers to keep attendance records for each of their classes but this data was also very much plagued by inaccuracy. When we first started to work with teachers to develop a system for keeping attendance records, it became clear that there was considerable variation from teacher to teacher as to the willingness to take attendance. It is perhaps this variation which was reflected in the substantial inconsistency in the accuracy of attendance records. Rather than draw important inferences from flawed data, we reluctantly opted to circumscribe our use of this very interesting aspect of classroom behaviour in the analysis.

From the very beginning of the research, it was clear to us that student attitudes rather than performance would be the focus of our concern. Nonetheless, we recorded final marks for all students. These, as the reader will discover below, ultimately allowed us to respond to some preliminary findings in the research and to explore variations between attitudes and achievement levels, an exploration which had not been anticipated in the original research design.

C. QUALITATIVE DATA

Since students in the experimental classes were required to do process writing as one of the feminist strategies under investigation, this writing was catalogued and filed for anaylsis. We also encouraged participating experimental teachers to keep careful written records of their use of each of the strategies and these, along with taped, in-depth interviews with the teachers at the end of each semester, became part of our assessment data (appendix 2).

One of the essential pillars of feminist research is the commitment to give voice to the research subject. Coming, as we do, from this tradition, we were most uncomfortable with a research design which relied exclusively on an attitude survey as a means to understand the experiences of the students with whom we were working. We therefore resolved, in the earliest stages of the development of the research design, to interview all of the students in the experimental classes and a representative sample of students from the control group and thus to explore the stories behind the attitudes which we were measuring. Two interview schedules were developed (and are included in appendices 3,4,5, and 6), the one to be used within the first few weeks of class and the other to be administered toward the close of the semester.

These schedules were pre-tested on a small sample consisting of seventeen introductory level physics students, both male and female. Through this pre-testing, we discovered that the interview process had more impact than we would have predicted on the students whom we interviewed and also on the class from which they came. Within a few days, the class was buzzing with talk of the "two research ladies". As we became more conscious of the research effect of our attentions, we resolved to attempt to interview all of the students in both control and experimental classes, at both the beginning and the end of the semester.

All students were therefore asked to sign up for these interviews on a sheet which was circulated by their teacher and they were given a small card with the time, date, and place for the interview as a reminder of their appointment. The interviews were conducted in the privacy of an office or a small classroom and were recorded on cassettes. Overall we were pleasantly surprised at how well this relatively simple recruiting system worked. As Table III.1 illustrates the "show rate" for the initial interview in most classes was very good, although there was some variation from class to class which seemed to reflect the zeal of the individual teacher in pursuing more reluctant volunteers, and the rate for control group classes tended to be slightly lower.

Table III.1 Number of students Interviewed During the Course of the Project

	Experimental group		Control group	
Term	pre-semester	post-semester	pre-semester	post-semester
H91	78	59	62	41
A91	43 (1 group deleted)	28	34 (1 group deleted)	17
H92	74	51	27	10
A92	one interview 68		one interview 26	

It was, however, more difficult to get students to sign up for interviews at the end of the semester. This seemed to be due to a variety of factors. By the last weeks of the semester, many students were overwhelmed by their course work and of course, some were feeling quite discouraged. In some cases, students who had felt most anxious to air their feelings about physics and their physics courses at the beginning of the semester, now felt that they had been heard and were consequently less motivated to make time for us in their already hectic schedules. During the first two semesters of the research, we were able to address some of these issues by bringing the second interview date forward so as to avoid the end of semester panic. However, by the third semester of the project, many of our participants were more marginal students and workload pressures took a greater toll. This was reflected in a much lower return rate for the second interview overall, and, in those classes where the teacher did succeed in getting students to the interview, we felt that the interviews themselves were less fruitful. By the fourth semester of the project, we were concerned enough about the potentially adverse effects of these second interviews on student morale to abandon our original design. In this last semester, students were interviewed only once, at a point midway through the semester, using a longer interview schedule which explored both previous and current experiences with the subject.

Interviewing all of the students in the way that we did was an immensely labour intensive, time-consuming task. It is one, however, which we have never regretted undertaking. Rich and variegated, these interviews have become absolutely central to the research which we set out to do. The stories, shared with us by these students, women and men, some at the top of their classes and some struggling to persist, have forced us, as the reader will discover below and throughout this report, to re-examine the constructs with which we began and to refine our approach to their assessment.

D. ANALYSIS OF DATA

1. Interviews

When the first semester of interviews had been completed, the quality of the data was so impressive that we felt drawn to make more systematic use of these descriptions in our assessment of the impact of the strategies. Since the research funding could not cover the prohibitively expensive procedure of transcribing and coding the interviews themselves, we devised a method for rating each of the student interviews with respect to the three variables under investigation: self-confidence, involvement in the subject, and commitment to continue. We constructed a 10 point scale, ranging from -5 to +5 for each of these variables and, using a set of criteria developed for this purpose, we trained a person to rate the first and most relevant section of the student interviews (see appendices 7a and 7b). A representative sample of the interviews were re-rated by a second rater as a check on accuracy.

The difference between the students' scores in the final interviews and their scores on the initial interviews would then become a measure of change in students' attitudes toward physics, a supplement to the measure obtained from the Physics Attitude Inventory. The interviews from the first two semesters of research were treated in this way until problems with the returning rate for these interviews finally undermined the whole endeavour. By this stage, however, we had already been disappointed to discover that analyses of variance on this data were revealing none of the significant differences between genders and classes that were beginning to emerge from similar tests on the Inventory data. This stage of the research, an apparent dead-end in terms of the generation of results, nonetheless, served to push other aspects of the research forward.

As we pondered the failure of the rating instrument to produce significant results, it became more clear to us that its failure was related in part to our rating of self-confidence on a single scale as though it were a single construct. The more we listened to the interviews with students, the more we realized that the single scale, in fact, represented a complex of variables to which the Physics Attitude Inventory, with its six sub-scales, seemed more accurately attuned. We were, however, able to run an analysis of the correlation between the ratings of the interviews and the items on the Physics Attitude Inventory. The hundreds of positive correlations which resulted reassured us that the two instruments did, indeed, represent different approaches to the same terrain. By the end of the first year of experimentation then, we had become more confident about the validity of the Physics Attitude Survey as an instrument to measure change in students' attitudes to the subject and we had settled upon an approach which would draw upon the interview material as a means to further our ability to interpret these, and other, more quantitative markers.

The rating of the interviews provided us with a starting point for organising the interview data and the process of rating helped us to see issues which we might otherwise have overlooked. Moreover, the exercise had immediate methodological implications. As we worked to elaborate criteria for rating self-confidence in the interview material, we were forced to confront the extent to which self-confidence was itself intertwined with issues of performance for many of the students. This led us to build another level of analysis into the treatment of our final data, one which explored more directly the relationship between attitude and achievement.

2. The Attitude Survey

For each student in both control and experimental classes, a score representing the rate of maturation or change on each of the sub-scales of the Inventory was calculated by subtracting the initial score from the final score on the scale. Students who did not complete Inventories at both the beginning and the end of the semester were therefore eliminated from the sample for the purposes of this analysis. This process reduced our sample by about 10%. (Of the 547 students who received marks in their physics courses, 422 completed both surveys.)

Analyses of variance were then performed on each of the sub-scales. The initial analysis measured variations in the rate of maturation between cells and over all the six cells and compared control and experimental groups with respect to change. The analysis then proceeded to compare the difference in the maturation rates between the genders, between control and experimental groups taking gender into account and finally to explore the interaction between gender and pedagogical intervention. The statistician who worked so ably with us on this project developed a computer program to report the results of all of these operations in a single, reader-friendly table.

This data was also subjected to a Principal Components Analysis to explore trends in the relationship between the six sub-scales of the survey. As part of our effort to monitor the interaction between the teacher and the pedagogy, the rate of change for each sub-scale was also explored on a cell by cell basis.

The final stage of the analysis was developed in response to our growing sense of the interaction between attitudes to physics and performance in the course. We sought to explore this interaction statistically by performing an analysis of variance, comparing control and experimental groups and taking achievement level as well as gender into account. For the purposes of this exploration, two different approaches to the analysis were used. In the first, students were sorted into one of three achievement levels on the basis of their final marks: 0-59%, 60%-74%,and 75%-100%. In the second approach, we looked only at students who had achieved more than 60% in the course, thereby eliminating those who failed or never completed the course.

3. Failure Rates, Final Marks, Office Visits

Analyses of variance, exploring the interactions between gender and experimental status were performed with respect to failure rates, and the final marks achieved by students.

Using contingency tables, we also were able to examine variations in the rate of office visits made by men and women overall and comparing control and experimental groups.

4. Student Use of the Strategies

Although important information about the students' experiences in working with Peer Support Partnerships and writing for the Question/Answer Box emerged from the final interviews, we sought to subject the strategies to additional analysis. Toward this end, students in each of the experimental classes were asked to write open-ended evaluations of each of the strategies at the end of each semester. These evaluations were then rated by the researchers as to content, using a four point scale. The result was that we were able to perform an analysis of variance for each of the strategies to explore the interactions between gender, successful completion of the activities of the strategy, the students' evaluation of the strategy, and the students' level of achievement in the course. The final assessment of each of the strategies weaves the results of this statistical analysis into a more qualitative appreciation of the teachers' and the students' work and experiences, thus reproducing in microcosm the methodological approach of the larger design.

CHAPTER IV

RESULTS

After four semesters of experimentation, we proceeded to an analysis of variance to explore the effects of the feminist pedagogy, using changes in the scores on the Physics Attitude Inventory as a measure. This analysis came ultimately to include an exploration of the interactions between pedagogy, gender, and achievement level. However, it is useful, for the purposes of clarity, to begin our discussion by looking at the results obtained using the initial research design, which limits itself to the effects of pedagogy and gender on the sub-scales of the survey. The specific questions corresponding to each of the scales of the Inventory are contained in appendix 8. In all cases, appropriate average item scores were used for any individual items which had been omitted by the student.

A. THE EFFECTS OF PEDAGOGY AND GENDER

In this chapter, the reader will discover that two different types of data were reported for each scale. The first cluster of data represents basic variations between students, cells, groups, and, later, genders, calculated using an overall averaging technique of both pre-semester and post-semester scores on the Inventory. For the purposes of clarity, these scores are referred to as **absolute scores** in the text. The second, and for our purposes more important, cluster of data represents **the rate of change** in students' attitudes over the semester. This change, referred to as maturation and calculated by subtracting the pre-semester score from the post-semester score, was analysed for variation between cells, between control and experimental groups, and between genders, first looking only at the effects of feminist pedagogy and then looking at the effects of feminist pedagogy and gender and the interaction between the two.

Scale I: Perception of the Physics Teacher

Overall there was a highly significant difference (p=.000) between control and experimental groups with respect to changes in the perception of the teacher, with students in the experimental group becoming significantly more positive toward their teachers over the course of the semester than students in the control group, yielding a pedagogical effect of +1.86 on this scale (Table IV.1). This pattern held true for five of the six cells, with some variation from cell to cell in the magnitude of the difference between control and experimental groups. The single exception to the over-all pattern appeared in a cell in which the majority of the students were mature students and in which the accuracy of the comparison between control and experimental groups may have been compromised by the fact that the number of students in the control group who completed two surveys was relatively low.

Table IV.1. Scale I - Perception of the Physics Teacher

Source of variation	SS	df	MS	F	sig of F
BETWEEN STUDENTS	5981.30	405	14.77		
BETWEEN CELLS	580.43	5	116.09	7.86	0.000
BETWEEN GROUPS	681.22	6	113.54	7.69	0.000
CELLS MATURATION	315.72	5	63.14	6.28	0.000
MATURATION	323.38	1	323.38	32.15	0.000
FEMINIST PEDAGOGY effect	412.77	6	68.80	6.84	0.000
RESIDUAL ERROR	4074.30	405	10.06		

score averages

Group	Absolute score	Pre-score	Post-score	Maturation in the group	FEMINIST PEDAGOGY effect
All	25.35	24.68	26.02	1.34	
Feminist trt	25.69	24.56	26.83	2.26	1.86
Control	25.00	24.80	25.21	0.41	
Diff (F-C)	0.69	-0.24	1.62		

The data would seem to indicate that there was a significant effect of feminist pedagogy on students' perceptions of the teacher. This effect remained very highly significant when gender was taken into account (p=.000). There were no significant differences between the genders on this scale and no evidence that the pedagogy interacted significantly with gender to affect the genders differently (Table IV.2).

Table IV.2. Scale I - Perception of the Physics Teacher Taking Gender into Account

Source of variation	SS	df	MS	F	sig of F
BETWEEN STUDENTS	5859.95	393	14.91		
BETWEEN CELLS	573.43	5	114.69	7.69	0.000
BETWEEN GROUPS	712.22	6	118.70	7.96	0.000
BETWEEN GENDERS	71.12	6	11.85	0.79	0.574
GROUPS * GENDERS	59.63	6	9.94	0.67	0.677
CELLS MATURATION	310.71	5	62.14	6.18	0.000
MATURATION	338.90	1	338.90	33.72	0.000
MATURATION * GENDERS	96.79	6	16.13	1.61	0.144
FEMINIST PEDAGOGY effect	436.75	6	72.79	7.24	0.000
PEDAGOGY * GENDERS	27.67	6	4.61	0.46	0.839
RESIDUAL ERROR	3949.50	393	10.05		

score averages for males

Group	Absolute score :	Pre- score	Post- score :	Maturation in the group	FEMINIST PEDAGOGY effect
All	25.39 :	24.85	25.94 :	1.09	
Feminist trt	25.93 :	24.90	26.95 :	2.05	1.92
Control	24.86 :	24.79	24.92 :	0.13	
Diff (F-C)	1.07 :	0.11	2.03		

score averages for females

Group	Absolute score :	Pre- score	Post- score :	Maturation in the group	FEMINIST PEDAGOGY effect
All	25.26 :	24.41	26.11 :	1.70	
Feminist trt	25.47 :	24.11	26.82 :	2.72	2.04
Control	25.06 :	24.72	25.40 :	0.68	
Diff (F-C)	0.41 :	-0.61	1.43		

Scale II: Anxiety Toward Physics

There were no significant differences between control and experimental groups with respect to change on this scale. In fact, anxiety levels remained fairly constant in both groups over the semester, although there was a small, non-significant tendency for students in the experimental group to become less anxious and students in the control group to become more anxious (Table IV.3). We were interested to note that there was a highly significant difference (p=.013) between the scores of males and females on this scale. Our survey found that, overall, women were significantly more anxious about physics as a subject than were the men and this is consistent with the findings of other researchers (Table IV.4).

Table IV.3. Scale II - Anxiety Toward Physics

Source of variation	SS	df	MS	F	sig of F
BETWEEN STUDENTS	9706.75	411	23.62		
BETWEEN CELLS	204.53	5	40.91	1.73	0.126
BETWEEN GROUPS	82.21	6	13.70	0.58	0.746
CELLS MATURATION	136.92	5	27.38	4.55	0.000
MATURATION	5.57	1	5.57	0.93	0.337
FEMINIST PEDAGOGY effect	59.76	6	9.96	1.65	0.131
RESIDUAL ERROR	2473.78	411	6.02		

score averages

Group	Absolute score :	Pre-score	Post-score :	Maturation in the group	FEMINIST PEDAGOGY effect
All	16.46 :	16.55	16.37 :	-0.18	
Feminist trt	16.32 :	16.56	16.08 :	-0.48	-0.62
Control	16.60 :	16.53	16.67 :	0.13	
Diff (F-C)	-0.28 :	0.03	-0.59		

Table IV.4. Scale II - Anxiety Toward Physics Taking Gender into Account

Source of variation	SS	df	MS	F	sig of F
BETWEEN STUDENTS	9221.16	399	23.11		
BETWEEN CELLS	215.54	5	43.11	1.87	0.099
BETWEEN GROUPS	82.48	6	13.75	0.59	0.735
BETWEEN GENDERS	377.21	6	62.87	2.72	0.013
GROUPS * GENDERS	86.19	6	14.36	0.62	0.713
CELLS MATURATION	140.15	5	28.03	4.68	0.000
MATURATION	5.50	1	5.50	0.92	0.338
MATURATION * GENDERS	52.95	6	8.83	1.47	0.186
FEMINIST PEDAGOGY effect	57.54	6	9.59	1.60	0.146
PEDAGOGY * GENDERS	34.48	6	5.75	0.96	0.453
RESIDUAL ERROR	2390.85	399	5.99		

score averages for males

Group	Absolute score	Pre-score	Post-score	Maturation in the group	FEMINIST PEDAGOGY effect
All	15.82	16.04	15.59	-0.46	
Feminist trt	15.86	16.29	15.43	-0.87	-0.82
Control	15.77	15.79	15.75	-0.05	
Diff (F-C)	0.09	0.50	-0.32		

score averages for females

Group	Absolute score	Pre-score	Post-score	Maturation in the group	FEMINIST PEDAGOGY effect
All	17.04	16.99	17.09	0.10	
Feminist trt	16.74	16.83	16.65	-0.18	-0.56
Control	17.34	17.15	17.53	0.38	
Diff (F-C)	-0.60	-0.32	-0.88		

Scale III: Value of Physics in Society

There was a significant difference (.043) between control and experimental groups in the rate of change on this scale. While both groups lowered their assessment of the value of physics over the course of the semester, the experimental group experienced a larger drop in mean scores on this scale (-.39 as compared with -.25 for the control group). The pattern held true for four of the six cells (Table IV.5). There was also a significant difference (p=.001) between the genders on this scale, with men tending to see physics as more valuable than women, although there were no significant differences between the genders with respect to their rate of change in this area. The significance of the effect of the pedagogy remained when gender was taken into account. There was no significant interaction between gender and pedagogy (Table IV.6). It should be mentioned, however, that the significant difference between control and experimental groups which emerged on this scale was the least stable of all of the significant differences to emerge from the survey data. When we removed one of the four cells from the analysis, the significance of the pedagogical effect disappeared.

Table IV.5. Scale III - Value of Physics in Society

Source of variation	SS	df	MS	F	sig of F
BETWEEN STUDENTS	6967.49	411	16.95		
BETWEEN CELLS	116.85	5	23.37	1.38	0.231
BETWEEN GROUPS	133.10	6	22.18	1.31	0.252
CELLS MATURATION	44.55	5	8.91	1.81	0.110
MATURATION	18.71	1	18.71	3.80	0.052
FEMINIST PEDAGOGY effect	64.74	6	10.79	2.19	0.043
RESIDUAL ERROR	2024.97	411	4.93		

score averages

Group	Absolute score :	Pre-score	Post-score :	Maturation in the group	FEMINIST PEDAGOGY effect
All	22.99 :	23.15	22.83 :	-0.32	
Feminist trt	23.02 :	23.22	22.83 :	-0.39	-0.14
Control	22.97 :	23.09	22.84 :	-0.25	
Diff (F-C)	0.06 :	0.13	-0.02		

Table IV.6. Scale III - Value of Physics in Society Taking Gender into Account

Source of variation	SS	df	MS	F	sig of F
BETWEEN STUDENTS	6474.99	399	16.23		
BETWEEN CELLS	105.93	5	21.19	1.31	0.261
BETWEEN GROUPS	160.28	6	26.71	1.65	0.133
BETWEEN GENDERS	364.11	6	60.68	3.74	0.001
GROUPS * GENDERS	69.04	6	11.51	0.71	0.642
CELLS MATURATION	41.22	5	8.24	1.68	0.138
MATURATION	19.98	1	19.98	4.08	0.044
MATURATION * GENDERS	24.11	6	4.02	0.82	0.555
FEMINIST PEDAGOGY effect	64.52	6	10.75	2.19	0.043
PEDAGOGY * GENDERS	42.06	6	7.01	1.43	0.201
RESIDUAL ERROR	1954.74	399	4.90		

score averages for males

Group	Absolute score	Pre- score	Post- score	Maturation in the group	FEMINIST PEDAGOGY effect
All	23.42	23.66	23.19	-0.46	
Feminist trt	23.55	23.63	23.48	-0.14	0.64
Control	23.29	23.69	22.90	-0.78	
Diff (F-C)	0.26	-0.06	0.58		

score averages for females

Group	Absolute score	Pre- score	Post- score	Maturation in the group	FEMINIST PEDAGOGY effect
All	22.54	22.64	22.43	-0.21	
Feminist trt	22.46	22.77	22.15	-0.62	-0.83
Control	22.61	22.51	22.71	0.20	
Diff (F-C)	-0.15	0.26	-0.57		

Scale IV: Self-concept in Physics

There were no significant differences between control and experimental groups with respect to changes in students' self-concept with respect to physics (Table IV.7). There were, however, interesting gender differences which emerged. There was a very highly significant difference (p=.000) between men and women in their absolute scores on this scale, with men scoring higher then women. Furthermore, there was a highly significant difference (.011) between the genders in the rate of change in these scores over the semester. Not only did the women's absolute scores remain lower than those of the men but the men's scores went up slightly while the women's scores went down slightly. The feminist strategies had no significant impact upon the students' self-concept with respect to physics nor was there significant interaction between gender and pedagogy on this scale (Table IV.8).

Table IV.7. Scale IV - Self-concept in Physics

Source of variation	SS	df	MS	F	sig of F
BETWEEN STUDENTS	8990.13	411	21.87		
BETWEEN CELLS	231.41	5	46.28	2.12	0.063
BETWEEN GROUPS	106.38	6	17.73	0.81	0.562
CELLS MATURATION	133.11	5	26.62	5.20	0.000
MATURATION	4.43	1	4.43	0.86	0.353
FEMINIST PEDAGOGY effect	43.32	6	7.22	1.41	0.210
RESIDUAL ERROR	2105.60	411	5.12		

score averages

Group	Absolute score	Pre-score	Post-score	Maturation in the group	FEMINIST PEDAGOGY effect
All	21.92	21.84	21.99	0.16	
Feminist trt	21.72	21.58	21.86	0.28	0.25
Control	22.11	22.09	22.12	0.03	
Diff (F-C)	-0.39	-0.52	-0.26		

Table IV.8. Scale IV - Self-concept in Physics Taking Gender into Account

Source of variation	SS	df	MS	F	sig of F
BETWEEN STUDENTS	8291.59	399	20.78		
BETWEEN CELLS	239.93	5	47.99	2.31	0.044
BETWEEN GROUPS	118.22	6	19.70	0.95	0.460
BETWEEN GENDERS	547.44	6	91.24	4.39	0.000
GROUPS * GENDERS	108.64	6	18.11	0.87	0.516
CELLS MATURATION	139.93	5	27.99	5.58	0.000
MATURATION	3.53	1	3.53	0.70	0.402
MATURATION * GENDERS	84.84	6	14.14	2.82	0.011
FEMINIST PEDAGOGY effect	33.85	6	5.64	1.13	0.347
PEDAGOGY * GENDERS	17.38	6	2.90	0.58	0.748
RESIDUAL ERROR	2000.15	399	5.01		

score averages for males

Group	Absolute score :	Pre-score	Post-score :	Maturation in the group	FEMINIST PEDAGOGY effect
All	22.70 :	22.44	22.96 :	0.52	
Feminist trt	22.44 :	22.05	22.83 :	0.78	0.51
Control	22.96 :	22.82	23.09 :	0.26	
Diff (F-C)	-0.52 :	-0.77	-0.26		

score averages for females

Group	Absolute score :	Pre-score	Post-score :	Maturation in the group	FEMINIST PEDAGOGY effect
All	21.15 :	21.27	21.03 :	-0.24	
Feminist trt	20.94 :	21.08	20.79 :	-0.29	-0.11
Control	21.36 :	21.45	21.26 :	-0.18	
Diff (F-C)	-0.42 :	-0.36	-0.47		

Scale V: Enjoyment of Physics

There was a highly significant difference (p=.011) between control and experimental groups with respect to change on this scale. In the experimental group, students scores increased by .01, however, in the control group the scores decreased by .71 (Table IV.9).

On this scale, there was also a significant difference (p=.014) between the genders. The absolute scores of the men were significantly higher than were the absolute scores of the women with respect to enjoyment of physics. Although there were no significant differences with respect to the rate of change on this scale for the two genders, an interesting, non-significant pattern did emerge. Among the men, the score of students in the experimental group went up slightly over the course of the semester and the scores of men in the control group decreased slightly. However, among the women, everyone's score decreased but the scores of women in the control group decreased more than the scores of women in the experimental classes. When these gender differences were taken into account, the effect of the feminist pedagogy remained significant (p=.017), suggesting that, in terms of their enjoyment of the subject, both men and women benefitted from the strategies, with the effect of the pedagogy being +.72. There was no significant interaction between gender and pedagogy on this scale. The positive effect of the strategies appeared in four of the six cells (Table IV.10).

Table IV.9. Scale V - Enjoyment of Physics

Source of variation	SS	df	MS	F	sig of F
BETWEEN STUDENTS	10224.11	411	24.88		
BETWEEN CELLS	161.92	5	32.38	1.30	0.262
BETWEEN GROUPS	157.52	6	26.25	1.06	0.389
CELLS MATURATION	52.84	5	10.57	1.96	0.084
MATURATION	21.93	1	21.93	4.07	0.044
FEMINIST PEDAGOGY effect	91.42	6	15.24	2.82	0.011
RESIDUAL ERROR	2217.04	411	5.39		

score averages

Group	Absolute score :	Pre- score	Post- score :	Maturation in the group	FEMINIST PEDAGOGY effect
All	21.43 :	21.60	21.26 :	-0.35	
Feminist trt	21.63 :	21.63	21.64 :	0.01	0.72
Control	21.22 :	21.58	20.87 :	-0.71	
Diff (F-C)	0.41 :	0.05	0.77		

Table IV.10. Scale V - Enjoyment of Physics Taking Gender into Account

Source of variation	SS	df	MS	F	sig of F
BETWEEN STUDENTS	9743.05	399	24.42		
BETWEEN CELLS	170.69	5	34.14	1.40	0.224
BETWEEN GROUPS	156.03	6	26.01	1.06	0.383
BETWEEN GENDERS	393.46	6	65.58	2.69	0.014
GROUPS * GENDERS	49.30	6	8.22	0.34	0.918
CELLS MATURATION	57.38	5	11.48	2.12	0.063
MATURATION	22.41	1	22.41	4.13	0.043
MATURATION * GENDERS	41.22	6	6.87	1.27	0.272
FEMINIST PEDAGOGY effect	84.67	6	14.11	2.60	0.017
PEDAGOGY * GENDERS	11.71	6	1.95	0.36	0.904
RESIDUAL ERROR	2164.90	399	5.43		

score averages for males

Group	Absolute score :	Pre-score	Post-score :	Maturation in the group	FEMINIST PEDAGOGY effect
All	21.98 :	21.95	22.02 :	0.06	
Feminist trt	22.14 :	21.93	22.35 :	0.42	0.71
Control	21.83 :	21.98	21.68 :	-0.29	
Diff (F-C)	0.31 :	-0.05	0.66		

score averages for females

Group	Absolute score :	Pre-score	Post-score :	Maturation in the group	FEMINIST PEDAGOGY effect
All	20.86 :	21.25	20.47 :	-0.78	
Feminist trt	21.12 :	21.33	20.90 :	-0.43	0.71
Control	20.61 :	21.18	20.05 :	-1.13	
Diff (F-C)	0.50 :	0.15	0.86		

Scale VI: Motivation in Physics

There were no significant differences on this scale with respect to either pedagogy or gender, although the scores of all students tended to decrease over the semester, a movement which is perhaps related to the fact that the vast majority of these students were experiencing their first exposure to college level physics (Tables IV.11 and IV.12).

Table IV.11. Scale VI - Motivation in Physics

Source of variation	SS	df	MS	F	sig of F
BETWEEN STUDENTS	9274.79	411	22.57		
BETWEEN CELLS	123.79	5	24.76	1.10	0.361
BETWEEN GROUPS	47.68	6	7.95	0.35	0.909
CELLS MATURATION	71.87	5	14.37	3.38	0.005
MATURATION	173.99	1	173.99	40.93	0.000
FEMINIST PEDAGOGY effect	24.08	6	4.01	0.94	0.463
RESIDUAL ERROR	1747.07	411	4.25		

score averages

Group	Absolute score :	Pre-score	Post-score :	Maturation in the group	FEMINIST PEDAGOGY effect
All	20.49 :	20.98	20.00 :	-0.98	
Feminist trt	20.54 :	21.01	20.08 :	-0.93	0.09
Control	20.44 :	20.95	19.93 :	-1.02	
Diff (F-C)	0.10 :	0.05	0.15		

Table IV.12. Scale VI - Motivation Taking Gender into Account

Source of variation	SS	df	MS	F	sig of F
BETWEEN STUDENTS	9121.28	399	22.86		
BETWEEN CELLS	112.94	5	22.59	0.99	0.425
BETWEEN GROUPS	48.91	6	8.15	0.36	0.906
BETWEEN GENDERS	66.01	6	11.00	0.48	0.822
GROUPS * GENDERS	82.71	6	13.78	0.60	0.728
CELLS MATURATION	78.38	5	15.68	3.70	0.003
MATURATION	164.39	1	164.39	38.78	0.000
MATURATION * GENDERS	31.32	6	5.22	1.23	0.289
FEMINIST PEDAGOGY effect	27.61	6	4.60	1.09	0.370
PEDAGOGY * GENDERS	26.83	6	4.47	1.05	0.389
RESIDUAL ERROR	1691.55	399	4.24		

score averages for males

Group	Absolute score	Pre-score	Post-score	Maturation in the group	FEMINIST PEDAGOGY effect
All	20.55	20.85	20.25	-0.60	
Feminist trt	20.51	20.62	20.40	-0.22	0.77
Control	20.59	21.08	20.10	-0.98	
Diff (F-C)	-0.08	-0.46	0.31		

score averages for females

Group	Absolute score	Pre-score	Post-score	Maturation in the group	FEMINIST PEDAGOGY effect
All	20.43	21.10	19.76	-1.34	
Feminist trt	20.59	21.35	19.82	-1.53	-0.38
Control	20.28	20.86	19.71	-1.15	
Diff (F-C)	0.30	0.49	0.11		

B. THE EFFECTS OF PEDAGOGY, GENDER, AND ACHIEVEMENT

In the final stage of the statistical analysis of this data, we sought to further refine our understanding of the operation of the feminist strategies by including students' achievement level in the course as a possible confounding factor in the study. For the purposes of this analysis, students were sorted into one of three achievement levels based on their final mark in the course. This yielded three separate groups: those who achieved a mark ranging from 0-59%, those whose final mark fell between 60% and 74%, and, finally, students who received a mark between 75% and 100% on the course. In a variation on this "achievement study", we also re-analysed the data, using only the Inventory scores of students who had passed the course. The picture which emerged from this level of analysis was considerably more complex. We, therefore focus attention upon those features which are of particular relevance to the significance of the effects of the feminist strategies.

Scale I: Perception of the Teacher

As Table IV.13 illustrates, the significant effect of the feminist strategies on students' perception of the teacher remained when the different achievement levels of students in the study were taken into account (p=.000). It is interesting to note that there was a significant difference (p=.021) in the magnitude of the change registered for each of the three achievement levels in the class, with the scores of students in the middle group (60% to 74%)

undergoing the largest increase, 1.95 as compared to an increase of 1.04 for the students who achieved a mark of 75% or more in the course, and an increase of only .36 for students with marks ranging from 0-59% (Table IV.14).

Table IV.13. Scale I - Perception of the Physics Teacher Taking gender and achievement into account

Global design

Group	Absolute score	Pre-score	Post-score	Maturation in the group	FEMINIST PEDAGOGY effect
All	25.25	24.70	25.81	1.12	
Feminist trt	25.60	24.58	26.62	2.04	1.85[1]
Control	24.91	24.81	25.00	0.19	
Diff (F-C)	0.69	-0.23	1.62		

[1] p=0.000

Table IV.14. Different maturation rates on Scale I for the different achievement levels

Achievement levels (final mark)

Group	Absolute score	Pre-score	Post-score	Maturation in the group
Less 60		24.65	25.01	0.36[2]
60 to 74		24.49	26.44	1.95[2]
75 and more		24.95	25.99	1.04[2]

[2] p=0.021

Scale II: Anxiety Toward Physics

There was a significant difference in the level of anxiety measured for each of the three achievement levels of students in the sample (p=.002) and the rate of maturation with respect to anxiety also varied significantly from level to level (p=.000), with scores on this scale following a predictable pattern. Students in the lowest achievement group (0-59%) registered an increase in anxiety levels and a difference of 1.32 between pre-and post-semester scores. The scores of students in the other two groups (60%-74% and 75%-100%) decreased by .11 and 1.04 respectively (Table IV.15).

Table IV.15. Scale II - Anxiety Toward Physics measured for each of the different Achievement levels (final mark)

Group	Absolute score	Pre-score	Post-score	Maturation in the group
Less 60	17.11[1]	16.45	17.76	1.32[2]
60 to 74	16.80[1]	16.86	16.75	-0.11[2]
75 and more	15.65[1]	16.17	15.13	-1.04[2]

[1] p=0.002; [2] p=0.000

When these differences related to achievement level were taken into account, the significant differences between the genders with respect to absolute scores on this scale remained (p=.001), with women being significantly more anxious than men and scoring 17.10 on the scale as opposed to a score of 15.94 for the men (Table IV.16).

Table IV.16. Scale II - Anxiety Toward Physics measured for each of the different genders

Group	Absolute score :	Pre- score	Post- score
Male	15.94[3]:	16.04	15.85
Female	17.10[3]:	16.94	17.25

[3] p=0.001

However, it should be noted from Table IV.17, that when differences of gender, cell maturation rates and achievement levels were taken into account, the effect of the feminist pedagogy became almost significant (p=.051), yielding an effect of the pedagogy of -.62, as the experimental group score dropped by .25 and the control group score on the anxiety scale increased by .37.

Table IV.17. Scale II - Anxiety Toward Physics Taking Gender and Achievement into account

Global design

Group	Absolute score :	Pre- score	Post- score :	Maturation in the group	FEMINIST PEDAGOGY effect
All	16.52 :	16.49	16.55 :	0.06	
Feminist trt	16.38 :	16.50	16.25 :	-0.25	-0.62[1]
Control	16.66 :	16.48	16.84 :	0.37	
Diff (F-C)	-0.28 :	0.03	-0.59		

[1] p=0.051

When the Inventory scores of failing students were eliminated from the analysis, the effect of the feminist pedagogy became non-significant once again, suggesting that the feminist pedagogy had a particular impact in reducing the anxiety levels of failing students. Among students who passed the course, significant differences between students achieving 60-74% and those with marks of more than 75% persisted with respect to the rate of change on this scale.

Scale III: Value of Physics in Society

In the analysis of variance which took the three different levels of achievement into account, the significant differences which had emerged on this scale in the original design persisted. The men's absolute assessment of the value of physics in society was significantly higher than that of the women (Table IV.18), 23.49 as compared to 22.34 (p=.000), and students in the experimental group lowered their assessment of this value significantly more than students in the control group (Table IV.19), -.52 as compared with -.39 (p=.041).

Table IV.18. Scale III - Value of Physics in Society measured for genders

Gender	Absolute score :	Pre-score	Post-score
Male	23.49^{2}:	23.76	23.21
Female	22.34^{2}:	22.53	22.16

[2] p=0.000

Table IV.19. Scale III - Value of Physics in Society Taking Gender and Achievement into account

Global design

Group	Absolute score	Pre-score	Post-score	Maturation in the group	FEMINIST PEDAGOGY effect
All	22.91	23.14	22.69	-0.45	
Feminist trt	22.93	23.20	22.67	-0.52	-0.14[1]
Control	22.89	23.09	22.70	-0.39	
Diff (F-C)	0.04	0.11	-0.03		

[1] p=0.041

We were interested to note, however, that this significant effect of the feminist pedagogy disappeared (p=.106) when the scores of failing students were eliminated from the analysis, suggesting that it was the scores of the failing students which were responsible for the difference between control and experimental groups (Table IV.20).

Table IV.20. Scale III - Value of Physics in Society. Analysis of Variances eliminating failing students

Global design

Group	Absolute score	Pre-score	Post-score	Maturation in the group	FEMINIST PEDAGOGY effect
All	23.10	23.18	23.02	-0.15	
Feminist trt	23.17	23.27	23.07	-0.20	-0.10[1]
Control	23.03	23.08	22.98	-0.10	
Diff (F-C)	0.14	0.19	0.10		

[1] p=0.106

Scale IV: Self-concept in Physics

The overall effect of the pedagogy remained non-significant even when achievement levels were introduced into the analysis (p=.072). However, the differences between the genders with respect to their rate of change on this scale remained significant at this level of analysis (p=.001). Men tended toward a significantly greater improvement in self-concept over-all than women, +1.06 as compared to +.37. There was also a significant interaction between the feminist pedagogy and students' achievement level (p=.034). As Table IV.21 illustrates, the effect of the pedagogy was most positive among students who failed the course and high achieving women differed from the other groups in that the feminist pedagogy appeared to have a negative effect: high achieving women in the control group improved slightly in their scores on this scale, while the scores of high achieving women in the experimental group actually went down slightly, yielding a feminist pedagogy effect of -.80.

Table IV.21. Scale IV - Self-concept in Physics
FEMINIST PEDAGOGY effect by Gender and Achievement Levels

FEMINIST PEDAGOGY effect

Achievement Levels (final marks)	Gender	male	female		by Achievement levels only
	Less 60	1.49	1.25	:	1.17[1]
	60 to 74	1.03	0.68	:	0.86[1]
	75 and more	0.65	-0.80	:	0.25[1]
by Gender only		1.06[2]	0.37[2]		

[1] p=0.034; [2] p=0.001

When we looked only at the scores of students who had passed the course, we also found a significant interaction between the effect of the feminist pedagogy and the students' achievement level ($p=.017$). While, over-all, students who achieved a mark higher than 75% in the course improved significantly more than students whose mark fell between 60% and 74% ($p=.009$) on this scale, students in the control group whose final mark was above 75% actually improved more on the self-concept scale than this same group of students in the experimental group, +1.40 as compared to +.93, yielding a feminist pedagogy efect of -.48. The reverse was true for students in the middle range whose final marks were between 60% and 74%. In this group, students in classes experiencing the feminist pedagogy improved on the scale by .61, while those in the control group registered lower self-concept scores at the end of the semester than at the beginning and their scores dropped by .27, yielding an effect of the feminist pedagogy of +.87 (Table IV.22).

Table IV.22. Scale IV - Self-concept in Physics By Achievement Level

Achievement level 60 to 74

Global design

Group	Absolute score	Pre-score	Post-score	Maturation in the group	FEMINIST PEDAGOGY effect
All	21.24	21.16	21.33	0.17[2]	
Feminist trt	21.29	20.99	21.59	0.61	0.87[1]
Control	21.19	21.32	21.06	-0.27	
Diff (F-C)	0.10	-0.33	0.54		

Achievement level 75 and more

Global design

Group	Absolute score	Pre-score	Post-score	Maturation in the group	FEMINIST PEDAGOGY effect
All	23.53	22.94	24.11	1.16[2]	
Feminist trt	23.45	22.99	23.91	0.92	-0.48[1]
Control	23.60	22.90	24.31	1.40	
Diff (F-C)	-0.16	0.08	-0.40		

[1] p=0.017; [2] p=0.009

Scale V: Enjoyment of Physics

The effect of the feminist pedagogy on enjoyment of physics remained significant at this level of analysis (p=.032), with the scores of students in the control classes dropping by .87 as compared with the significantly smaller drop of .15 for students in the experimental classes, yielding an effect of the pedagogy of +.72 (Table IV.23).

Table IV.23. Scale V - Enjoyment of Physics
Taking gender and achievement into account

Global design

Group	Absolute score	Pre-score	Post-score	Maturation in the group	FEMINIST PEDAGOGY effect
All	21.37	21.62	21.12	-0.51	
Feminist trt	21.57	21.65	21.50	-0.15	0.72[1]
Control	21.17	21.60	20.73	-0.87	
Diff (F-C)	0.41	0.05	0.77		

[1] p=0.032

When students who failed the course were eliminated from the sample, the significance of the difference between control and experimental groups increased (p=.009). Among passing students in the experimental class, the average score on the enjoyment scale went up over the semester by .39, while in the control group the tendency for this score to decrease persisted even among passing students, whose scores dropped by .52, yielding an effect of the feminist pedagogy of +.90 (Table IV.24).

Table IV.24. Scale V - Enjoyment of Physics
Eliminating Failing Students

Global design					
Group	Absolute : score :	Pre- score	Post- : score :	Maturation in the group	FEMINIST PEDAGOGY effect
All	21.64 :	21.67	21.61 :	-0.07	
Feminist trt	21.92 :	21.73	22.11 :	0.39	0.90[1]
Control	21.36 :	21.62	21.10 :	-0.52	
Diff (F-C)	0.56 :	0.11	1.01		

[1] p=0.009

When all achievement levels were taken into account, the difference in the rate of change between the genders became significant (p=.023). Men tended to report a higher absolute level of enjoyment of physics than women and their enjoyment decreased over the semester less than did that of the women, -.15 for the men versus -.87 for the women (Table IV.25). When students with failing marks were eliminated from the sample, the difference in maturation rates for men and women became even more significant (p=.015). In this group, the enjoyment of men, in fact, increased by .38, while the scores for the women went down by .52 (Table IV.26).

Table IV.25. Scale V - Enjoyment of Physics by Gender Taking Achievement into account

Group	Absolute score	:	Pre-score	Post-score	:	Maturation in the group
Male	21.98	:	22.05	21.91	:	-0.15[3]
Female	20.76	:	21.20	20.33	:	-0.87[3]

[3] p=0.023

Table IV.26. Scale V - Enjoyment of Physics by Gender (final marks 60 and more)

Group	Absolute score	:	Pre-score	Post-score	:	Maturation in the group
Male	22.24	:	22.05	22.43	:	0.38[2]
Female	21.04	:	21.30	20.79	:	-0.51[2]

[2] p=0.015

There were also significant differences in the rate of change by achievement level (p=.000). The scores of students who ultimately failed the course decreased more than those of students in either the 60% to 74% range or in the range above 75%. In fact, the scores of students who achieved a mark higher than 75% in the course increased by .64 (Table IV.27). There were no significant interactions between the feminist pedagogy and any of these differences, however, and we therefore conclude that, in spite of these differences, the feminist pedagogy did have a positive effect.

Table IV.27. Scale V -Different Maturation Rates on Scale V for the different Achievement levels (final mark)

Group	Absolute score	Pre-score	Post-score	Maturation in the group
Less 60	20.83	21.57	20.10	-1.47[2]
60 to 74	21.15	21.41	20.89	-0.51[2]
75 and more	22.22	21.90	22.36	0.64[2]

[2] p=0.000

Scale VI: Motivation in Physics

No significant differences between control and experimental groups emerged on this scale even when achievement levels were taken into account. However, this level of analysis did reveal significant and interesting differences in the rate of change for scores on the motivation scale with respect to students' achievement level in the course (p=.001). With respect to change over the semster on this scale, students who failed the course predictably experienced the most dramatic decrease in motivation and their scores dropped by an average of 1.83. They were followed by students who achieved a mark between 60% and 74% whose scores decreased by 1.13. Students whose final mark was above 75% registered a drop of only .34 on this scale. We were interested to note, however, that the initial survey of students at the beginning of the semester showed a remarkable similarity in motivation scores for the three groups. In this initial survey, the average score for students below 60% was 21.14, whereas students with marks between 60% and 74% scored 20.79, and those above 75% scored 21.15 (Table IV.28).

Table IV.28. Scale VI - Motivation Scores by Achievement levels (final mark)

Group	Absolute score	Pre-score	Post-score	Maturation in the group
Less 60		21.14	19.31	-1.83[1]
60 to 74		20.79	19.66	-1.13[1]
75 and more		21.15	20.81	-0.34[1]

[1] p=0.001

A similar pattern pertained with respect to the differences between genders on this scale. While women scored slightly higher than men in the initial pre-semester survey, 21.08 as compared with 20.97 for men, including achievement levels in the analysis of variance revealed a significant difference (p=.031) in the rate of change between the genders. When the different achievement levels of students were taken into account, it became clear that the decrease in the score on this scale for women (-1.40) was significantly greater than the decrease in the men's score (-.79). Similar differences between men and women with respect to maturation persisted when failing students were removed from the sample (p=.024).

Table .IV.29. Scale VI - Motivation Scores by Gender

Group	Absolute score	Pre-score	Post-score	Maturation in the group
Male		20.97	20.18	-0.79[2]
Female		21.08	19.68	-1.40[2]

[2] p=0.031

CHAPTER V

DISCUSSION OF RESULTS

As we move to interpret these results, it is useful to think of the six scales of the Physics Attitude Survey as an inventory of the points of attachment which students may experience in their relationship to this subject. Given this orientation, we performed a Principal Components Analysis to explore the correlation between the scales of the Physics Attitude Inventory and to isolate the mathematical trends which emerged from the students' scores. The first trend we found was that the Anxiety Scale (Scale II) was negatively correlated with the other five scales and that these other five scales were all more or less correlated with each other. The strongest correlations emerged between scales IV and V, IV and VI, and V and VI. Students tended to have high scores on all scales (reversed for Scale II) or low scores on all of the six scales.

The second trend was that the score on Scale I (Perception of the Teacher) was the most important factor distinguishing students from one another, taking the first trend into account.

It is interesting that these mathematical trends were echoed in the interviews which we conducted with the students. In fact, in these interviews, the importance accorded to the physics teacher was a recurrent and striking theme. In the initial, pre-semester interview, we began by asking students to describe their previous experiences with physics as a subject. We were impressed by how frequently students included their previous experiences with physics teachers as an integral part of this discussion, sometimes to the exclusion of all other considerations. More specific questioning in this area revealed that there was almost universal dependence upon the teacher among these students, and that the teacher was important not simply as a guide but as the source of knowledge. In the words of one student, "The teacher is really important. What he knows is what you know." This attitude also finds reflection in the use which students seem to make of textbooks and readings in physics courses. While we were not surprised to discover that few students reported reading beyond course material in the area of physics, we were surprised at the number of students who reported making minimal use of the required text in their physics courses. For many students, the theoretical discussions in their books were a source of confusion which they resolved by ignoring the text in favour of class notes. Some students told us that they did not even purchase the text. Furthermore, many students suggested that in this respect physics was distinguished from other subjects, including other science subjects. As one student said, "Physics is a different language. The teacher is the translator."

On the basis of both quantitative and qualitative data, we have been drawn to conclude that, in physics, the teacher plays a critical role in affording students a point of entry to and engagement with the subject. Within this context, the fact that an improvement in students' perception of the teacher was a fixed, solid, and constant effect of the feminist pedagogy, regardless of gender and taking variation with regard to achievement level into account, is a matter of some import. Precisely how the strategies operated to produce this effect is a subject which we reserve for fuller treatment in a later chapter. Suffice for the moment to say that an item by item analysis of the student response to Scale I revealed consistently more positive attitudes on the part of students in the experimental class. These students were likely to see their teachers as significantly more responsive to their needs and more sensitive to their problems.

Moreover, there are some indicators to suggest that the teacher, important for all students, may have a particular role to play in the case of women. The data which bears upon this conclusion was produced, in part, by our efforts to record the impact of the strategies on student-initiated contacts with the teacher. As part of this effort, we asked teachers in both control and experimental groups to keep a careful record of their contact with students in their offices. The teachers found this to be a difficult task and over the course of the semester they worried about the accuracy of their tallies for each student. In response to this concern, we included students who had never sought out such individualized attention in our analysis since teachers felt most confident about the accuracy of their records for this group. When the data was treated in this way, a comparison between men and women with respect to their use of office appointments revealed a very highly significant difference (p=.000) between the two genders. As Table V.1 shows, more than half of the men (51.6%)

never met with the teacher in his or her office but only 35.7% of the women fell into this category.

Table V.1. OFFICE by GENDER

OFFICE	Count / Row Pct / Col Pct	GENDER: Men 1	Women 2	Row Total
never	.00	133 59.1 51.6	92 40.9 35.7	225 43.6
sometimes	1.00	125 43.0 48.4	166 57.0 64.3	291 56.4
	Column Total	258 50.0	258 50.0	516 100.0

Chi-Square	Value	DF	Significance
Pearson	13.24774	1	.000
Minimum Expected Frequency	112.500		

It seems to us that these findings may be interpreted in several different ways. Certainly it is possible to see in the greater tendency of women to seek out individual attention from the teacher a reflection of the fact that their anxiety levels were higher than those of the men, their confidence in their ability to "perform" (self-concept) lower. Researchers have suggested that women may turn their lower self-confidence to their advantage by compensatory means: working harder or, in this case, seeking out more individualized help. Perhaps the women who met with teachers in their offices were also availing themselves of an opportunity to lay claim to attention which they seem less likely than the men to do in a large classroom setting. Indeed, the findings of other researchers in this area, reviewed in Chapter 2, were echoed in our interviews. The voice of one young woman here captures the sentiments of many when she spoke of her feelings about this issue:

> Oh, I could never ask questions in class. Like, if nobody else is asking it, they must already know. Anyway I don't want to interrupt ... But some teachers tell you come to their office, and I like to do that. It's a lot easier that way to ask what I need to know.

The fear of exposure in class is certainly not unique to women. It is, however, significant that the teacher's office is perceived as quite a different domain by these women, as reflected in the striking gender difference with respect to student-initiated consultations. As we seek to make sense of this statistic, it is perhaps necessary to introduce a different theoretical framework and to see in this phenomenon evidence of a preference for a different approach to learning, one which favours a more personal context than the large classroom provides. The work of Belenky et al (1986) in defining the characteristics of the "connected" learner seems to us to be of great relevance here, particularly in that it opens the door to underscoring the importance of the relationship between teacher and learner for such students. Our own work would seem to lend weight to their assertion that such learners are over-represented among women. If this is indeed the case, then it is possible that improving students' perception of the teacher might, in the long run, impact differently upon women and men and how they situate themselves with respect to physics.

It is interesting that the effect of the feminist pedagogy in rendering the students' perception of the teacher more positive did not correspond to a decrease in the experimental group in the number of students who never came to see the teacher. In fact, taking the data on office appointments as a barometer, the feminist pedagogical strategies had the opposite effect. In the experimental group, there were significantly more students who never sought out the teacher in her or his office (p=.005), with 48.6% of the experimental group falling into this category as opposed to only 36.0% of the control group (Table V.2).

Table V.2. OFFICE by EXPGR

OFFICE	Count / Row Pct / Col Pct	EXPGR: Control group 0	EXPGR: Experimental gro 1	Row Total
never	.00	72 31.7 36.0	155 68.3 48.6	227 43.7
sometimes	1.00	128 43.8 64.0	164 56.2 51.4	292 56.3
	Column Total	200 38.5	319 61.5	519 100.0

Chi-Square	Value	DF	Significance
Pearson	7.91745	1	.005
Minimum Expected Frequency -	87.476		

Given the potential for teacher variability in the collection of this data, our explanation of this difference remains tentative; however, it does seem possible that the feminist strategies themselves operated to change classroom dynamics and to alter the way in which students used the teachers' expertise. For example, as will become clear in the next chapter, the Question/Answer Box allowed students to establish a contact with the teacher in a way which the traditional classroom rarely allows. On a practical level, many specific problems were solved in this way; as well teachers became more conscious of shared misunderstandings and they could deal with them in the classroom. Beyond this, however, many students saw their correspondance with the teacher as a connected and personal one. Perhaps fewer students in the experimental class sought out the teacher in his or her office because more students had an on-going relationship with the teacher through the Question/Answer Box.

It also seems likely that the Peer Support Partnerships functioned to reduce the pressure on the teacher to solve individual problems. In the experimental classes, students helped each other more and they saw each other as resources. Once again, it should be noted that this more connected learning environment may have particular benefits for women who can exercise their preference for this approach without necessarily increasing their dependence upon the teacher. In fact, as Table V.3 suggests, the experimental group effect really only operated for the women. Among the men, there was no significant difference between control and experimental groups with respect to the percentage of men who never sought out the teacher in his or her office. However, among the women, the percentage of women who never sought out the teacher in this way was significantly higher (p=.017) in the experimental classes.

Table V.3. OFFICE by EXPGR controlling for GENDER

OFFICE by EXPGR for Men only

OFFICE	Count Row Pct Col Pct	EXPGR Control group 0	Experimental gro 1	Row Total
never	.00	46 34.6 45.5	87 65.4 55.4	133 51.6
sometimes	1.00	55 44.0 54.5	70 56.0 44.6	125 48.4
	Column Total	101 39.1	157 60.9	258 100.0

Chi-Square	Value	DF	Significance
Pearson	2.39699	1	.122

Minimum Expected Frequency - 48.934

OFFICE by EXPGR for Women only

OFFICE	Count Row Pct Col Pct	EXPGR Control group 0	Experimental gro 1	Row Total
never	.00	26 28.3 26.5	66 71.7 41.3	92 35.7
sometimes	1.00	72 43.4 73.5	94 56.6 58.8	166 64.3
	Column Total	98 38.0	160 62.0	258 100.0

Chi-Square	Value	DF	Significance
Pearson	5.73917	1	.017

Minimum Expected Frequency - 34.946

The feminist pedagogy also appeared to have a significant and positive impact upon students' enjoyment of physics as a subject. It must be emphasized that both genders benefitted from the effect of the pedagogy; however this effect is best understood as operating to counteract an overall tendency (with some exceptions related to achievement level) for students in general, and women students in particular, to enjoy physics less as the semester wore on and the material became more complex. On the basis of the interviews, we can suggest that curriculum may well be implicated in women's more pronounced disenchantment with physics. Certainly the women seemed to be less readily drawn into discussions of the workings of cars and motors and military equipment and in a course as intensely problem driven as physics has become, it is difficult to ignore the fact that women were less likely than men to see problem solving as a game. Still, the value of the pedagogy as a "brake" upon a negative slide should not be underestimated, particularly since we have measured its effects over a single semester and do not know the impact it might have when practised over a longer period of time.

Our data also suggested that the feminist pedagogy may have had a particular impact upon students who ultimately failed the course. The reader will recall that it was among these students that feminist pedagogy seemed to have the greatest impact in reducing levels of anxiety and, interestingly enough, it was failing students in the experimental class who ascribed the least amount of value to physics in society. We want to suggest that both of these tendencies are perhaps related to the extent to which the strategies served to demystify physics for these students. Thus, failing students in the experimental classes faced their failure with less anxiety (and they did so for a variety of reasons to be discussed in the following chapters), but they were also able to protect their self-esteem by ascribing less importance to physics in terms of themselves and their futures. While it is difficult to argue that seeing physics as less valuable is a desirable outcome, there is perhaps something to be said for allowing students, especially marginal students, a place in which they can explore a subject and even fail, without their feeling that the consequences need be devastating.

When we compared the failure rates in control and experimental groups, we found a higher failure rate (30.4%) in the experimental group than in the control group where the rate was 25.5% (Table V.4). However, these differences were not significant.

Table V.4. FAILING RATES by EXPGR

	Count Row Pct Col Pct	EXPGR Control group 0	Experime ntal gro 1	Row Total
FAIL success	.00	175 44.6 74.5	217 55.4 69.6	392 71.7
fail	1.00	60 38.7 25.5	95 61.3 30.4	155 28.3
	Column Total	235 43.0	312 57.0	547 100.0

Chi–Square	Value	DF	Significance
Pearson	1.59572	1	.207
Minimum Expected Frequency –	66.590		

We want to emphasize that these statistics must be read with a great deal of caution since failure rates are particularly subject to teacher variation. They are also difficult to interpret since at least some of the students recorded as failures are, in fact, students who either never attended the class or who disappeared early in the semester. In the experimental class, this meant that they could hardly have been said to have experienced the strategies.

We sought to address this latter problem by re-analysing failure rates using only students who were included in the survey sample. Because these students completed both pre-and post-semester surveys, we could be reasonably certain that they had participated in the course throughout the semester, and we took the completion of two surveys as a mark of some minimal level of engagement in the course.

As Table V.5 illustrates, among these more "engaged" students, the failure rate in the experimental group was higher than in the control group but not significantly so (21.2% as compared to 18.8%).

Table V.5. FAILING RATES AMONG "ENGAGED" STUDENTS by EXPGR

FAIL	Count / Row Pct / Col Pct	EXPGR: Control group 0	Experimental gro 1	Row Total
success	.00	151	186	337
		44.8	55.2	79.9
		81.2	78.8	
fail	1.00	35	50	85
		41.2	58.8	20.1
		18.8	21.2	
	Column Total	186	236	422
		44.1	55.9	100.0

Chi-Square	Value	DF	Significance
Pearson	.36300	1	.547
Minimum Expected Frequency - 37.464			

There were almost no differences between men and women with respect to the failure rate and a negligible difference between control and experimental groups among the men. Among the women, however, a different, although still non-significant pattern emerged. Here, the experimental group had a higher failure rate, 21.4%, than did the control group where only 17.2% of the women failed (Table V.6). Certainly it is possible that feminist pedagogy produced more failures in this group. However, there is little supporting evidence. Class averages for the two groups, excluding failures, were almost identical, as were the averages for men and women. Within the context of the survey results, we want to suggest that what we see here is one small index of a trend which we think may have long term implications, namely that the feminist strategies seem to "hold" students (and in this case they were women students) who ultimately fail the course.

Table V.6. FAILING RATES by EXPGR controlling for GENDER

FAILING RATES by EXPGR for MEN

FAIL	Count / Row Pct / Col Pct	EXPGR Control group 0	Experimental gro 1	Row Total
success	.00	74 44.0 79.6	94 56.0 79.0	168 79.2
fail	1.00	19 43.2 20.4	25 56.8 21.0	44 20.8
	Column Total	93 43.9	119 56.1	212 100.0

Chi-Square	Value	DF	Significance
Pearson	.01061	1	.918
Minimum Expected Frequency –	19.302		

FAILING RATES by EXPGR for WOMEN

FAIL	Count / Row Pct / Col Pct	EXPGR Control group 0	Experimental gro 1	Row Total
success	.00	77 45.6 82.8	92 54.4 78.6	169 80.5
fail	1.00	16 39.0 17.2	25 61.0 21.4	41 19.5
	Column Total	93 44.3	117 55.7	210 100.0

Chi-Square	Value	DF	Significance
Pearson	.57158	1	.450

Finally, it is useful to place these modest changes in student attitudes within a larger context. The majority of the students in the physics classes making up our sample had opted not so much for physics as for a programme in which physics was a required course. With the exception of the Mature students in cell five, the majority of these students were either already in or attempting to enter the Cegep Science Programme. When we asked these students why they had chosen the sciences, we found a wide range of response; however, it is certainly accurate to say that many students reported choosing the science programme at Cegep as a way to "keep their options open" and out of a recognition of the status of science in the hierarchy of disciplines.

As discussed in Chapter I, Sheila Tobias (1990) has observed that people who stay in science do so for reasons that have little or nothing to do with their education in the present. Indeed, many of the students whom we interviewed were most accurately characterized as "waiting." Few had deep commitments to life in the sciences, but when they did, they tended to be connected to the sciences by what we have come to call "career glue", and here, it is our clear impression that the men were much more firmly "stuck" than the women, with specific and reasonably attainable career goals, among which "becoming an engineer" figured prominently. The career ambitions of the men may well be reflected in the significantly higher value which they ascribed to physics in society on the Inventory.

If, as we suggested in Chapter I, men are more firmly attached to physics by virtue of their career goals, their classroom experiences are perhaps of less consequence in shaping the course of their future choices. The results of our research to date suggest that, at least on the basis of one semester of intervention, feminist pedagogy is most effective in improving the immediate classroom experience: the teacher is seen in a more positive light, the subject is more enjoyable, and, for some students, anxiety is reduced. In these areas, the gains are distributed equally for men and women. However, we believe that the import of these gains may be greater for women precisely because their points of attachment to physics beyond the classroom are fewer and more fragile. It is possible that the gap which emerges and grows over the semester between men and women on the Motivation Scale of the Inventory is one measure of this fragility.

While it is true that the feminist strategies appeared to improve students' attitudes to both teacher and subject vis à vis the control group, it is also true that these strategies had no such clear effect when it came to changes in students' self-concept in physics. It is helpful to think of the Self-concept scale on the Physics Attitude Inventory as measuring attitudes related to self-confidence in physics, particularly those attitudes which bear upon a sense of "can do" with respect to the material. Such attitudes are perhaps enmeshed in more complex ways with issues of achievement than are others measured by the Inventory and they are thus less susceptible to change as the result of one semester's intervention. This interpretation makes sense of the significant interaction which we found between the feminist pedagogy and levels of achievement in the class. The reader will recall that here the pedagogy had its most positive effect among students in the failing group and the 60% to 74% mark range. It seems likely that such students would be most responsive to the greater supportiveness of the feminist classroom and the reduced levels of competition.

Indeed, it is these students who, in our interviews, most frequently expressed negative feelings about competition in the course or said that they felt remote from students who engaged in comparisons of test results. After only one semester of intervention, it is impossible to say whether the more positive effect of the pedagogy on these students is the first sign of what might have become, over time, a trend which would affect all students, or whether this is the group that would always benefit most from this pedagogy.

Finally, we want to focus some more specific attention upon the fact that, overall, the women in our sample had significantly lower self-concept scores than the men and they were significantly more negative in their rate of change over the semester. A good deal of research energy has been directed toward the issue of self-confidence in education. When one reviews the literature in this area, much of which draws upon some aspect of attributional theory, there is evidence to suggest that the way in which students view success and failure is indeed a gendered matter (Maccoby, 1974; Frieze et al, 1975; Crombie, 1983; Erkut, 1983; Vollmer, 1984; Licht, 1987). One of the recurrent findings in this work, is that female students tend to externalize success ("I did well on the test because it was easy") and internalize failure ("I did badly on the test because I am dumb"). Licht (1987) has argued that this attributional pattern affects women's motivation to tackle subjects (what we here call self-concept) in complex ways: exercising a positive influence in the early years of schooling but ultimately demotivating them as tasks become more difficult and outcomes more uncertain.

As we have worked with this difficult construct, we have become increasingly conscious of the extent to which the maintenance of high self-confidence is also related in important ways to the ability to suppress self-doubt and to ignore negative or contradictory evidence. Women, we would argue, are less able or less willing to perform this act, as their scores on the self-concept scale bear witness. And if women are less given to such suppression, it must be said that they operate at a particular disadvantage in the science classroom. Many of the markers of high self-confidence in the research literature - that is, ascription of success to effort and ability, the manifestation of persistence and tenacity even in the face of adversity - are the central tenets of the dominant ideology in science education (Hacker,1989).

The feminist strategies which were introduced into the physics classes, far from encouraging students to suppress negative feelings and "soldier" on, encouraged them to express and reflect upon their doubts and concerns. As students' feelings come out of the shadows and move to a more central place in the physics class, we need to work at learning more about responding to them with greater effectiveness. Lenney (1983) has observed that "women may have an unstable or 'vulnerable' rather than a simply low level of self-confidence (940). However, there is another way to read women's self-confidence scores. We want to suggest that we need to think about women as being a "sensitive" rather than a "vulnerable" group, a group which registers with far greater accuracy than an "insensitive" or "invulnerable" group certain problematics in a given system of achievement.

To date, we as teachers have tended to encourage denial in our students ("Have more confidence in yourself" we say) but it will perhaps be necessary to change our approach and to turn to dismantle those structures which, predicated upon the suppression of doubt, continue to disadvantage students who are less given to such suppression: competitive grading systems, inflexible and timed exams, consistent emphasis upon the "correct" answer, the division of courses into ever smaller units organized around a rigid system of tests and rewards.

These considerations also have important implications for researchers who would continue to explore the issue of self-confidence in the classroom. In response to our interview questions on self-confidence, a young woman, returning to college begins: "I'm pretty confident, I guess. I'm doing well ... getting good marks ... but I have to work at it." A male peer replies: "I know that I can do it. I work at it. I get it." These two small fragments are paradigmatic. Both of these students rate high in self-confidence. When such students are asked to reflect upon their confidence in their abilities in physics, their responses are structured by three central terms: competence, confidence, and effort. Students who are rated high in self-confidence tend to express a belief in the virtues of hard work and they see their own hard work as ensuring success. They speak of the connection between discipline, concentration, repetition, and understanding, and they see themselves as forging this connection. Many of these students see self-confidence itself as a kind of self-fulfilling prophesy: "If you believe that you can do it, you can."

It is certainly possible to hear a subtle difference between the young woman and the young man. Hard work for her qualifies *her* success and diminishes our assessment of her ability ("I can do it BUT I have to work hard"). Researchers have explored this terrain under the general rubric of modesty in female self-reports of confidence. Heatherington et al. (1989) review the findings with respect to the lower self-confidence of women and place them within the context of their own research which documents some of the negative consequences for girls who are immodest about their scholastic achievements, particularly in the areas of science and music. From this point of view, self-confidence can only be imperfectly de-coded from a gendered script: femininity demands modesty; heroes remain heroes by acting with bravado. Needless to say, we know little about the ways in which race and class interact with the gendered roles. The school as a social system reinforces the dominant tradition.

As we interpret the scores of women on self-confidence tests, we need, certainly, to remind ourselves that there is a social and historical context within which women interpret their experiences and give meaning to their lives. Beyond this, however, we would argue that there are solid grounds for raising some very fundamental questions about the meaning of self-confidence. Our thinking in this area draws inspiration from the work of Sally Hacker (1989) in exploring the central ethos of engineering training. She traces the origins of this ethos to the military and she reminds us that military institutions have "constructed a kind of masculinity useful for them" (p.60). Hacker's work is critically important in that she delineates the concrete historical process shaping this form of masculinity and carrying it into other organizational structures. Brian Easlea (1987) has traced similar connections in the area of physics.

What we want to focus on, however, is the nature of this masculinity. First of all, we want to emphasize that this is a masculinity which stands at the top of a hierarchy of masculinities. That is, in a given historical context, the tremendous attraction exercised by specific institutions has much to do with the fact that these institutions offer the possibility of entrance to membership in the elite. Secondly, it is important to underline that the prospect of entry to the elite is conflated with the experience of pleasure in the discipline of control. At the core of what Hacker calls "the masculine eroticization of engineering" lie the terms central to the development of self-confidence as a construct in the research literature: effort, tenacity, perseverance, and significantly, "the control of sensuality, the emotions, passion" (p.56).

It is possible, then, to see self-confidence as a construct which privileges behaviour rewarded in elitist masculinist organizations and to hear in the rhetoric of self-confidence some measure of the individual's adherence to an ideology associated with such organizations. Clearly adherence comes more easily to some than to others. Perhaps it is a question of appeal in the sense that Hacker gives to the term as she talks about the appeal of organizations like the Green Berets in the United States to young working class males. What is important here is the insistence upon a "fit" between organizational structure, ideological structure, and individual psychology. Hacker describes how, in the daily routine of engineering training, control is experienced physically - "inscribed on the body", as Foucault would say (p.56). She reminds us that such training is not without its pleasures, but that the seductions of technology, like those of eroticism, "reflect primarily the desires of men" (p.55).

In a different way, Evelyn Fox Keller (1985) has also explored the extent to which the masculine identity, forged out of separateness and maintained by the defence of rigidly controlled boundaries, has shaped and been served by the paradigm dominating Western science. The point which we wish to retain and underline here is the extent to which all that we have been observing is connected to a particular psychological development. It is neither a question of choice nor of style, but deeply rooted in the way in which men become men in our society.

As researchers, we need to think about the extent to which our notion of self-confidence is masculine in this sense, oriented toward a masculine system of ego defence, protective for some, but, in fact, militating against other kinds of development. Many of the most persuasive studies support the hypothesis that confidence is the central gender-related predictor of persistence in the area of mathematics and science (American Association of University Women 1990; Meece et al 1982; Mura 1986). However, our work with college level women has led us to the conclusion that the notion of self-confidence must be re-evaluated if we are to avoid the pitfall of imposing a masculine standard upon women's behaviour. The way in which women tend to respond to tests of self-confidence in general, and to our own survey, in particular, is perhaps a symptom of their outsider status, confirmation of the fact that they are not "one of the boys", but it can also be read, on a deeper psychological level, as a sign of their resistance to the imposition of a view of self that is neither recognizable nor comfortable for these women.

CHAPTER VI

STUDENT USE OF THE PARTNERSHIP ACTIVITIES IN PHYSICS

The Peer Support Partnerships which we asked the physics teachers to encourage in their classrooms were, as described in Chapter II, permanent term-length dyads or triads of the students' own choosing. Since Cegep physics courses include a two-hour-per-week laboratory period during which students traditionally work in pairs, these lab partnerships became the basic functioning units for the Peer Partnership work of the Project. All teachers allowed the students to choose their own units, ensured that these units were established early in the semester, and made certain that some problem solving and review exercises were done in class in dyadic configurations. Though partnerships were theoretically fixed, some flexibility was necessary with respect to student absence. On some occasions, two sets of partnerships joined together briefly to solve disputes and countercheck their work. One of the teachers encouraged students to try changing partners occasionally to increase their sense of camaraderie in the class.

The teachers awarded a total of either two, three, four, or five marks for the completion of the required number of partnership tasks. The work might or might not have been corrected by the teacher, but the student's Peer Support Partnership score depended only upon completion of the task process, not upon the quality of the product. The precise number of marks depended upon various departmental curriculum constraints which the teacher had to deal with at his or her particular college. Students who did all the partnership work got full marks; students whose partnership work was not complete were marked accordingly, with some students obtaining a partial score and some no score at all. As will be seen in the following table, we have used these scores in various ways in order to assess the degree of engagement of the individual student.

TABLE VI.1 STUDENT SCORES ON COMPLETION OF PARTNERSHIP WORK

Gender	Fail	Partial	Complete
Males	3 4.5%	22 33.3%	41 62.1%
Females	5 5.8%	27 31.4%	54 62.8%

Total number of student files: 158
Total males: 66 Total females: 86

Table VI.1 shows the extent to which students involved themselves in Partnership activities. The column "Fail" represents those students who failed to complete a sufficient number of activites to receive a passing grade on the strategy. The centre column, "Partial", represents those students who received an imperfect but passing grade. The column "Complete" represents those students who received full credit. As can be seen, 62.1% of the male students and 62.8% of the female students completed the full number of activities required for the semester. In the middle category, satisfactory but not complete, we see 33.3% of the males and 31.4% of the females. The percentages of males and females in the lowest category is 4.5% and 5.8% respectively. An obvious observation to be made here is that the majority of students involved themselves quite satisfactorily or better in the Partnership activities. The failing percentages are very low. We note also that, calculated in this way, the involvement of males and females is identical.

Taking the scores of four, five, and six marks and transforming them into a score based on 100% allows us to see that the average mark on this strategy was 90.7% (91.0% for males and 90.4% for females). Since this is a great deal higher than the overall mark average in physics for this specific sample of students, that is, 67.5% (68.1% for males and 67.1% for females), to include the Partnership activities as a part of the evaluation appears not to have compromised their success: rather, it has likely given them a few extra marks, overall. And this is true for both males and females.

Analysis of variance of student marks in physics by their score on the Partnership activities shows no relationship between the strategy scores and the overall marks in physics. Only one male student (1.5%) who failed physics also failed the Partnership work; only three female students (3.4%) who failed physics also failed on the strategy score. Furthermore, analysis of the Partnership score with class attendance shows no connection whatever between these variables. It is of some interest to note that the success of the strategy seems to have operated rather independently of much else that went on in the course, as if the activity called upon quite different skills and personal qualities than those involved in the actual study of physics. Indeed, these skills and qualities seem to be much more readily available to this population of students than are some of the performance skills required by their physics subject tasks. In this sense, what we observe here tends to hark back to issues of isolation and elitism ideologically linked to the study of science and discussed in earlier chapters of this report. Since Partnerships may almost be said to work against such prevailing ideas and practices, it is not surprising to see that students' performance patterns within these Partnerships is rather different from much of the rest of their work.

This contrast, however, between the Partnership work and the competitive individualism traditionally associated with science education does not mean that the strategy has been ineffective. Far from it. Indeed, insofar as student attitude towards these activities is concerned, we see important connections between successful Partnership work and success in the course.

In order to evaluate student attitude toward the Partnership work, we asked them to use one of their final Question/Answer Box submissions to write freely, fully and confidentially about their individual experiences as members of a partnership. We asked them what they did when they worked together, how they chose their partnerships, and how the relationship with the other student worked. Our principal concern, however, was to determine to what extent they had liked working in this particular configuration, and whether they felt it had been profitable. Careful reading of these submissions then led us to describe four categories of response. Each evaluation was then coded and placed in one, and only one, of the following categories:

1. Negative: Disagreement with the principle of collaboration (J'aime mieux faire mes rapports seul c'est vraiment ma note"), a general distrust of peers ("I will always choose to go directly to the instructor first before I ask another student for help"), or a real preference for independent learning ("je préferais travailler seul car cela me permettait de voir ou j'en étais rendu dans la compréhension de la matière"). Some students' negativity was based on having a partner whom they found "parasseux", or "dépendent de moi", or "a total disaster in the work field", or "too competitive" or "stubborn, always arguing".

2. Qualified Positive: Generally satisfied with both the experience and the partner but expressing some specific criticism, sometimes of themselves ("I would not learn on my own and always depend on the partner"), sometimes of the partner whom they found "très lunatique", or "very competitive", or unreliable in some way. Some students who saw the benefit of explaining things to others nevertheless found it "frustrating" and "time-consuming" to do so. Some who had liked their partners very much were angry because the partner dropped the course; others complained that "we never did any work and talked the whole time" or "travailler à deux...je me

concentre beaucoup moins."

3. Instrumental Positive: Complete satisfaction with the way in which the Partnership helped the student to master material: "two heads are better than one." Efficiency was often cited: "Together the procedure was faster and easier." Some students seemed to prefer working with partners to asking for teacher help because the partner "could have the answer and explain in coherent English because he is on the same level of physics, and vice-versa". Others found Partnership work led to greater independence: "Cela m'aide parce que souvent, une des deux ne comprenait pas et l'autre comprenait le problème, alors on pouvait s'expliquer sans toujours demander au professeur."

4. Affective Positive: Complete satisfaction with the process and the partner, and including reference to affective issues in the evaluation: "I found that working with my partner was the most positive aspect of this course. We were both eager to help each other out and we even had some fun times." "J'ai adoré travailler avec un coéquipier durant la session, car cela est beaucoup plus intéressant travailler à deux. On peut s'entraider mutuellement, on s'encourage et on sait qu'on peut compter sur l'autre en cas de difficulté." "We got along well and learned more than physics."

Table VI.2 shows how male and female students evaluated their experience with the Partnerships.

TABLE VI.2. STUDENT EVALUATION OF THE PARTNERSHIP WORK.

Gender	Negative	Qual.Pos.	Pos.Instr.	Affect.Pos.	Tot.
Male n Row % Col %	9 10.8 64.3	11 13.3 61.1	45 54.2 58.4	18 21.7 24.3	83 45.4
Female n Row % Col %	5 5.0 35.7	7 7.0 38.9	32 32.0 41.6	56 56.0 75.7	100 54.6
Tot.	14 7.7	18 9.8	77 42.1	74 40.4	183 100.0

Chi-Square	Value	DF	Significance
Pearson	22.35374	3	.000

It is of great importance to note how few students offered negative evaluations of this strategy: only 10.8% of the males and 5.0% of the females are situated in this category. The qualified positive category is also very small, with 13.3% males and 7.0% females. Even in these sparsely populated categories, however, we begin to note the trend toward more positive evaluation on the part of female students. 64.3% of the wholly negative population is male. Among the males, wholly positive evaluations total 75.9% (54.2% + 21.7%), whereas for the females, completely positive responses come from 88.0% (32.0% + 56.0%) of the students. When we examine the Positive Instrumental column, we note that males are more likely to cite the instrumental value of these partnerships, whereas 56.0% of the entire female population cite the Partnership strategy as affectively positive in their experience of physics. That these gender differences are indeed very highly significant is shown by the p value of less than 0.00. That they bear out research upon the learning preferences of women is not only obvious but suggestive that this kind of pedagogical intervention is particularly well designed to answer these preferred styles of learning.

TABLE VI.3. STUDENT ATTENDANCE COMPARED WITH THEIR EVALUATIONS OF THE PARTNERSHIP WORK.

Evaluation	Good Attendance	10 or More Abs.	Row
Negative n	10	5	15
Row %	66.7	33.3	8.2
Col %	6.5	16.7	
Qual.Pos.n	13	5	18
Row %	72.2	27.8	9.8
Col %	8.4	16.7	
Inst.Pos.n	65	12	77
Row %	84.4	15.6	41.8
Col %	42.2	40.0	
Pos.Aff. n	66	8	74
Row %	89.2	10.8	40.2
Col %	42.9	26.7	
Col	154	30	184
Tot	83.7	16.3	100.0

Chi-Square	Value	DF	Significance
Pearson	6.58980	3	.086

Contingency tables in which evaluations are compared with performance in the strategy or with attendance in class show no strong relationships between these factors. Table VI.3 does suggest, however, that students with high absence rates (more than 10) are more highly represented among the negative evaluators (Row % 33.3% compared to 27.8%, 15.6% and 10.8%) than in any other category. In fact, the evaluations by these chronic absentees make up a noticeably small percentage of the top two evaluation categories, 15.6% and 10.8%. However, though interesting, these differences are not significant (p= .086).

TABLE VI.4. STUDENT MARKS IN PHYSICS COMPARED WITH THEIR EVALUATIONS OF THE PARTNERSHIP WORK.

Evaluation	Marks Below 75%	75% or More	Row
Negative n Row % Col %	14 93.3 11.1	1 6.7 1.7	15 8.2
Qual.Pos.n Row % Col %	15 83.3 11.9	3 16.7 5.2	18 9.8
Inst.Pos.n Row % Col %	46 59.7 36.5	31 40.3 53.4	77 41.8
Pos.Aff. n Row % Col %	51 68.9 40.5	23 31.1 39.7	74 40.2
Col Tot	126 68.5	58 31.5	184 100.0

Chi-Square	Value	DF	Significance
Pearson	8.86346	3	.031

Contingency tables comparing evaluations with achievement in physics, however, offer us important information on the different ways in which high and low achieving students view the strategy. Table VI.4 compares student evaluations with overall marks in physics, using two different categories of grade level: the centre column describes students whose marks in physics are below 75%, including failures, whereas the right column describes students whose marks are 75% and above. Notice how 93.3% of the negative evaluators are students whose marks are less than 75%. Note also that 83.3% of the qualified positive evaluators also achieve lower grades. Among students with superior grades, we find a high concentration of instrumental (53.4%) and affective positive (39.7%) evaluations of the strategy. This is a significant finding with a p value of less than 0.05.

If we drop failing students from our grade level categories and construct contingency tables comparing evaluations with achievement of all those who passed, we find an even greater significance in these relationships between success in physics and high evaluation of the Partnership work (p= .013). Table VI.5 shows students with grades of 60%-74.5% in the centre column and students with 75% or better in the right. Again we note the high concentration of negative evaluations among the lower achieving students (Row % 91.7% compared to 8.3%), with an even greater proportion of their total numbers represented in the Instrumental Positive and Affective Positive evaluation categories. High achieving students once again form the major population in the higher categories, especially instrumental positive.

TABLE VI.5. ACHIEVEMENT OF STUDENTS WHO PASS IN PHYSICS COMPARED WITH THEIR EVALUATIONS OF THE PARTNERSHIP WORK.

Evaluation	Marks 60%-74.5%	75% or More	Row
Negative n	11	1	12
Row %	91.7	8.3	8.5
Col %	13.3	1.7	
Qual.Pos.n	10	3	13
Row %	76.9	23.1	9.8
Col %	12.0	5.2	
Inst.Pos.n	27	31	58
Row %	46.6	53.4	41.1
Col %	32.5	53.4	
Pos.Aff. n	35	23	58
Row %	42.2	39.7	41.1
Col %	42.2	39.7	
Col	83	58	141
Tot	58.9	41.1	100.0

Chi-Square	Value	DF	Significance
Pearson	10.76707	3	.013

How are we to interpret this consistent pattern in which low evaluations are twinned with moderate or low achievement in physics? Certainly, it explodes the myth that it is the inadequate learner, seeking to lean on someone, who prefers to work with others. This information also suggests that the ideology of competitive individualism is not entirely shared by these physics students, particularly those whose study strategies are obviously rewarding them with good marks in these courses. It is possible that students who have, for one reason or another, high potential for success in physics also have more success in choosing their partners and therefore work more comfortably with them. A high degree of engagement in the course is perhaps seen both in the superior grade and in the positive view of the Partnership, and it could be that those students naturally gravitate together. Interview data, however, suggests that this is not how the students perceive the process of choosing a partner: a very high proportion of them either work with a friend because the friend is the only known quantity, or must turn to the person nearest them in the room, because they know no one. Given this kind of anecdotal data, we are inclined to think that the strategy itself has some role to play here. Either the comfortable Partnerships are actually assisting achievement in some way, or good physics students enjoy working with others on their physics tasks. In either case, collaborative work is being recognized as an appropriate and enjoyable activity in classes where traditionally such activity has not been given much space. Numerous students in the experimental classes have told us in their post-semester interviews that they have now "discovered" how to work with other students on their physics, and how this discovery has helped increase both their enjoyment and achievement. Words such as "comforting", "interesting", and "helpful" are common descriptors of the Partnership experience. One young woman said she liked working with her friends because they "accept you where you are." Another recurrent theme among these positive assessments of this strategy has been the ease with which a student can understand another student, sometimes much better than the same student can understand the teacher. At least two male students, very recent immigrants to

Canada, spoke at length of how much they had learned from other students, one of them implying that this connection kept him in the course. This communication did not appear to be linguistically based, as the immigrant students had formed Partnerships with students of quite different ethnic backgrounds. "You need a friend," said another student, speaking for hundreds and hundreds of his peers.

This interview material has also helped us understand more fully the pitfalls of Partnership work. Many students told us that the success or failure of the strategy depends upon the partner: many fear inequity of workload, being left to do all the work, and contributing to someone else's success without receiving any reciprocal reward. Very occasionally, this did seem to happen, though surprisingly few students complained about such Partnership failures at the end of the course; their fears were much more anticipatory than actual. Other students spoke of the difficulty of finding a partner in a class of unfamiliar students. One male student confided that "It's hard when a teacher demands that you choose a partner when you don't know many kids, but the teacher can help you find somebody if he wants to." In several instances which we have been able to document, young women chose to reinstate Partnerships with someone who had not been a particularly satisfactory collaborator in a previous semester: when asked why they did this, they were unable to offer much explanation. The interviewer's sense was that finding someone to work with was difficult, and it was better to slide back into an unsatisfactory arrangement than to have none at all. The fewest complaints of this kind arose in the classes of the teacher who always began his first class with an introduction game, in which students had the task of researchers, finding out as much as possible about as many other students in the class as they could. Students in these classes began with the distinct advantage of having a sense of who was in the class with them, and with whom they might feel most comfortable.

Student interviews, Partnership evaluations, and interviews with participating teachers underline the fact that some very few students simply do not like to work with others. One teacher called them "distrustful personalities;" another called them "independent." All the teachers saw this phenomenon as one of personality rather than of gender. Their perception certainly reflects the reality that both males and feamles can be found among the negative evaluators of this strategy. The percentage differences between males and females providing negative evaluations of Partnerhsip work (discussed above with reference to Table VI.2) is certainly weighted toward the males, but both males and females have told us "I prefer always to ask the teacher, not a student;" both males and females have said "I really like to work alone." Teachers within the experiment seemed quite willing to allow such persons to exempt themselves from collaborative work, if they insisted upon their preference to work alone. Unfortunately, however, since within the parameters of our research, such students would lose the two or three marks given for Partnership work, it is hard to know how many really felt free to avail themselves of such an option.

To what degree do Partnerships in physics provide women students with the collaborative experiences which their learning preferences seem to demand? Much of the statistical information given thus far in this chapter would seem to furnish a positive answer to this question. Women like the Partnerships even better than the men do, and simultaneous with this enjoyment is the incidence of high achievement in physics. Does this mean, then, that collaborative modes of learning are hereby confirmed as both preferred and proven strategies for women entering the science field?

The answer to this question is not as straight-forward as one might wish. The voices of female students in one of the dropped cells, where the illness and absence of the control teacher caused such havoc (see Chapter III), have been so instructive for us in this regard that we pause here to consider them, despite the fact that they are not represented in any of our statistics. The experimental class of this abandonned cell was unique in many ways. It was made up almost completely of re-entry women students (there were only two males in the class), many of whom had been out of school for years and most of whom lacked high school pre-requisites in science and math. These "mature students" came to the physics class knowing no one and, in most cases, knowing not even their own potential for learning. Their choice of partners was therefore made at a point where no one could have predicted who would be best suited to work with whom, or how the course of study might proceed for each one. Both interviews with the students and their written evaluations suggest that, during the first few weeks of the course, the Partnerships were effective and supportive. Students picked up from the teacher that "everyone deserves respect and space, and you have to be patient while people try to get the point." An atmosphere of mutual repect and collaboration was therefore well established in the class and modelled by the teacher. The women in the class all said they enjoyed being together, that it was "lovely" to be grouped together as women in this way. Nevertheless, this class was one in which we observed the greatest problem with the Partnership strategy.

Let us assert at this point that in no way would the statistics of this class contradict the statistics of the sample as a whole. None of the women were totally negative about Partnership work; all of them saw its value for class morale, and for the experience of working through problems with someone whose perspective was different from their own. Some of them wrote affectively positive evaluations. It is, however, the actual content of their evaluations and of their personal interviews that sets them apart as unique.

Contrary to most classes within the experiment, this group began to be identified, during the semester, by both teacher and students, as "very competitive." Our first awareness of this development came through the mid-semester student interviews. It became clear that several of the most confident and competent of these returning women students had become determined to achieve superior grades and were, in fact, fulfiling these ambitions. Some of these high achieving students spoke of being "frustrated" by having to go over points of theory for partners who were "not as quick" as they were. "Instead of being challenged, some students are being stuck with explaining it to slower students," said one young woman. One of these high achieving students spoke of beginning to hold back in class, aware that she was already far in advance of others and might cause them to feel distress. Interviews with lower achieving students showed that, indeed, distress was being experienced: "It upsets me to see how people can get 96, 98 - I get 60. For them it's a blow off. I don't understand. It feels... I work so hard. It doesn't seem fair." Were the higher achieving students really acting in a competitive fashion? One young woman freely admitted it: "I know I'm competitive. I'm competitive with myself and with others. I want the top marks, and I'm going to get them."

This particular class thus became the focus of much of our attention. When we received the written evaluations of Partnership work, it was not surprising to find that high achieving students wrote about their "frustration", "impatience" and "irritation" with women who really could not work to their level. These same students wrote glowingly about an overall cameraderie in the class, and how they liked to be able to turn to another student when they needed help, but the actual Partnerships seemed not to have worked for many of them. In the same vein, many low achieving students wrote about being made to feel unwanted by partners who "brushed them off" or were "so worried about getting the right answer (being very competitive can be a big barrier in the communication department!!!)" These lower achieving students spoke about experiencing a real lack of support from their partners, though once again there was a sense that the class as a whole was a supportive unit.

This microcosm of unrest has made us listen more attentively to minority voices from the student sample as a whole. One of the areas we have begun to look at more closely is the whole area of competition, and how the students feel about it. Few students speak of it as an essential feature of their pursuit of science; competition has, in fact, seemed less and less significant as a source of motivation as we have studied more and more student profiles. Nevertheless, there is a disinct range of opinion on the subject.

There is a group of students who speak with enthusiasm about competition with others as a challenging factor: "without it, you might not try as hard." Some students, many more males than females but certainly not exclusively males, speak of it as "fun", and use sports analogies when discussing their efforts in physics. Some others, again mainly males, talk about "friendly competition," which seems to indicate that students compete only with their friends for top marks, and view the whole matter as a game. A statement such as the follwing suggests that students see such activity as instrumentally effective: "I like friendly competition:

it pushes us to the limit."

On the other hand, there is a group of students who say that competition "upsets" them, that it "depresses," "irritates," "frustrates," "discourages," and "intimidates" them, and generally "puts them down." This group tends to theorize that "only the top students are competitive," a position that seems at first glance to be substantiated by the very articulate voices in the experimental class of the dropped cell. Yet closer examination of the achievement records of some of the students in the rest of the sample suggests that achievment is not the distinguishing feature, as very high achieving women often simply say they "don't mind the competition," and some high achieving males say "It isn't something positive in the long run; it's not a positive environment for the development of friendship."

Looking even more deeply into this matter has led us to reconsider whether we can really call all of this comparison of self with others "competition," defined as it is so differently by different students. One of the most informative comments in our investigation of this matter comes again from the rejected experimental class. It is articulated by one of the high achieving students, the woman who admitted that she herself was highly competitive, wanted the top marks, and was frustrated and impatient with slow-learning partners. At one point in her interview she said with great enthusiasm about the class:

"What's nice is the recognition that yeah, women can get along. We're supposed to be hating each other because we're supposed to be more beautiful than the other. But not in this class. We're like sisters, almost."

The analogy here with the systemically encouraged competition of women with each other for the attentions of men reminds us of the possibility that much of what may be going on here may also be systemic, a deep-seated rift between haves and have-nots, empowered and powerless, privileged and disadvantaged. This kind of tension is not what we normally think of as competition, that rivalry of well-balanced teams playing vigorously at a game with rules about fairness and equity which favour neither side.

This woman student's remark also forces us to look back over some of the affect associated with discomfort in this and other classes. We note how often students admit to being "jealous", or "envious" of the accomplishments of their peers. It begins to seem that what we are observing here is not competition as we normally define it, but the politics of envy, inspired once again (see Chapter I) by an ideology which sets achievement in science subjects as the gateway to a societal elite. Any student, male or female, may become prey to this state of envy, but it is more likely to strike those who experience some particular sense of standing outside some privileged or even normative group. This intense desire to join the hierarchy, the tension between desire and exclusion, is experienced with particular poignancy by mature women students who come to their Cegep education with full awareness of sexism and ageism in the workplace, an intense awareness of the fragility of their chance to join the elite. And so we see it so dramatically in the class of re-entry women, and only occasionally in the larger sample.

Nevertheless, wherever such powerful envy occurs, it is a signal of particular suffering, requiring very careful attention by the teacher, and a recognition that what we have loosely (and, as we now here say, inaccurately) called competition can be enormously harmful and must be very delicately dealt with. The women in the problem class advocated the changing of partners to reduce such tensions: the fact that such tensions were least evident in the classes where the students were best equipped to make informed choices of whom to work with suggests that full introductions as well as flexibility might be guidelines for teachers to keep in mind.

Also important, clearly, is the kind of work assigned to the partners, and the way in which it is monitored and evaluated. One of the teachers restricted the Partnership work to certain problem sets, review exercises and sample tests. He asked that the Partnership hand in one set of answers, and ensured that each person in the Partnership received a corrected copy from him. The focus of the Partner work in this class was therefore on further mastery of problem solving techniques. Another teacher, during one semester, focused the Partnership work very much more upon an experimental process, assigning laboratory-type questions such as dropping a ruler and measuring the time taken to catch it in order to determine whether Galileo's experiment to measure the speed of light is practical. She also had Partnerships present solutions to problems for the class, allowing them to field class questions and argument in the service of empowering them and giving them confidence in their work. Her comments on this series of Partnership activities included some sense that they were very lengthy and difficult for students, but that they appeared to be worthwhile.

One of the teachers who monitored the Partnership work very carefully observed three types of response to a Partnership assignment. He said that certain Partnerships worked individually through each of the problems and compared answers at the end of each set. A second group worked together, out loud, through each phase of each problem. A third group tended to divide up the problems between the two or among the three Partners and each person completed only his or her share. Obviously, the third approach is not a particularly effective choice and the teacher said that it was a more common strategy among male Partnerships who tended to want to leave class early. Of the two first approaches, he felt either might be appropriate depending on the persons involved. Another teacher, however, commenting on the "parallel work style" of students who only check with each other after they have finished, said that this approach can be limiting, especially if students simply check the answers. Good students, especially, who are likely to get these answers right, are not given much real shared actitivity through this approach. The first teacher, who saw this as a valid apprach, was quick to point out that the students are told not simply to check answers, but solution methods. The entire instrumental point of Partnership work is, for him, that students begin to consider the many ways in which a given problem can be approached. This focus upon a variety of methods encourages students to reason out what a question aims at and how they will go about solving it. Too many students wish to move directly into a mathematical formula, skipping the reasoning stage - a process he likened to attacking a kitchen with hammer and saw before deciding upon what renovations one desired. "If they talk the problem through together, they are more likely to explore more."

Some teachers found it extremely difficult to evaluate the Parternship work as we had asked. The idea of simply checking off completion seemed so foreign to these teachers that, in the final analysis, they could not do it. The need to correct is still a powerful interfering factor in the implementation of these process-orientated strategies. Other teachers found no difficulty with this at all, and marked it exactly as they did the Question/Answer Box entries and, indeed, presence in class and office visits. In all but one cell, Partnerships tended to be more single sex than male-female, and though teachers were loathe to be specific, there seemed to be a general agreement that female-female Partnerships were more likely to be effective working units.

It appears that, on the whole, the Partnership work contributed significantly to the success of the experiment. All students tended to like it very much, with women students even more positive than their male counterparts. Achievement also seems to be positively related to those who worked positively in these Partnership units. Teacher observation tends to support these positive findings, and these teacher commentaries also point out new ways for other teachers of science subjects to make use of collaborative learning in the classroom. Most importantly, for our research, the student voices are loud and clear: working with other students is almost always helpful and supportive. Even the small sample of negative commentary leaves openings for teachers to find ways to make use of a natural inclination, especially among the young women students, to work at their learning together.

CHAPTER VII

STUDENT USE OF WRITING IN THE PHYSICS COURSE

The writing strategies with which we asked the physics teachers to work were, as described in Chapter II, the Question/Answer Box and the Collective Class Log. Since we had discovered in our 1988-1989 project A Practical Assessment of Feminist Pedagogy (Davis, Steiger and Tennenhouse, 1990) that physics teachers felt quite comfortable with the Question/Answer Box, that is what we used in the first semester of the present research, H91. In A91, however, we asked the teachers to experiment with the Collective Class Log.

We had originally adapted this Class Log strategy from a similar type of log used in a Biology course described to us in our preliminary talks with teachers, and we used it successfully in the 1988-1989 project for classes in English and Nutrition (Early Childhood Education). In the latter study, giving students access to each other's writing appeared to enhance the democratization of student learning and add to the atmosphere of collaboration in the classroom.

What emerged in the writing for physics, however, was that students continued to address only the teacher, almost never one another, and they did not appear to read each other's log entries at all. They used it, in fact, as if it were a Question/Answer Box. A very small number of them openly questioned the point of filing their work in such a log, stating that they had no intention of reading their fellow students' writing and knew very well that no students would read theirs. One student actually complained about lack of confidentiality, an attitude that never surfaced in the 1988-1989 project. Since the major difference here was the subject area, we had to assume that there is something about the study of physics that does not lend itself to this particular kind of sharing. We cannot conclude that students do not want to share their learning, as we have seen in Chapter V how positively most of them felt about working in one permanent term-length partnership. Sharing their questions, thoughts and feelings on paper with an entire class, however, appears to be another matter. There is no way to tell whether there is a lack of interest in this interaction, or whether such a broad uncharted area of differing student perspectives which have never been part of their study of physics might appear threatening to them. In any case, since the log writing itself did not differ much from Question/Answer Box work, and several students seemed to be either perplexed or disturbed by the collective aspect of the log, we reverted to the Question/Answer Box for the rest of the experiment. We have nonetheless elected to analyze all the writing as part of a single pedagogical intervention, since, in general, neither student engagement with nor performance in the writing differed noticeably during the one semester when the log was in use.

As with the Partnership study, total numbers of student files vary marginally in the tables and discussions that follow. We have elected to work with the largest number of students for whom appropriate information was available for any given study. In general, however, there are marginally more student files available for the writing study than for that of the Partnerships.

The teachers awarded a total of either four, or five, or six marks for the completion of the required number of writing entries: the exact mark total depended upon various departmental curriculum constraints which the teacher had to deal with. Students who did all the writing got full marks; students whose submissions were incomplete were marked accordingly, with some students obtaining partial scores and some no scores at all. As will be seen below, we have used these scores in various ways in order to assess the degree of engagement of the individual student.

TABLE VII.1 STUDENT SCORES ON COMPLETION OF WRITING TASKS

Gender	Fail	Partial	Complete
Males	22 23.7%	29 31.2%	42 45.1%
Females	20 18.5%	39 36.1%	49 45.4%

Total number of student files: 201
Total males: 93 Total females: 108

Table VII.1 shows the extent to which students involved themselves in this activity. The column "Fail" represents those students who failed to complete a sufficient number of entries to receive a passing grade on the strategy. The column "Partial" represents those students who received an imperfect but passing grade. The column "Complete" represents those students who received full credit. As can be seen, 45.1% of the male students and 45.4% of the female students completed the full number of writings required for the semester. In the middle category, satisfactory but not complete, 31.2% of the males and 36.1% of the females appear. The percentages of males and females in the lowest category is 23.7% and 18.5% respectively. Thus, though males seem slightly less involved than females, there is no significant difference in the way in which males and females involve themselves in the writing activity.

Taking the scores of four, five, and six marks and transforming them into a score based upon 100% allows us to see that the average mark on this strategy was 78.1% (77.4% for males and 78.9% for females). Since this is somewhat higher than the overall mark average in physics for the group of students in this particular part of the study, that is, 67.8% (68.6% for males and 67.1% for females), to include the writing as a part of the evaluation appears not to have compromised their success: rather, it may, in some cases, have given them a few extra marks, overall. And this is true for both males and females.

Analysis of variance, taking writing scores, gender, and overall achievement in physics into account, has shown that there is a main effect of achievement level that is highly significant ($p= .000$). Students who fail in physics have a much lower score on the writing than students who succeed. Table VII.2 shows the average scores on 100% for the Question/Answer Box work for each of the three overall levels of student achievement.

TABLE VII.2 STUDENT WRITING PERCENTAGE SCORES COMPARED TO OVERALL ACHIEVEMENT IN PHYSICS.

Gender	-60% in Physics	60%-74.5% in Phys.	75%+ in Physics
Males: Aver.Score n	45.3% 17	84.4% 43	84.8% 33
Females: Aver.Score n	63.1% 26	81.8% 52	87.6% 30

Total number of student files: 201
Total males: 93 Total females: 108

It is obvious here that students who fail physics receive much lower scores on Question/Answer Box writing than do students who succeed. This fact should be noted by physics teachers who have occasionally expressed concern that the feminist strategies which reward process, not product, will disproportionately "inflate" marks and allow students to pass who ought not to do so: in general, it appears that students who fail the subject, do poorly in the strategy. For convenience, Table VII.3 categorizes student writing scores as "Fail," "O.K." and "Perfect." It should be noted that even "Perfect" scores could only have gained students four or five marks; "O.K." scores constituted only 60% of the four or five mark total. It can be noted that, in the entire experimental population, only three men students (17.7% of failing men) and six women students (23% of failing women) obtained high scores on the

Question/Answer Box strategy while still failing the physics course.

TABLE VII.3. STUDENT WRITING SCORES FOR STUDENTS FAILING IN THE PHYSICS COURSE.

Gender	Fail Q/A Box	O.K. Q/A Box	Perfect Q/A
Males: n %	12 70.5%	2 11.8%	3 17.7%
Females:n %	10 38.5%	10 38.5%	6 23%

Total number of student files: 43
Total males: 17   Total females: 26

There is also a highly significant relationship between high scores on the Question/Answer Box and good attendance in class (p= .000). Describing student attendance in class as falling into two categories, poor (less than 90%) and good (90% or more), and comparing these figures with possible writing scores on 100%, Table VII.4 shows quite clearly that high scorers in the writing are also good attenders, again suggesting that serious students involved themselves in the strategy in an appropriate fashion and less serious students were less involved.

TABLE VII.4. STUDENT WRITING SCORES COMPARED WITH CLASS ATTENDANCE.

Attendance	Writing Score on 100%
Poor (less than 90%	50.7%
Good (90% or more)	79.5%

Total Student Files: 201
Total males: 93   Total females: 108

Concerning gender difference, if we return to Table VII.2, we can observe an almost significant difference (p= .054) between the writing scores of males and females, with females receiving higher scores. This is very marginally noticeable in the highest achievement level, where women obtain writing scores of 87.6% and men scores of 84.8%. It is more remarkable in the failure category, where women obtain writing scores of 63.1% whereas men obtain scores of 45.3%. Though the differences between the genders are not significant, it is interesting that these analyses of writing scores reveal that even the low achieving women students here again appear to be a little more exigent with themselves in fulfilling course objectives, and perhaps particularly in fulfilling the objectives of the writing strategy because they liked it better.

That women students did indeed like writing for physics better than the men did can be ascertained through careful study of student evaluations. Because the grade which students received in the Question/Answer Box served as an incentive for participation, the Box became the instrument by which we collected student evaluations of the feminist strategies. Students were asked to write as much as they could about their experience of this strategy, to explore its strengths and weaknesses in terms of their own experience, and to make whatever suggestions they wished for future use by physics teachers of this particular strategy. On the basis of these written evaluations, we constructed four categories of response to the Question/Answer Box. Each evaluation was then coded and placed in one, and only one, of the following categories:

1. Negative: Disagreement with the principle of the writing, focused on the "extra burden" of work ("On a d'autres cours que la physique quand même") or a dislike of writing itself ("My English and Humanities are already a big nuissance. A physics journal is not neccessary "), or a style of learning that does not suit process evaluation ("I don't think they were very useful to me because I only attempt the problems 2 1/2 weeks before the test...And I won't change my study habits either.") Some students giving negative evaluations added that they would go to see the teacher if they had a question, and they therefore did not need to write.

2. Qualified Positive: Overall satisfaction but including some specific criticism, such as the schedule for handing in responses or their mandatory nature, even though "You might not always have a question and then you have to drudge one up." Students who felt no shyness about asking questions found the writing too "impersonal"; some students found it "hard and a burden to remember

when to hand them in," while others noted that their own study schedule was too irregular to allow them to profit: "some weeks ...I hadn't had any time to look at Physics and therefore had no problems to discuss."

3. Instrumental Positive: Complete satisfaction with the way in which the writing helped the student in mastering material ("...ce système m'a fait découvrir combien il est important de savoir bien exprimer ses questions; ainsi la plupart du temps, en démêlant ses idées par la formulation d'une question, on trouve la résponse soi-même et tout devient clair"), and sometimes in shaping curriculum ("...the student gets the answer to the question h/she wanted and the teacher can be informed of what the students in general are having trouble with, so he/she can plan the leacture period according.")

4. Affective Positive: Complete satisfaction including reference to affective issues in the evaluation: "I liked doing the question and answer box. It gave me the chance in asking things which I was too shy to ask in class." "La physique est une matière qui me fait un peu peur, car pour moi c'est la matière la plus difficile....Je trouve que l'idée de la boite aux questions-reponses me sécurise. Dans le sens que je me sens surveillée, suivie, je vois que nous sommes important pour toi...."

Table VI.5 shows how male and female students evaluated their experience with the writing.

TABLE VII.5. STUDENT EVALUATION OF THE WRITING STRATEGY.

Gender	Negative	Qual.Pos.	Pos.Instr.	Affect.Pos.	Tot.
Male # Row % Col %	19 20.4 48.7	37 39.8 49.3	23 24.7 54.8	14 15.1 30.4	93 46.0
Female# Row % Col %	20 18.3 51.3	38 34.9 50.7	19 17.4 45.2	32 29.4 69.6	109 54.0
Tot.	39 19.3	75 37.1	42 20.8	46 22.8	202 100.0

Chi-Square	Value	DF	Significance
Pearson	6.23520	3	.101

It is of some importance to note that negative evaluations are computed to be 20.4% for males and 18.3% for females, an interesting but insignificant gender difference, but a much larger percentage of negative reports than was found on the Partnership study. Clearly, writing is seen as an unnecessary burden by some students, especially those who do not like to write. The largest of the four groups of students, among both males and females, was those who gave a qualified positive evaluation to the strategy. As we look at instrumentally positive evaluations, we begin to see the emergence of a gender difference which becomes quite striking at the affective positive level, where 15.1% of the males but 29.4% of the females appear. Twice as many female students as males evaluated the strategy in affectively positive terms (69.6% females compared to 30.4% males.) This difference strongly suggests that the strategy appealed to students whose connections to learning include a high affective component, and the high ratio of women in this category rejoins the research that this group of affective learners includes a high proportion of women.

Contingency tables comparing student evaluations with their writing scores, with their overall achievement in physics, with their class attendance, and with their patterns of elective visits to the teacher's office reveal interesting and important information.

TABLE VII.6 . STUDENT WRITING SCORES COMPARED WITH THEIR EVALUATIONS OF THE WRITING STRATEGY.

Evaluation	Fail Q/A	O.K. Q/A	Perft.Q/A	Row Tot.
Negative n	9	17	14	40
%	22.5	42.5	35.0	19.8
Qual.Pos.n	18	27	30	75
%	24.0	36.0	40.0	37.1
Inst.Pos.n	10	10	22	42
%	23.8	23.8	52.4	20.8
Aff.Pos. n	6	14	25	45
%	13.3	31.1	55.6	22.3
Col.Tot.	43	68	91	202
	21.3	33.7	45.0	100

Chi-Square	Value	DF	Significance
Pearson	7.02272	6	.319

Table VII.6 presents a comparison of Question/Answer Box evaluations and Question/Answer Box scores. It is not surprising that the group of students who evaluated the strategy as affectively positive (the highest level of evaluation) also achieved the highest scores on the strategy (85.3% on a possible 100%). Note that 55.6% of all those students evaluating the strategy as affectively positive obtained perfect scores on the strategy. Hence it appears that students who very much like the strategy are likely to involve themselves in it.

TABLE VII.7. STUDENT ACHIEVEMENT IN PHYSICS COMPARED TO THEIR EVALUATIONS OF THE WRITING STRATEGY.

Evaluation		-60%	60%-74.5%	75%+	Row Tot.
Negative	n	11	17	12	40
	%	27.5	42.5	30.0	19.7
Qual.Pos.	n	11	35	29	75
	%	14.7	46.7	38.7	36.9
Inst.Pos.	n	11	20	11	42
	%	26.2	47.6	26.2	20.7
Aff.Pos.	n	12	23	11	46
	%	26.1	50.0	23.9	22.7
Col.Tot.		45	95	63	203
		22.2	46.8	31.0	100

Chi-Square	Value	DF	Significance
Pearson	5.79784	6	.446

Analysis of evaluations by achievement in physics shows us, however, in Table VII.7, that students who evaluated the strategy as qualified positive achieved the highest average marks in physics. In fact, Table VII.7 indicates that "top" students (75%+)

are most highly represented among those evaluating the strategy as qualified positive, second most highly represented as evaluating the strategy as negative, third most highly represented as evaluating the strategy as instrumentally positive, and least highly represented among those evaluating the strategy as affectively positive. Cross-reference back to Table VI.5 shows that even the highest percentage of perfect scoring students on Question/Answer Box does not lie among the affective positive evaluators (22.3%), but with the qualified positive evaluators (37.1%). Though these differences are not statistically significant, they nevertheless make it impossible to correlate high evaluation of the writing strategy with high achievement in physics. We might well conclude something quite different: students who experienced the strategy in an affectively positive fashion may have been those who felt the need for such assistance, and though we do not see them as achieving the highest marks, they do nevertheless pass the course and therefore may have obtained in this way the help they needed.

As Table VII.8 shows, attendance is also somewhat related to affective positive evaluation in that 80.4% of those students who evaluated the strategy as affectively positive also had good attendance in class. However, only 55% of those who evaluated the strategy negatively had good attendance in class. Again, though this item is not significant (p=.070), we observe high engagement among those students who give high evaluations to this strategy.

TABLE VII.8. STUDENT ATTENDANCE COMPARED WITH THEIR EVALUATIONS OF THE WRITING STRATEGY.

Evaluation	Poor Attendance	Good Attendance	Row Tot.
Negative n	18	22	40
%	45.0	55.0	19.7
Qual.Pos.n	23	52	75
%	30.7	69.3	36.9
Inst.Pos.n	16	26	42
%	38.1	61.9	20.7
Aff.Pos. n	9	37	46
%	19.6	80.4	22.7
Col.Tot.	66	137	203
	32.5	67.5	100

Chi-Square	Value	DF	Significance
Pearson	7.07012	3	.070

This engagement can also be seen in Table VII.9 where the evaluation categories are analyzed in relation to records of elective visits to see the teacher in his or her office . Though this comparison does not yield significant difference (p= 112), it is interesting that 65.2% of those who gave affective positive evaluations to the strategy elected to see the teacher outside of class; on the other hand, 60% of those who gave negative evaluations of the strategy never went to see the teacher.

TABLE VII.9. RECORDS OF STUDENT-ELECTED VISITS TO THE TEACHER'S OFFICE COMPARED WITH THEIR EVALUATIONS OF THE WRITING.

Evaluation	Never Visited	Sometimes Visited	Row Tot.
Negative n	24	16	40
%	60.0	40.0	19.7
Qual.Pos.n	35	40	75
%	46.7	53.3	36.9
Inst.Pos.n	17	25	42
%	40.5	59.5	20.7
Aff.Pos. n	16	30	46
%	34.8	65.2	22.7
Col.Tot.	92	111	203
	45.3	54.7	100

Chi-Square	Value	DF	Significance
Pearson	5.99218	3	.112

It is hard to say whether this cluster of information on student engagement simply means that highly engaged students liked this strategy, or whether, given their grades, these affective positive evaluators increased their engagement through their commitment to the strategy. In any case, these quantitative measures of engagement such as attendance and office visits suggest that the writing strategy taps in some way the involvement of students in their studies. That a high ratio of women students keeps reappearing in these figures suggests that the pedagogy is positively affecting the women students' experience of the course.

Table VII.10 allows us to look at the ways in which overall achievement in physics interacts with gender, Question/Answer Box scores and Question/Answer Box evaluations. Analysis of variance of achievement by gender, writing scores and writing evaluations shows significant evaluation effects (p=.035) and very highly significant writing score effects (p=.000) on final marks in physics. The three-way interaction of these factors is in itself significant (p=.018). This significance is best understood in an examination of certain salient features of the table below.

TABLE VII.10. OVERALL GRADE AVERAGES IN PHYSICS, GENDER, WRITING SCORES AND WRITING EVALUATIONS.

Scores	Evaluation Category: Negative	Qual.Pos	Inst.Pos.	Aff.Pos.
Fail Q/A: Male Phys. Av.	50.0	68.1	51.2	46.7
n	4	10	5	3
Female Phys Av	53.5	58.0	69.4	48
n	4	8	5	3
O.K. Q/A: Male Phys. Av.	76.1	76.9	58.0	73
n	7	11	6	5
Female Phys Av	63.6	69.8	71.0	63.9
n	10	16	4	9
Perfect Q/A Male Phys. Av.	74.5	71.8	71.9	66.7
n	8	16	12	6
Female Phys Av	70.0	74.9	64.2	71.4
n	6	14	10	19

Table VII.10 illustrates that, consistently, in each category of writing score level, the women students with highest grades in physics give higher evaluations to the writing strategy than do the highest achieving men. For those who failed the Question/Answer Box strategy, the highest physics grade average for women was 69.4%, and these students gave an instrumentally positive rating to the strategy; the highest physics grade average for men was 68.1% and these students were qualified positive on the writing. For students receiving O.K. in the Question/Answer Box strategy, the highest physics grade average for women was 71.0% and these students again gave instrumentally positive ratings; the highest physics grade average for men was 76.9% and they gave qualified positive evaluations. For students receiving Perfect scores on Question/Answer Box writing, the highest physics grade average for women was 74.9% and they evaluated the writing with qualified positive ratings; the highest physics grade average for men was 74.5% and they tended to evaluate the strategy negatively.

We observe here the tendency, referred to and illustrated in Table VII.7, for the higher achieving student to value the strategy less than more moderately successful students. However, this tendency is much more marked among men than women. The men's highest grade averages are concentrated in qualified positive (76.9%) and negative (76.1%) evaluation categories; the women's highest grade averages are concentrated in qualified positive (74.9%) and instrumental positive (71.0%) evaluation categories. Even among high achieving women, the strategy is slightly more valued than it is by the men. High achieving women students also are more involved in the strategy than are high achieving men: the highest male grade average (76.9%) was achieved by men who did only part of the Question/Answer Box work and therefore received O.K. scores; the highest female grade average (74.9%) was achieved by women who did all the Question/Answer Box work and therefore received Perfect scores.

Women therefore appear not only to feel more positive about the strategy, not only to be more involved in fulfilling the requirements of the strategy, but this positive attitude and exigent behaviour seems to be somewhat more highly correlated with their high achievement in physics than are positive evaluations and good writing scores correlated with the high achievement of men. That something about the writing experience renders it more comfortable for women than for men has appeared in earlier parts of this study: in some instances, however, as we examined earlier data, we might have been led to conclude it was only the weaker, more alienated students who could profit from this strategy. Table VII.10 suggests that this latter trend was less true for women than it was for men. Why this might be so and how it showed itself in the writing samples will emerge as we enter now into a more detailed discussion of this student work.

Though the point of the intervention was to allow students to write what they wished and to ensure that whatever they produced would be validated by the teacher, it is clear to us from studying this student material that there are more and less effective ways to use the strategy, and that we ought to share some of this qualitative material with future researchers in the field. As we read through these hundreds of writing samples, the criteria became clearer and clearer to us. Though we had described to the teachers what we wanted, it has only been in the act of describing what the students themselves have done that we have been able to isolate where the pitfalls lie, and what are the sine qua non of using writing in a physics course.

After careful reading of the student material, we have established a ten-point list of criteria, describing an effective semester's use of writing-to-learn in physics. It will be noted that the list deals much more specifically with items such as verbal and computational balance, affect and cognition, question and answer than did our original instructions. The list also leaves items such as frequency and length of submission slightly more open-ended, a change that realistic assessment of student use and attitude has led us to make. The list, then, is as follows:

CRITERIA FOR WRITING ASSESSMENT

FEMINIST PEDAGOGY IN THE PHYSICAL SCIENCES

1. Writing is frequent, submitted at regular intervals (at least 5 times a semester), and sustained for at least two thirds of a page.

2. Writing is personal, informal and consists of at least 50% verbal communication (i.e. not more than 50% mathematical computation).

3. Writing deals at least occasionally with affective concerns.

4. Writing shows some integration of affective concerns with cognitive processes.

5. Writing is usually course-connected in some observable way.

6. Writing demonstrates attempts to link new with existing knowledge.

7. Writing is explicit in its approach to the chosen topic, exploring the nature of the difficulty or interest rather than simply stating a question.

8. Writing submissions vary rather than recycling identical concerns.

9. Writing demonstrates open explorations of uncertainty, doubt or confusion.

10. Writing allows for response, by not drawing inappropriate closure to a questioning or self-reflective process.

One of the things that has become even more clear to us than it was before we began is that teacher response to the Question/Answer Box writing is just as important as implementing the strategy for the students. Some teacher responses are much more effective in encouraging the students in their learning. It is clear that some teachers were more successful than others in maintaining the student-centred nature of the process by limiting themselves to very brief and carefully chosen written commentary. Consider, for instance, the following piece of student writing:

> Well, it seems like the problem now is trying to get a picture with all these F(net), F(fric), F(app), etc. pieces. It's confusing to know when to use what so the best I can do is go over notes and the textbook. But I'm sure it shouldn't be so confusing and I'm sure it is easy to see when we have to use what. I wonder if it would help if I could write out (or see one, it's faster) all the units, symbols, and some formulas and uses that I can think of. You see, the textbook has one example, and then it asks you to do one yourself in the review section but it is slightly altered. And because I'm not grasping the original example that firmly (I'm taking its word for it), by the time I struggle with the one I'm supposed to do myself, I'm merely winging it. I hate winging it!

In response to this extremely honest and step-by-step revelation of difficulty, the teacher merely replied: "Try using diagrams," and supplied a particulary useful example. His response is not only centred on appropriate procedure for the learning of physics, but on the needs of this particular young woman, who wants "to get a picture", who is willing to write out her formulae but would prefer to "see one, it's faster." This teacher's interventions were often of this nature, and his students made particularly good use of the Question/Answer Box.

Student problems are not always so easily dealt with, however. Sometimes their writing reveals large areas of confusion or gaps in knowledge. The following piece of student writing illustrates the on-going process of learning which the Question/Answer Box can both stimulate and sustain.

> I understand mostly of the notion in chapter 8 and 9. Also, I am happy that you answered my question of my last question and answer box. At first, I was surprised that you were calling me. Then, you came and explained the problem. It's great!
>
> In chapter 9, I don't clearly understand a completely inelastic collision. For a inelastic collision let's say that a car crashes in a wall. $\vec{P}$ initial was larger than O because of it's mass and speed. But, when it crashes on a wall, V=0 and P=0. Therefore, $\vec{P}(i) \neq \vec{P}(f)$. (The car sticks to the wall, so it's inelastic).
>
> In chapter 8, I have some trouble to understand conservative and non-conservative forces. Also, there is a problem that I was not able to do. It was number 47. What kind of

energies does the racket have at the starting point and ending point? I have a question also about number 39. It is a problem including vectors. In the second part of the solution we have

$$\vec{F}.\vec{d} = -\ (2\hat{i} - 5\hat{j})\ .\ (-5\hat{i} + 6\hat{j})$$

$$= -\ (-10\ -30)J = 40J$$

How come we lose the vectors? I know that work is not a vector, but there we don't take care of the vector and we do a simple substraction. I find that strange.

In the first paragraph of this submission, the student thanks the teacher for his help. This particular teacher dealt with complex issues by writing at the end of student work: "See me in the lab." As he returned the writing to the students, he checked to see if he had written such a notation: when he found one, he went directly to the student in question and took a few minutes of the lab time to deal with the problem on a person-to-person basis; where such interventions were not enough, office appointments were made on the spot. In this way, the teacher was able to gauge the exact needs of the student in an informal, non-threatening situation, while the students were working with each other on their labs. He was also able to give much fuller explanations than he felt he either could or should give in written form. Here, in this writing sample, the student refers to an occasion so common for the teacher that when we asked him about it he could not distinguish it from any other. For the student, however, it was of immense importance, and he not only mentions it here with enthusiasm and gratitude but spoke of it glowingly a month later in his interview.

Encouraged by this response, the student has come forward with many more areas of confusion. Though he opened by saying he "mostly" understood these chapters, his summary of inelastic collisions is garbled, and the teacher wrote at the end of paragraph two: "Crashing into a wall is (technically) not an inelastic collision!" If the student had not been writing out his thoughts, this confusion might never have surfaced nor been caught. At the end of the submission, the teacher provided a useful equation for the solution of one of the problems, plus a reminder of a basic principle. Then he added: "If you need help with the dot product, please ask." Following his usual routine, we can assume that, on returning this submission to the student in the lab, the teacher would ask whether these notations were sufficient to remove the blocks. He might also choose to review inelastic collisions in the next lecture period, since a number of students seemed to be having difficulties with the concept.

One of the teachers, however, shifted the emphasis of the writing strategy in such a way that she, the teacher, was doing the major part of the writing. Though it seemed to us that she had begun with the same interests in exploring the possibilities of writing-to-learn as the other teachers, she rapidly allowed the students to write less themselves and demand more from her. Her students asked many interesting and important questions, sometimes about the course ("Does a v-t graph and an a-t graph, when dealing with the same time intervals, have a pattern?"), but more often about larger issues which the course of study had led them to consider ("How did scientists calculate the size of a galaxy and does it have a shape?"). They asked these questions, however, from a completely passive, learner-as-banker position, making no attempt to reason out what they might or might not discover on their own. This situation accorded to the teacher a very eclectic expertise and to the students a kind of curious ignorance, a relationship perpetuated by the teacher's willingness to answer at length, sometimes writing two and three pages of response, and sometimes even doing extra research to find the answers. In her interview with us, this teacher explained herself by saying that she could tell how much the students appreciated her personalized answers to her questions. Sometimes, however, she really could not find the time to respond, and because this happened only occasionally, the student whose question she did not deal with was offended. Furthermore, because the questioning process asked so little of them, many students did not take it very seriously, handing in many two-line questions at the same time.

It must be said that this teacher stimulated students' curiosity and gave them a good sense of the fascination of physics. She also stimulated many of them to connect their learning to their lives, as when a male student asked for the physical laws that enabled him to accelerate on his skate board by pumping down on the board while in transition. The teacher was not only able to answer the question quite simply but to supply a xeroxed article on the subject, and when the student received the answer, he was so pleased that the classroom became a stage for demonstration and discussion of the principles. We must note the extent to which the teacher's use of the Question/Answer Box has here responded to the interests and knowledge of the students and thus completely transformed the classroom. This was, no doubt, a moment of learning which none of those students will ever forget. Hence we must conclude that, though the students were not led to learn on their own through the writing strategy, the opportunity to pose questions was, in fact, empowering to a certain extent and, in this case at least, led to a real integration of academic learning and student life.

In our interviews with them, we also asked the teachers to think beyond the strict rewarding of credit for quantity of submissions which we had asked them to do, and to consider whether they had formed any impressions about which students used the strategy to the best advantage. Three were quite clear that women students seemed to like it better than men and to use it somewhat more seriously. One of these teachers was so adamant about the dislike that "all the male students" had for the strategy that we felt compelled to challenge her with the evaluation statistics which indicated that indeed, a large percentage of her male students had not liked it (43%), but that this was by no means the whole story. This interview moment brought to our attention how forcefully male voices make themselves heard, and how even less than half a class of males (and 7% of the women students) can affect a teacher's decision that "the Question/answer Box does not work." The teacher of one of the abandoned cells (A91), whose class of Electrotechnology students he had finally excused from the writing (all but two of whom were male), said that the students had a generally low opinion of their ability and were most unwilling to expose themselves to anyone. One of the other teachers said he felt that marginal students in physics often had marginal verbal skills as well and were therefore unable to make good use of the strategy.

The teacher with the greatest experience with the strategy said: "There has to be a certain amount of self-discipline in the students for any of these methods to work. Some kids just aren't mature enough to take advantage of such opportunities." It was his opinion that as an actual learning strategy, the writing benefitted about half the students. He readily admitted, however, that the word "learning" for him was limited to entirely cognitive processes, and he described for us many instances in which the expression of affective material was helpful to both him and the student ("a bit like a letter to your M.P."), as well as instances in which personal material was of great assistance to him in providing appropriate pedagogical interventions. "In teaching high school," he said," you would get to know these things about the students. In Cegep you don't, and the Question/Answer Box makes up for that."

Applying our own refined criteria (see above), we ourselves have been inclined to conclude that more women than men students have used the writing effectively. What we have observed is that marginal, average and superior women students tend to find their own uses for the Question/Answer Box and to consistently write informally and naturally about the course, link affect with cognition, admit their uncertainties, and attempt to connect new with existing knowledge. Marginal achieving women ask questions apologetically, thank the teacher profusely for referring them to a learning centre, wonder how they will ever understand some particular new concept. Average achieving women tend to be more spirited and sometimes testier, complaining about the course now and then, perhaps describing a success with some particular problem, and, of course, asking questions about on-going work. The high achieving women students are eager to ask questions about on-going work and take the opportunity to do so; they also express personal difficulties such as those described by two very recent immigrants from Hong Kong who felt very strongly that "the object in Question 5 is absolutely new to me and I have never seen one before.... I hope that you will give me such new stuff in class as examples but not in test." Since the object in the test example was a snowmobile, it was very useful for the teacher to read these submissions; it was also clear to us, in interviews with these young women, that they would never have been able to tell the teacher of their difficulty, had they not had the chance to write to him.

The following is the submission of an average achiever, a young woman whose tone, remarks, and attitude have become very familiar to us in this project:

> In the past, my experience with Physics has not been so great. Through grade 11 physics, my teacher did not teach, and first semester in this course, my teacher once again I felt wasn't doing his job in actually teaching his students. I believe that if I didn't have to take physics because of the program I am enroled in I probably wouldn't. I am although, more confident this semester about my work in Physics 101X. I enjoy the lectures because I understand most of what's going on and try to participate as much as possible. I'm doing the work assigned although I don't understand some of the problems, I am trying them and will look at your solutions in the library. For example, Chapter 6 #5. I've now tried that problem many times and am still not sure how to do it. I'm still not sure how the forces are related by someone pushing an object, or whether I might be missing something in my isolation diagrams. I will work some more and

> then check the solutions.
> Concerning the last Q & A Box, I finally got the correct answer to problem #1 and realized how it was done.

We would simply like to call the reader's attention to the ease with which the student adopts a kind of letter-to-the-teacher style, frankly speaks her mind about the subject, talks about her difficulties, and tells the teacher her success with a former problem with complete assurance that he will know what she is talking about. It is not difficult to see how such an experience of communication has contributed to such significant changes in attitude to physics teachers.

Men who use the Question/Answer Box effectively are more likely to be average achievers such as the young man quoted earlier in this chapter, struggling with inelastic collisions and vectors. For some reason, a certain number of both marginal and high achieving men have, in our study, tended to use the Question/Answer Box in a different way. Here is a sample of writing from a superior male student who was very enthusiastic about the Question/Answer Box because, he said, he really liked to write and think about science:

> First, I would like to discuss and write about explosions. We shall center our attention on systems of anti-aircraft fire. A shell is shot

> at a plane flying overhead, with the task of bringing the plane down. There is a common misconception that the shell must hit the plane itself in order to fulfill its task. In reality, an antiaircraft gun propels a shell into the air as close as possible to the enemy plane, so that when the projectile explodes, shrapnel (known as flack to us airmen) as a result of the explosion sprays the plane. In this manner, there is greater chance to destroy the aircraft instead of sending one piece of metal through its hull. The question arises, how is it possible that those operating the gun can get the shell to explode at the right time and hieght?

This student delights in the formality of scientific discourse, rapidly abandoning the first person for something more universal, associating himself not only with scientific research but with the military area with which his question is concerned. By the time he has arrived at the last sentence, his writing sounds a bit like a text book. His question is perhaps a good one, and his curiosity seems genuine, but his use of the writing does not involve self-reflection. There is a showy quality about it that suggests that there is a different relationship between self and writing operating here than the one we had envisaged as we developed the Question/Answer Box.

Quite likely, this clever student quoted above has no real need to make use of the Question/Answer Box as we conceived it, and so he moves unhesitatingly into the more disciplined discourse with which he is, perhaps, more comfortable. The consequences of short-circuiting the self-reflective process are quite different for the marginal student, however, as the following case illustrates:

> For the last two weeks we have been learning about vectors. Now, vectors can easily be understood with just a little effort because I find them being very easy to understand. So, here I am on the day of the test all ready and prepared and determined to do well. Then, I read the questions quickly just to get a little grasp of what exactly it's all about. As I was doing the test, I was having problems understanding the questions, it's not that they weren't clear but I was just not able to answer them immediately. I had to think things over many times before proceeding. My conclusion on this test is: first of all. I wasn't focused or well concentrated while doing the test, maybe I wasn't as ready as I thought I was and last but not least I found the test to be a bit difficult. Anyways,

> whatever happens, happens, I'll just put it out of my mind and concentrate more on what I'm going to do now and the near future. That's all I have to say for now and I'm glad that I said what I feel. I'm feeling better now.

This student is not allowing himself to listen to what he is saying at all. He skips rapidly over the real meat of the matter, the fact that he could not do the problems easily at first glance and the perhaps related problem that he might not have been well prepared. He allows the ideology of discipline and hard work to spur him forward to being more "focused" and "concentrated" during test situations, without thinking through what this concentration really means. He also immediately dismisses the whole matter, suppressing any self-doubt that such an experience might raise. This suppression of doubt may make him feel better now, as indeed he says that it does, but it prevents him from learning from what has happened. And finally, he falsely concludes that writing this has been helpful: he has really not worked through his feelings about the test, but pushed them away, and some dim notion of what writing is supposed to accomplish has misled him into thinking that what he has done has been useful. The teacher, of course, placed a large asterisk beside the sentence "I had to think things over many times before proceeding", and wrote at the foot of the page: "That's to be expected: you have to read the questions slowly (several times), take the time to think about them, and then answer them." But the student was in no state of mind to absorb such a message: he has determined to dismiss the matter entirely, and in this sense he has shut the teacher out. And in fact, he paid no attention to the teacher's comment. He never grasped the importance of serious reasoning before he attacked a problem. And his whole semester's writing is like this; he never faces his difficulties; he continues to jolly himself along; he fails decisively at the conclusion of the course. He is not a good student, but we cannot help but feel that the writing, too, has betrayed him, and that for some reason, he is caught in a masculinist ideology that closes him off from the exposure and risk that are part of the writing-to-learn strategy.

The theory to which we owe this latter interpretation is developed by Evelyn Fox Keller (1985) and is related to the way in which men are observed to develop in our society. In a society in which children are raised by women, the masculine personality must ultimately draw away from the feminine (mother) and thus develop through separation and distance. This process ultimately lends itself to a dichotomizing of subjective and objective realities, and Keller has argued that this personality may in fact find comfort in a controlled distancing of the affective self. It must be emphasized that this personality is masculine, not male, and that it exists on a continuum with a feminine personality which develops in a context of connection and relation with the mother. In reality, individual men and women represent different balances of separation and connectedness; nevertheless it is apparent that distance and denial of feeling are important aspects of a personality structure that is frequently presented as desirable and necessary for men.

In this sense, then, women students may have an advantage, in that the ideology of soldiering on at a distance from one's feelings is less comfortable to them and thus perhaps less thoroughly integrated. In the writing, the subjective and affective components of their experience with a demanding and impersonal subject matter appear to surface readily. Men, on the other hand, may suffer a disadvantage, in that they may feel a greater stake in such an ideology, and may find it much harder to take the risk of exposure.

In any case, the writing strategy appears to contribute to important changes in student attitude and experience, and those changes appear to center around the precise student population with whom we have been most concerned, that is, the women students, particularly those with average or lower achievement records. We hope that our extensive discussion of the student writing itself has clarified two important matters. First, allowing students to express their difficulties and problems helps them take charge of their own learning: in their own way, at their own level, and in their own language. Second, this student writing exposes the hidden nine-tenths of the student learning ice-berg. Teachers who institute a writing process such as this cannot ignore the students whom they hear from relentlessly in batches of fifty submissions every fortnight. These student voices open questions about both the subject and the pedagogy: in responding to such questions, conscientious teachers stand at the threshold of enormous changes in the teaching of science subjects, for all students, everywhere.

CHAPTER VIII

SELF-DISCLOSURE IN THE PHYSICS CLASSROOM

The systematic self-disclosure which we asked the teachers to implement in this experiment involves, as described in Chapter II, a methodology for including appropriate personal material both in the teaching and correcting process. Teachers were asked to generate their own disclosures and to make systematic use of this material in their regular lecture classes and in laboratory explanations. Since the bulk of written correction for which physics teachers are responsible involves mathematics rather than language, we restricted our correction focus to the teacher commentary on Question/Answer Box work and oral assistance given to students in class.

Teachers were asked to keep some type of running record for us so that we could both understand what they had done and share it with other interested teachers and researchers. We also relied on the fact that we would be interviewing these teachers after each semester so that we could gather and document their records as well as what they might tell us orally about their experiences. Although there was no quantitative instrument for tracking the specific effects of such disclosures on the class, both our interviews with students and the pre- and post-semester attitudinal test contained substantial sections on relationship with the teacher and would, we felt, reflect at least some aspects of the process.

As it turned out, there were no records kept by any of the teachers in the project. As we interviewed them, at the close of each semester, and asked for their records, we were told that such record keeping had been too time consuming, too complicated, too intrusive upon their hectic before and after class routines, too foreign to their normal mode of operation. On each occasion, we sympathized with their dilemma, explained our wish to collect material, and asked them to try again. At the conclusion of the following semester, it became clear that once again there were no records.

Since all of these teachers were conscientious, imaginative and enthusiastic participants in the pedagogical experiment, we can in no way dismiss this lack of record keeping as unco-operative or obstructive. In fact, as we looked into what they had to say to us and some of the difficulties they were having, we have learned a great deal more about how the teaching of physics is structured to preclude the personal, and how hard the most humane of physics teachers must struggle to include self-disclosure in their classroom instruction. We are reasonably comfortable in concluding that the difficulties relate to the subject matter, since this is the second project in which science teachers have had difficulty complying with this request, whereas the teachers of other subjects such as literature and sociology were, in the 1988-1989 project, able to furnish us with records (Davis, Steiger and Tennenhouse, 1990). That our current group of physics teachers did use self-disclosure is very clear to us, both through the interviews we had with them and with their students, and through the questionnaire data on attitude to teacher, analyzed and discussed in Chapter IV. That they had trouble with this strategy, and found it impossible to keep serious and meaningful records, is so instructive to us that we begin our discussion of the strategy with this problem, since it conditions the way we must approach any assessment of success.

Let us examine four statements about the strategy, collected from four teachers whose experimental classes are included in our analysis:

> Self-disclosure is on-going, and very difficult to keep track of. I don't plan these things. I would feel it very artificial to say Now, today I'm going to talk about when I took physics, and what troubles I had. But when a student has trouble, then I access my experience. There is a lot of self-disclosure, but it comes out of an exchange with the student.

> It's not that I feel uncomfortable talking about myself. I feel uncomfortable planning to do it in a structured way.

> Je ne peux pas prédire ce que je trouverai utile - c'est dans la classe que je sais, et

je le fais.

> You can't plan it, you know. So much of teaching physics can't be planned anyway. You're dealing with the students, and you have to react to their questions.

It is clear that these teachers see self-disclosure as a means of forming relationships with their students, relationships which meet the students where they are and, where possible, reduce the distance between teacher and learner. "Self-disclosure fits into a whole range of strategies used to relax students, to help them feel it's okay to admit shortcomings," explained one of the teachers. This teacher ensures that he stops when he makes an error on the blackboard, and takes the students back over the faulty reasoning process which led him to make it. One of the other teachers makes consistent use of this particular technique as well. What is equally clear from this quoted material, however, is that to plan to include personal material in the presentation of information or explanation of theory is "artificial," "uncomfortable." Its inclusion is at odds with the objective ideology around which the physics curriculum is structured, and even these teachers, aware as they are of the alienation which many students suffer in the face of such ideology, have trouble integrating subjective and objective thinking in this way.

Interestingly enough, however, when pressed for an oral record of what they had done, these teachers had done a good deal to personalize and humanize their lecture presentations. One teacher said she had a set of stories about women friends involved in scientific work which she regularly accessed at certain points in the curriculum. These disclosures were not only personal but, she felt, supplied additional female role models for young women who might be interested in going on in science. All of the teachers frequently brought to class recognizable physical objects which were of interest both to them and to their students. The use of these demonstrations, which were most frequently connected to bicycling, was carefully planned in advance. One teacher was even conscious of the fact that arriving in class with his bicycle helmet had a particular effect on the class, an effect he sought to cultivate in a studied manner. Yet none of these teachers could see their way to write down their plans to use these stories and exhibits in a way which would connect them formally with the principles they were teaching. It was almost as if such a lecture plan could be an embarrassment to them.

Of great concern among these physics teachers was the unsuitable disclosure which might be experienced not only as useless but intrusive or damaging by students. Their caution about the dangers of subjective material seemed to us to be sensible, but there is no doubt that it was extreme. One of the teachers, whose use of self-disclosure became more and more conscious and effectual throughout his participation in the project, talked at some length with us about inappropriate disclosures made by his colleagues and about which his students had often complained. He also spoke of certain inappropriate connections that sometimes came to his mind in class, and which he often had to struggle to suppress. He was deeply sensitive to how hurtful it might have been, for instance, in a class of remedial and mainly low-achieving physics students, to refer to his children's grade school math, though there were often occasions when interesting parallels might have been made. He also added that it was totally inappropriate for him to comment on his own learning to the students in these classes, since he had no difficulties whatever to share with them. Other teachers also spoke of the importance of appropriate limits. One said that she was aware that the strategy could be turned against her by students who did not want to get on with the work, as they "tried to get me off the track - they take great delight in seeing how far they can get me off the track."

Struggling with these contradictions between the physics curriculum and personal experience, between their wish to bring concepts to life for the students and a strong sense that the concepts already have a life of their own, between the wish to help and an educated distrust of such affective impulses, these teachers can hardly be faulted for choosing to experiment with small and unrecorded ways to personalize their teaching.

The teacher who was initially, perhaps, the most reluctant to use self-disclosure was "converted" by his own classroom experience within the project. He was engaged in explaining concave and convex surfaces, and asked the class what really happened when they looked in the mirrors in amusement houses. A student asked him "When do <u>you</u> ever go to amusement houses?"

> So I answered, "Well, I take my kids." And she said "Oh, I didn't know you had kids. I pictured you at home with chalk boards all over the place and doing physics problems all the time."

Reflecting on this experience with us, the teacher first of all expressed his astonishment at the image which the student had of him, and how the simple fact of his having children had rendered him human. "I've always thought of myself as a very human person in class, but I'd never brought in personal examples before."

He then shared with us some of the changes he had made in his course. Formerly, at the beginning of a semester, he had always asked his students to fill out index cards introducing themselves to him so that he could have a sense of where they might be in their learning, but he had said nothing about himself. He now enriches this introductory period by talking briefly about himself, personal interests which he will draw upon to illustrate points later in the course, and so on. He now regularly includes himself and his children in his references to amusement house mirrors, the pendulum principle illustrated by the child's swing, force and energy exerted to turn the bicycle wheel. These references are noticed by students in his classes, and though he has always been a very popular teacher, it seems likely that his self-disclosures have added another important dimension to his teaching.

Assessing student reaction to self-disclosure, another teacher mused: "I don't know. I think they feel reassured, and find it less difficult to admit to not knowing things." Reducing the distance between himself and the students seems, to this teacher, to give them permission to be themselves. In two different interviews, this teacher said he felt that the women students responded better to self-disclosure than the men:

> They seem ready to take my cue to make themselves vulnerable. A lot of the males just continue to say "Well, he didn't teach us that" or "I never learned that in high school." The females come forward more easily to deal with their faults.

This observation appears to rejoin the work in object relations theory which theorizes the importance of the male maintenance of distance in the development of masculinity and as a process associated with the scientific enterprise. Since this matter has been discussed elsewhere (see Chapters II, IV, VI and VII), we will not elaborate upon it here. However, the fact that the self-disclosure technique is seen to work against such distancing, that it can be used by male teachers, and that it can draw women students into a more open, vulnerable and still non-threatening learning connection with their teachers comes as a strong endorsement of the strategy.

The interviews with the teachers also helped us to explore how teachers might correct students within the context of a democratized relationship with the teacher, conferring dignity upon the student. One teacher said:

> I've learned a lot about vocabulary, a way of saying things. Like saying "You still have to learn this particular aspect, you haven't finished learning it yet." Instead of saying "You don't know that." You have to choose the vocabulary carefully so kids don't think they can't do it, but are in the process, that their learning is in the future.

This teacher was also very careful in his remarks on Question/Answer Box writing. Though he himself denied that he used any of the self-disclosure techniques or strategies in responding to this writing, our observation has been that here too he was accepting and encouraging, inviting students to the office, reminding them of solutions on file in the library, suggesting a trip to the learning centre or briefly supplying a formula. He refrained from telling students they were wrong but encouraged them in their own struggles to learn. We ourselves regard these practices as well within our definition of using self-disclosure in response to student writing.

As we have already commented in Chapter VII, the major problem for teachers in dealing with student writing had to do with writing too much themselves and thereby appropriating the learning process of the student instead of encouraging that process. During the course of the research, we have come to appreciate how central the issue of appropriation is to the student-teacher relationship. For instance, when a student wrote "Je ne suis pas bon en physique," a teacher who wished to encourage the student crossed out the "ne" and the "pas." One can readily see the temptation to respond in this way. The impulse receives powerful reinforcement in the sciences, where there is widespread ideological support for the belief that self-confidence is one of the keys to success. However, the fact is that the denial of the student's own self-perception is an authoritative judgement which questions the right of the student to express affect, and might seriously interfere with a process of exploration of student difficulty. Since this teacher immediately made a personal intervention with the student, no harm whatever was done, but it might be important to note how easily the responding process can deny the student his or her voice. Self-disclosure theory is a helpful reminder that the reading self is one and the writing self is another, and that a constructive responder hears what is said without judgement or denial but with a view to drawing the learner forward on his or her own path.

Chapters IV and V present statistics and discussion on the significant improvement in attitude to teacher in the experimental classes. It is impossible to tell how important a role self-disclosure played in bringing about that improvement. Nonetheless, student interview data does allow us some additional insight into this matter.

In the interviews, students were invited to comment on the role of the teacher in their learning of physics. As students spoke openly about their experiences with teachers throughout their school careers, we heard stories which made it clear that there are excellent and highly regarded physics teachers involved in the education of today's young people. However, we were also privy to narrations of less than positive learning experiences.

What is particularly striking about these more negative accounts is that students frequently experience the teacher's impatience as a measure of their own inadequacy. One student captured this when she said "Sometimes it was like 'Aaaah you're asking me this again?' It really made me feel stupid." Another simply said "J'étais traumatisée."

Teachers' negative attitudes toward students may be internalized by students; however, the language which students use to describe those teachers betrays the extent to which the relationship is one of distance. Such distance is epitomized in this student's description of the physics teacher as a collective enemy: "When you ask a question, they look at you, like, why weren't you listening, but you were listening, it's just you didn't understand it." It is important to note that not all of these students who spoke to us in these terms were doing poorly; however, the line between teacher and students is clearly drawn.

Moreover, when students speak about a distance between themselves and the physics teacher, they almost always describe this distance in hierarchical terms. They say things like "It's hard to learn from him because he's on such a higher level." And, of particular importance, given our concerns in this project, the teacher-student hierarchy is reproduced almost inevitably among the students themselves. One student said:

> They really like talking to smart kids,
> kids more on their own level. They
> probably get bored of explaining and
> explaining you the basics, you know,
> so they like it when kids understand
> and start asking more complicated questions.

Another student, analyzing her experiences with a teacher whom she described as "brilliant," said:

> I'm sure, you know, he wanted us to do
> well but he was really in his own world
> of physics.... The ones who did well, he knew
> them, he really related to them. In class he
> would always ask them for the answers, asked
> them to explain it and we were kind of,
> you know....

Again it is important to note that some of these students were relatively high achievers, receiving marks in the 80s for which they worked very hard. However, in the classroom where a sense of hierarchy prevails and the teacher stands at the apex of learning, students who are not at the very top of the class feel excluded.

When we listened to students talk about their experiences in the experimental classes, we heard some grumbling about teachers there as well. There were students who blamed teachers for going too slowly or going too fast, for not giving enough quizzes, for asking certain kinds of test problems or not asking certain kinds of test problems, etc. As we have shown above, there were students who did not like the writing and some few who did not like the partnerships. But never did students in these classes talk about distance from the teachers. Never did they say the teachers did not care, or would not offer help, or got impatient with their mistakes. In fact, students in the experimental classes typically described their teachers as "reassuring," "respectful," and "caring." From their comments, it was clear that they saw these teachers as their allies: "He likes us a lot and he wants us to achieve."

It is the communication of approval, acceptance and encouragement that characterizes these teachers' relationship with their students. The students note the absence of hierarchy and of distance and the relief which they experience as they settle into the more democratic learning environment is palpable: "It's like he likes us all and he doesn't have favourites or anything and he knows everybody's name and that's sort of neat when it's such a big class."

CHAPTER IX

CONCLUSIONS

Three years ago, we hypothesized that feminist pedagogical strategies would produce more confident, more committed, amd more engaged women students in physics classes where these strategies were systematically practised. As is often the case in evaluating the results of pedagogical research which involves intervention over a brief period of time and in a complex sphere, the results are mixed and the long term implications difficult to predict.

On one hand, the pedagogy does appear to have positive impact in a number of areas which would seem to have important bearing upon the level of commitment to and engagement with physics as a subject. Our attitude surveys revealed consistently more positive perceptions of the teacher among the students in the experimental classes, and these same students also reported a significantly greater enjoyment of physics as a subject over the course of a semester. When the achievement level of students was taken into account, the students in classes where the feminist pedagogy was being practised also experienced an almost, but not quite statistically significant, reduction in their level of anxiety vis à vis their peers in the control group.

On the basis of this attitude survey, it can be said that these classroom practices do indeed have an impact upon students, and that in even a single semester they may change the nature of their experience of a course. There is, in this same attitude survey, no evidence that feminist pedagogy as it has been practised in these physics classes directly and immediately benefits women more than men. In fact, in the key areas where we observed significant positive effects, they accrued to both sexes. We have, however, argued in the course of the more detailed discussion that there may be long term and particular benefits for women when the advantages of the pedagogy are placed within the context of what we know about the ways in which women approach learning in general and learning in the sciences in particular.

Given the fact that these interventions took place over a single semester, the implications of these significant differences should not be underestimated. However, the attitude survey also reveals that there are important aspects of student attitudes which were less susceptible to change, at least by this pedagogy and within this time-frame. Of particular concern, given the objectives of this research project, were the absence of any significant differences between control and experimental groups on the Inventory's self-concept and motivation scales, since these bear most directly upon the issue of self-confidence.

Furthermore, our analysis of the Physics Attitude Survey indicates that in the areas of self-concept and motivation with respect to physics, as in the area of anxiety, significant gender differences form a consistent presence in the classroom. Semester after semester, women students scored lower than their male counterparts on the self-concept and motivation scales, while they registered higher levels of anxiety at the beginning and throughout the semester. It is these negative attitudes among the women students in our study that have most captured our attention. They first of all suggest that, though this set of interrelated teaching strategies is clearly effective, it may not be sufficient to arrest the continuing tendency of women to become discouraged with, and to drop out of, their science studies at higher levels of education. This has important implications for the way that we intervene vis à vis women in the classroom and it also affects future research orientations.

Over the past three years, we have repeatedly felt that the combination of quantitative and qualitative methodologies in the present research design has been a happy one. The interviews with students have afforded us the opportunity to enrich our understanding of the gender differences measured by our Inventory and the Inventory has alerted us to the salience of some issues which we might otherwise have overlooked. The analysis of student writing, an initial and, to our knowledge, original contribution to the detailed exploration of feminist pedagogy as a lived experience, has underlined for us the fact that this pedagogy operates differently for students who are situated differently with respect to the hierarchies of gender and academic status. It is clear that we are only beginning to understand something of these relationships and that much work remains to be done. Moreover, our work has not yet addressed the complexities of class and race which, we strongly suspect, are also at issue here.

From the very beginning of this research project, we have thought about our work as listening to the students' voices. These voices have forced us to hear and take cognizance of a range of experiences which have not always conformed to our expectations of what these students might be living. Many of our notions about who studies science and how they study science have been overturned over the past several years. However, among the most central of the tenets to have been challenged is surely the idea that self-confidence as the key to success is a gender neutral construct. As we have listened to these student voices, we have become increasingly sensitive to the extent to which self-confidence may be predicated upon the denial of a range of evidence which, in fact, might offer the individual important, perhaps crucial information. Several theorists have suggested that the traditional conception of self-confidence is masculinist in that it is oriented to maintaining a particular and gendered system of control (Keller, 1985; Hacker, 1989).

It is interesting to note that Australian researchers have begun to explore similar difficulties in an assessment of self-confidence in culturally diverse communities. Their comments have particular resonance for those of us who work in the multi-ethnic, culturally diverse Cegep milieux. Furthermore, they caution "that seeking to raise self-esteem within the terms of the educational and social status quo may well have the effect of underscoring the dominant sex, class, and ethnic groups of the society" (Kenway and Willis, 1990, p. 11-12). In a very similar vein, insofar as competition has been understood as a rivalry of well-balanced teams, we want to note how ill-suited is this theoretical concept to the reality of the science classroom, or for that matter, any classroom in the educational system.

The research project which now draws to a close has given us occasion to appreciate the fragility of women's connection to the physical sciences. As we have observed women squaring their shoulders and stoically deciding to endure another semester of college level science, we have felt increasingly drawn to expand our framework for understanding the relationship between women and their science education. For us, this has come to mean that we must open the research question to include an interrogation of curriculum as well as pedagogy, and expand the research design to permit a longitudinal assessment of women's experiences. This is the direction in which we now move. We are, however, heartened by the range of significant effects which we have uncovered, and we are convinced of the extent to which even relatively small changes in the pedagogy can impact positively on women.

References

Aisenberg, Nadya and Harrington, Mona. (1988). Women of academe: Outsiders in the sacred grove. Amherst: University of Massachusetts.

American Association of University Women. September/November 1990. Shortchanging girls, shortchanging America: A nationwide poll to assess self esteem, educational experiences, interest in math and science, and career aspirations of girls and boys ages 9-15. Washington: The Analysis Group (Greenberg-Lake).

Atwell, Nancie. (Ed.) (1990). Coming to know: Writing to learn in the intermediate grades. Portsmouth: Heinemann.

Baruk, Stella. (1985). L'âge du capitaine: De l'erreur en mathématiques. Paris: Seuil.

Bazerman, Charles and Paradis, James. (Eds.) (1990). Textual dynamics of the professions. Madison: University of Wisconsin Press.

Belenky, Mary Field et al. (Eds.) (1986). Women's ways of knowing: The development of self, voice and mind. New York: Basic Books.

Bordo, Susan, R. (1987). The flight to objectivity: Essays on cartesianism and culture. Albany: Sate University of New York Press.

Britton, James. (1970). Language and learning. London: Penguin Books.

Brooke, Angela and Driver, Rosalind. (1986). The construction of meaning and conceptual change in classroom settings: Case studies on energy. University of Leeds: Centre for Studies in Science and Mathematics Education.

Canada. Ministry of Supply and Services. (1989). Education in Canada: A statistical review for 1987-1988. Ottawa: Statistics Canada.

Chodorow, Nancy. (1978). The reproduction of mothering: Psychoanalysis and the sociology of gender. Berkely: University of California Press.

Crombie, Gail. Women's attribution patterns and their relation to achievement: An examination of within-sex differences. Sex Roles, 9 (12), 983, 171-1182.

Culley, Margo and Portugues, Catherine. (1985). Gendered subjects: The dynamics of feminist teaching. London: Routledge and Kegan Paul.

Davis, Fran, Steiger, Arlene, and Tennenhouse, Karen. (1989). A practical assessment of feminist pedagogy. Quebec: PAREA.

Davis, Fran and Nemiroff, Greta Hofmann. (1993). Towards a Gender-Fair Education in the Cegeps. Quebec: PAREA.

Des Rivières, Marie-Josée. (1982, janvier). Université Laval, un cadre feministe (ou a tout le moins sexiste) de recherche et d'enseignment à l'université. Québec: Université Laval.

Dinnerstein, Dorothy. (1976). The mermaid and the minotaur: Sexual arrangments and human malaise. New York: Harper.

Easlea, Brian. (1987). Patriarchy, scientists, and nuclear warriors. Kaufman, Michael (Ed.) Beyond patriarchy. Toronto:Oxford. 195-215.

Epstein, Cynthia Fuchs. (1974). Bringing women in: Rewards, punishment and the structure of achievement. Kundsin, Ruth B. (Ed). Women and success: The anatomy of achievement. New York: William Morrow.

Erkut, Sumra. Exploring sex differences in expectancy, attribution, and academic achievement. Sex Roles, 9 (12), 1983, 217-231.

Freire, Paulo. (1973). Education: The practice of freedom. Londond: Writers and Readers Publishing Co-operative.

Frieze, Irene Hanson. (1975). Women's expectations for and causal attributions of success and failure. Mednick, M. et al (Eds.). Women and achievement. New York: Wiley.

Fulwiler, Toby. (1980). Journals across the disciplines. English Journal, 69 (9).

Gilligan, Carol. (1982). In a different voice: Psychological theory and women's development. Cambridge: Harvard University Press.

Gilligan, Carol et al. (1990). Making connections: The relational worlds of adolescent girls at Emma Willard School. Cambridge: Harvard University Press.

Hacker, Sally. (1989). Pleasure, power and technology. Boston: Unwin Hyman.

Heatherington, Laurie et al. (1989). Toward an understanding of social consequences of "feminine immodesty" about personal achievements. Sex Roles, 20 (7 & 8), 371-380.

Horner, Matina. (November, 1969). Fail: bright women. Psychology To-day, 3, 36-68.

Industry, Science and Technology Canada. (1991). Women in science and technology: Volume I, Universities. Ottawa.

Johnson, David W. and Johnson, Frank P. (1990). Joining together: Group theory and group skills. Fourth Edition. Englewood Cliffs: Prentice Hall.

Keller, Evelyn Fox. (1985). Reflections on gender and science. New Haven: Yale University Press.

Kostash, Myrna. (1987). No kidding: Inside the world of teenage girls. Toronto: McClelland and Stewart.

Laforce, Hélène. (automne,1987). La pédagogie feministe frappe à nos portes. Remue-meninges.

Lafortune, Louise. (Ed.). (1986). Femmes et mathématique. Montréal: Editions du remue-menage.

Lenney, Ellen et al. Sex differences in self-confidence: The influence of comparison to others' ability level. Sex Roles, 9 (9), 1983, 925-942.

Licht, Barbara G. (1987). The interaction between children's achievement-related beliefs and the characteristics of different tasks. Paper presented at the Annual Meeting of the American Educational Research Association, Washington D.C., April 20-24.

Lunneborg, P.W. and Lunneborg C.E. (1985). Non-traditional and traditional college students. Journal of college student personnel, Jan., 33-36.

Maccoby, Eleanor Emmons and Jacklin, Carol Nagy. (1974). The psychology of sex differences. Stanford: Stanford Press.

McLeod, Susan H. (Ed.) (1988). Strenthening programs for writing across the curriculum. San Francisco: Jossey-Bass.

Martin, Nancy et al. (1976). Understanding children talking. London: Penguin.

Morgan, Robin. (1977). Going too far: The personal chronicle of a feminist. New York: Random House.

Meece, Judith L. et al. (1982). Sex differences in math achievement: Toward a model of academic choice. Psychological Bulletin, 91 (2), 324-348.

Mura, Roberta et al. (1986). Attitudes expériences et performances en mathématique d'étudiantes et d'étudiants de cinquième secondaire selon leur choix scolaire. Québec: Cahiers de recherche de GREMF, No. 9.

Murray, Donald. (1990). Read to write: A writing process reader. (2nd ed.). New York: Holt, Rinehart and Winston.

Neilsen, Lorri. (7 March, 1990). Writers, context, and power. Writing Seminars, McGill University, Montreal.

Rich, Adrienne. (1979) On lies, secrets, and silences. New York: W.W. Norton.

Serbin, Lisa A. and O'Leary, K.D. (1975). How nursery schools teach girls to shut up. Psychology To-day, 9, 57-102.

Shor, Ira. (Ed). (1987). Freire for the classroom: A sourcebook for libratory teaching. Portsmouth: Heinemann.

Slavin, Robert. (Ed). (1985). Learning to cooperate, cooperating to learn. New York: Plenum Press.

Spender, Dale. (1980). Man-made language. Boston: Routledge and Kegan Paul.

T.V. Ontario. (1983). The pinks and the blues. Toronto: Ontario Educational Communications Authority.

Vollmer, Fred. Sex differences in personality and expectancy. Sex Roles, 11 (11 & 12), 1984, 1121-1139.

White, Janet. (1988). The language of science. London: Department of Education and Science.

Weiler, Kathleen. (1988). Women teaching for change: Gender, class and power. Massachusetts: Bergin and Garvey.

Appendix 1: Report of Pre-test of Physics Attitude Inventory

Vanier College,
821 Ste. Croix Blvd.,
Montreal, H4L 3X9.
Feb.6,1991.

Mr. Bahadur C. Bhatla,
Principal,
St. George's School of Montreal.

Dear Mr. Bhatla,

We have completed the statistical analysis of the tests which were administered to your physics classes before the holidays and thought that you might be interested in the results. We do, however, want to begin with a very strong note of caution as to the danger of drawing any conclusions from this information. Firstly, the survey which was administered to your students is a variation of a mathematics attitude inventory developed by Richard Sandman and adapted to measure the attitudes of students to physics by ourselves. We are therefore still in the process of exploring its utility in this form. Even more importantly, it must be emphasized that it is really impossible to make any sort of generalizations on the basis of a sample of students as small as the one presently under consideration, particularly given the relatively small number of young women in the sample.

Proceeding then with this caveat in mind, we can tell you that among the 39 students who responded to the survey, there is no significant difference between males and females with respect to overall score on the physics attitude inventory. There is also no significant difference between males' and females' scores on any of the six scales of the inventory. (These scales are designed to measure: 1. perception of the teacher 2. anxiety toward physics 3. perception of the value of physics in society 4. self-concept in physics 5. enjoyment of physics and 6. motivation in physics.) Because of the relatively small size of this sample, it is difficult to interpret these findings. Certainly, it remains possible that the inventory is an instrument not sufficiently sensitive to measure differences with respect to attitudes among females and males. The smallness of the group also may affect the ability of the scales to measure differences.

The inventory did, however, detect some more specific differences between female and male students in this group. Although there was no significant difference in the mean scores of males and females, there was a mild difference in the standard deviation of the scores for these two groups. The scores for both males and females tended to deviate little from the mean; however the deviation for males was even smaller than that for females; that is, in responding to the items of the attitude survey, there was slightly more agreement among males than among females.

It was also of interest to us to note that there were some items on the inventory which did serve to discriminate between these two groups. Although we want to reiterate the note of caution with which we began, we thought that you, too, might be interested in this aspect of the results.

The set of items which do appear to discriminate between males and females is:

Item 3: I like the easy physics problems best.

Item 24: It is important to know physics in order to get a good job.

Item 28: I enjoy talking to other people about physics.

Item 48: If I don't see how to do a physics problem right away I never get it.

Item 12: Most people should study some physics.

Item 31: My physics teacher doesn't seem to enjoy teaching physics.

Item 20: I feel tense when someone talks to me about physics.

Item 43: I have a good feeling toward physics.

Item 42: It is important to me to understand the work I do in physics.

Item 16: I usually understand what we are talking about in physics class.

Looking at the responses of your students to this set of items, one finds that females were more likely than males to agree with the first statement ("I like the easy physics problems best.") and to feel that if they did not get a physics problem right away that they would never get it.

While both males and females were likely to agree that it is important to know physics in order to get a good job, males tended to believe this more strongly. This same pattern was repeated in the students' responses to item 12 ("Most people should study some physics.") On the other hand, more females than males said that they enjoy talking to other people about physics.

Both males and females perceived their teacher as enjoying teaching physics but males did so more strongly than females. Similarly both males and females tended to report good feelings toward physics, an absence of tension about the subject, and a general tendency to feel that they understand what is being discussed in class. However, for each of these items, the males' score reflects more positive feelings and less negative feelings than does the score for females. Both males and females agreed strongly with the statement "It is important to me to understand the work I do in physics"; and again males indicated stronger agreement with this statement than females.

It is interesting that this set of items is drawn from all of the scales. As we have mentioned previously, no single scale discriminates between males and females in this group. However, the scales which distinguish best between males and females are the scales which purport to measure motivation in physics and the perceived value of physics in society respectively.

We hope that you will find this information of interest as part of a larger consideration of the impact of gender differences in education. We are certainly growing increasingly convinced that the issues in this area are as important as they are complex. We do want to thank you once again for your co-operation and for the interest which you have shown in our work.

With gratitude to you and to the students of the physics classes.

Sincerely,

c.c. Mr. Bhardwaj

FINAL TEACHER INTERVIEW SCHEDULE:

1. What methods did you use? How?

a) Self-disclosure:

What kind of disclosures? Course-related? Other?

b) Peer-support groups:

How were they chosen? Gender mixed or gender separate? Did the support group become hierarchical?

c) Writing:

To what extent was it affective? To what extent was it focussed on course material?
To what extent did you use affective or cognitive questions?
To what extent did the students respond affectively or cognitively?

2. How did the methods go?
What kind of direction did you provide? Did you meet resistance?

What were the positive aspects? Negative aspects?

3. How do you feel the students felt about it?
Did all students feel the same way?

Did some type(s) of students benefit more than others?

What characteristics or learning styles in students did this method draw out?

Did you feel that there was a difference in the way that men and women reacted to this method?

4.Did the method have repercussions on other aspects of your teaching?
Consider: Workload, class atmosphere, ability to cover the course content, increasing the personal connections made by students to the material, effect upon the student/teacher relationship, the student/student relationship.

5. Would you use the method again? How would you change it? Do you have advice for others?

Student Interview Schedule: Pre-study

Rating Questions:

1. Why did you take physics in high school and college? Why are you taking this course?

2. Tell me about the physics courses which you have taken. What have you liked about them? What have you disliked? What have you felt neutral about?

3. Do you feel that physics is connected to your life/useful to your life?

4. Do you think that physics is a hard subject? Who does well in physics? What kind of student?

5. How do you expect to do in this course?
   a) What mark do you expect to get?

6. Are you satisfied with how you have done in physics up until now? Why or why not?

7. How confident do you feel about your abilities in physics in general?

8. Do you plan to take other courses in physics? Why or why not?

Attitude to Teacher:

1. How important is the teacher in physics courses?

2. How have you felt about your teachers?

3. How do you think that your teacher(s) have felt about you?

4. Have you felt that you have received the kind of help and attention you wanted?

Attitude to Students:

1. How do you feel about working with students?

2. Have there been different levels of abilities in your physics courses? If not, why not? If so, how did you feel about these different levels? Did your feelings affect your behaviour in the course?

3. Has your physics class been competitive? How do you know? How do you feel about this?

1. How do you study in physics? Describe your methods.

Appendix 4: Pre-semester Student Interview Schedule: French

Questions pour évaluer:

1. Pourquoi as- tu pris la physique au niveau de secondaire et ici au collège? Pourquoi prends-tu ce cours-ci?

2. Parles-moi un peu des cours de physique que t'as déjà pris. Qu'est-ce que t'as aimé dans ces cours? Qu'est-ce que tu n'as pas aimé? Quelles étaient les choses face auxquelles tu te sentais plutôt neutre?

3. As-tu l'impression que la physique est liée à ta vie? Est-elle utile?

4. Pense-tu que la physique est un sujet difficile? Quel type d'étudiant(e) réussit bien en physique?

5. A ce moment, est-ce que tu penses que tu vas réussir dans ce cours? Quelle note attends-tu?

6. Es-tu satisfait(e) avec tes resultats dans tes cours de physique jusqu'à date? Pourquoi ou pourquoi pas?

7. En general, as-tu confiance en tes capacités en physique?

8. Comptes-tu prendre d'autres cours en physique? Pourquoi ou pourquoi pas?

Attitudes face au professeur:

1. Dans les cours de physique, jusqu'à quel point le professeur est-il ou elle important(e)?

2. Peux-tu me parler un peu de tes attitudes face à tes professeurs jusqu'à là. Les as-tu aimés, ou appreciés par exemple?

3. Qu'est-ce que tu penses que tes professeurs ont pensé de toi?

4. Est-ce que t'as trouvé que t'as reçu l'aide et l'attention que tu voulais?

Attitudes face aux autres étudiant(e)s:

1. Qu'est-ce que tu penses de travailler avec d'autres étudiant(e)s?

2. As-tu remarque des capacités differentes parmi des élèves dans tes cours de physique? Si non, pouquoi pas? Si oui, comment as tu vécu ces niveaux différents? Est-ce que ces sentiments ont influencé ton comportement?

3. Il y avait-il de compétition dans tes cours de physique? Comment as-tu su? Qu'est-ce que tu penses de ce niveau de compétition?

1. Comment est-ce que t'études la physique? Decris-moi tes méthodes. (tes stratégies)

Appendix 5: Post-semester Student Interview Schedule: English

Student Interview Schedule: Post-study

Rating Questions:

1. Tell me something about your experience in this course. What did you like? What did you not like? What did you feel neutral about?

2. Do you feel that physics is connected/useful to your life?

3. As a subject, does physics seem harder or easier than it did at the beginning of the semester?

4. How do you expect to do in this course?

5. What mark do you expect to get now?

6. Are you satisfied with how you have been doing in this course? Why or why not?

7. Describe where you have done well, where you have done less well, and say whether this has surprised you. (Were there moments in the course when you discovered your strong points, your weak points?)

8. How confident do you feel about your abilities in Physics in general (now)?
   a) Has this confidence changed during this course?

9. Do you see a connection between your confidence in physics and your confidence in other areas?

10. Do you plan to take other courses in Physics? Why or why not?
    a). Have these plans been changed by this course? Explain.

Attitude to Teacher:

1. Have you been comfortable in this course?

2. Do you feel that the teacher knows you now? How do you think that your teacher has felt about you?
   b)Does the teacher feel the same about all the students in the class? How do you know?

3. Have you felt that you have received the kind of help and attention that you wanted?

Attitude to Students:

1. How did you feel about working with the students in this class?

2. Were there different levels of abilities in the classroom? If not, why not? If so, how did you feel about these different levels? Did your feelings affect your behaviour in the course?

3. Has this class been competitive? How do you know? How did you feel about this?

1. In retrospect, what things in the course helped you to learn the most?

2. Have your methods of studying physics changed during this course? Describe your methods.

3. There are people who have suggested that physics is a masculine subject. Can you see why they might think that? What do you think?

L'entrevue: post-session

Questions pour évaluer:

1.Raconte-moi tes expériences dans ce cours. Qu'est-ce que t'as aimé? Qu'est-ce que tu n'as pas aimé? Est-ce qu'il y avait des choses qui te laissaient plutôt neutre?

2. As-tu l'impression que la physique est liée à ta vie? Est-elle utile?

3. Comme sujet, est-ce que la physique te semble plus facile ou plus difficile qu'au début de la session?

4. Quels résultats attends-tu dans ce cours?

5. Quelles notes attends-tu maintenant?

6. Es-tu satisfait de tes résultats à date dans ce cours? Pourquoi ou pourquoi pas?

7. Décris-moi tes points forts et tes points faibles dans ce cours. (Ce qui marchait bien et ce qui marchait mal.) Etais-tu surpris par ça?

8. Es-tu confiant en tes capacités en physique en general maintenant?
   a) Est-ce que ton niveau de confiance a changé pendant ce cours?

9. Est-ce que tu vois un lien entre ta confiance en physique et ta confiance en d'autres domaines?

10. Attends-tu prendre d'autres cours en physique? Pourquoi ou pourquoi pas?
   a) Est-ce que tes plans ont changé à cause de ce cours? Peux-tu m'expliquer?

Attitudes face aux professeurs:

1. As-tu été comfortable dans ce cours?

2. As- tu l'impression que ton professeur te connait maintenant? Qu'est-ce que tu penses qu'il (elle) pense de toi?
   a) As- tu l'impression qu'il(elle) pense la meme chose de tous les élèves dans la classe? Comment sais-tu?

3. As-tu l'impression que t'as reçu l'aide et l'attention dont t'avais besoin et que tu voulais?

Attitudes face aux autres élèves:

1. Qu'est-ce que tu pensais de travailler avec les autres élèves dans ce cours.

2. Etais-tu conscient des capacités différents parmi des élèves dans ce cours? Si non, pourquoi pas? Si oui, comment as tu vécu ces différences pendant la session? Est-ce que t'as remarqué des changements dans ton comportement à cause de ces différences?

3. Est-ce qu'il y avait de la compétition dans ce cours? Comment as-tu su? Qu'est-que tu penses de ça?

1. En regardant tes expériences dans ce cours cette session, peux-tu me décrire les choses qui t'ont aidé le plus à apprendre?

2. Est-ce que tes methodes d'étudier la physique ont changé pendant ce cours? Décris-les.

3. Il y a du monde qui dit que la physique est une matière plutôt masculine. Peux-tu voir pourquoi ils penses ça? Qu'est-ce que tu penses?

CONFIDENCE CATEGORIES

For Rating Pre-Semester Interview Tapes: Answers to # 4,5,6,7

-5, Very Low:

4. Usually says it is hard, and "You have to have a feel for it," You are born with a gift for it." Usually admits "I don't seem to have it."

5. Will often say "I think I am going to fail." Might say "I hope I do better" or "I don't know." Does not make high mark predictions. If hopeful, whatever makes the difference definitely comes from outside the student's control. The hope, if referred to, is very remote.

6. Is most likely trailing low marks and believes these low marks to be accurate.

7. Usually admits to low confidence, but might not understand the term. Makes remarks like "I guess it's me and my head, it isn't really physics." Suggests in some way a great disappointment in self.

-2, Low:

4. Usually says it is harder than other subjects, or "harder for me than for some people." Usually says something about aptitude, but almost always adds the importance of work, dedication, good study habits.

5. Again, the word is "hopefully" or "I hope", rather than "I expect," but makes higher mark predictions, and talks with real hope and not despair. Often a little more in control of making the difference themselves, usually by working hard.

6. Might have been satsified with mediocre or low marks, or might have been dissatisfied, and have grandiose notions of what is aspired to, far above what has formerly been achieved. Might also reckon former marks were too high and misleading.

7. Usually admits to not being very confident, but often an interesting misunderstanding of confidence and competence.

0, Middle Group:

4. Never says it's very hard, qualifies with something like "The teacher can make it less hard", or, occasionally "If you put your mind to it, it's less hard." Sometimes refers to top students as those for whom it comes naturally, but also often speaks of background, study habits, concentration and attitude.

5. Prediction easier to get and often comes in mid-seventies.

6. Often did better in high school and not pleased with Cegep results (if already finished a Cegep course).

7. Will often say "Pretty confident - but it depends on the teacher." Might say "I'm confident in some things," or "It depends": confidence is at a very modest level, and can easily escape. Again confidence is sometimes confused with competence.

+2, Moderate Confidence:

4. Might say some topics are harder, but will always use the word "easy" somewhere in the answer: "It's easy to relate to," or "If you keep up, it is easier." Hard work is the secret of success.

5. Usually uses the word "expect", picking up the word of the question, whereas lower group cannot. Usually expects good results, though often hedges with "Because I like the teacher" or "Because I'm in second semester now."

6. Frequently not terribly satisfied with former marks, especially Cegep. Has high expectations.

7. Will say "pretty confident" or that it "depends on me."

+5, High:

4. Talks about physics as "very basic to life" or "commmon sense" or "quite simple, really." Talks about need to concentrate, to understand and to practice. Usually uses the word "thinking:" talks about how important it is to think, not just want to serve one's program needs for high marks.

5. Says will do well. Talks about results depending on selves, but will occasionally still talk about teachers, though in a different way. For instance: "If I can see myself in the teacher, I feel good about my chances." Teacher becomes model not savior.

6. Has had good marks which have been pleasing.

7. "I'm pretty confident - I've taken a few courses now, so I think I can master the challenge;" or, "I'm pretty confident: in high school I was #1, and last semester I was one of the best."

INVOLVEMENT IN SUBJECT CATEGORIES

For Rating Pre-Semester Interview Tapes: Answers # 2,3

-5, Very Low:

2. Has had very bad experiences of humiliation and/or disappointment. Often makes very clear statements like "I hate the stuff".

3. Sees little connection to life and does not feel its usefulness even for the proposed career.

-2, Low:

2. Has not done well, usually blames teachers, though sometimes admits did not work very hard. Might say "I don't mind physics, but I don't really like it."

3. Might see connection but doesn't care much, is more likely to see usefullness for career but not with enthusiasm.

0, Middle Group:

2. Hasn't done much with courses either because of

difficulty or lack of work, but generally talks about liking something eg. the labs, perhaps some of the problem-solving. A low key acceptance might characterize attitude here.

3. Usually very functional attitude: sees some connection to life but not with much interest, but will speak of its usefulness for engineering.

+2, Moderately High:

2. Usually has had some good experiences and wil discuss a good memory here, but might also have bad ones, of course. Will often say "I like mathy things" or "I enjoy solving puzzles."

3. Answers positively to both connection and usefulness, and gives some sense of interest and curiosity, may also be accompanied by a very strong career drive.

+5, High

2. Has liked topics, activities, and the answers to basic questions about the nature of physical reality: might be enthusiastic but often very cool, laid back, as if it were only to be expected that such enjoyment was part of science education. Might be critical of classes/courses/teachers/ but not to justify self. Gives impression that "Science is me."

3. Gives very philosophical answers here, sorting out usefulness from connection and discussing what some of the connections are.

COMMITMENT TO CONTINUE CATEGORIES

For Rating Pre-Semester Interview Tapes: Answers #1,8.

-5, Very Low: Special category

Pre-semester: Planning to abandon
Post-semester: Capable but won't continue

-4,Very Low:

1. Sometimes doesn't know, didn't have a choice. Often admits it was a mistake.

8. Talks about abandonning during the semester, or at the end if failure.

-2,Low:

1. Decision by elimination, or peer pressure, or ambition now recognized as possibly unrealistic, and certainly not physics-related.

8.Will drop as soon as possible.

0, Middle Group:

I'll drop it as soon as I can. I don't like it. I'm only taking it because of program requirements.

+1, Mild Interest:

1. Usually has an interest (parent who builds things) or an ambition that is still present, often somewhat physics-related.

8. Will continue, but usually not for the physics per se.

+3, Moderately High:

1. Speaks of interest, ability, ambition.

8. Strong career commitment.

+5, High:

1. Strong interest, ability and ambition .

8. "I love it" or a simple "Yes" with a smile: interested in learning more about physics per se at post-Cegep level.

Post-Semester Interview

Using your rating of the pre-semester interview as a base line, rate the post-semester interview, paying special attention to any changes. In which direction is the change?

Questions measuring confidence:

3,4,5,6,7,8,9.

Questions measuring involvement:

1,2.

Willingness to continue in the subject:

10

INDIVIDUAL INTERVIEW RATING SHEET H91

Student Name:______________________________

Student Number:__________ Language:__________ CO or EX______

PLACE A DARK PENCILLED X ON EACH SCALE WHERE YOU THINK THE STUDENT'S CONFIDENCE, COMMITMENT OR INVOLVEMENT LIES. USE THE RATING INSTRUCTIONS AS A GUIDE, BUT YOU MAY HEAR OTHER INDICATORS WHICH CONTRADICT SPECIFIC ANSWERS, AND YOU MAY RESPOND TO THEM TOO.

PRE-SEMESTER INTERVIEW RATING

CONFIDENCE SCALE:

-5____-4____-3____-2____-1____0____+1____+2____+3____+4____+5

INVOLVEMENT SCALE:

-5____-4____-3____-2____-1____0____+1____+2____+3____+4____+5

COMMITMENT TO CONTINUE IN SUBJECT SCALE:

-5____-4____-3____-2____-1____0____+1____+2____+3____+4____+5

POST-SEMESTER INTERVIEW RATING

CONFIDENCE SCALE:

-5____-4____-3____-2____-1____0____+1____+2____+3____+4____+5

INVOLVEMENT SCALE:

-5____-4____-3____-2____-1____0____+1____+2____+3____+4____+5

COMMITMENT TO CONTINUE IN SUBJECT SCALE:

-5____-4____-3____-2____-1____0____+1____+2____+3____+4____+5

Table 5

The Six Scales of the Mathematics Attitude Inventory-
Final Form

Item Number	Item Statement
Scale 1: Perception of the Mathematics Teacher	
5	My mathematics teacher shows little interest in the students.
17*	My mathematics teacher makes mathematics interesting.
21*	My mathematics teacher presents material in a clear way.
27*	My mathematics teacher knows when we are having trouble with our work.
31	My mathematics teacher doesn't seem to enjoy teaching mathematics.
40*	My mathematics teacher is willing to give us individual help.
44*	My mathematics teacher knows a lot about mathematics.
46	My mathematics teacher doesn't like students to ask questions.
Scale 2: Anxiety Toward Mathematics	
7	I feel at ease in a mathematics class.
11*	When I hear the word mathematics, I have a feeling of dislike.
20*	I feel tense when someone talks to me about mathematics.
25	It doesn't disturb me to work mathematics problems.
34*	Working with numbers upsets me.
36*	It makes me nervous to even think about doing mathematics.
39*	It scares me to have to take mathematics.
43	I have a good feeling toward mathematics.

The Mathematics Attitude Inventory was developed by Richard Sandman for The Minnesota Research and Evaluation Centre. The word physics was substituted for the word mathematics in the student version of the survey itself. This survey was also available in French.

Item Number	Item Statement
Scale 3: Value of Mathematics in Society	
1*	Mathematics is useful for the problems of everyday life.
9	There is little need for mathematics in most jobs.
12*	Most people should study some mathematics.
15*	Mathematics is helpful in understanding today's world.
23*	Mathematics is of great importance to a country's development.
24*	It is important to know mathematics in order to get a good job.
33	You can get along perfectly well in everyday life without mathematics.
38	Most of the ideas in mathematics aren't very useful.
Scale 4: Self-Concept in Mathematics	
4	I don't do very well in mathematics.
10*	Mathematics is easy for me.
16*	I usually understand what we are talking about in mathematics class.
19	No matter how hard I try, I cannot understand mathematics.
22	I often think, "I can't do it," when a mathematics problem seems hard.
30*	I am good at working mathematics problems.
35*	I remember most of the things I learn in mathematics.
48	If I don't see how to work a mathematics problem right away, I never get it.

Item Number	Item Statement
Scale 5: Enjoyment of Mathematics	
2*	Mathematics is something which I enjoy very much.
6*	Working mathematics problems is fun.
13	I would like to spend less time in school doing mathematics.
18	I don't like anything about mathematics.
26	I would like a job which doesn't use any mathematics.
28*	I enjoy talking to other people about mathematics.
29*	I like to play games that use numbers.
45*	Mathematics is more of a game than it is hard work.
Scale 6: Motivation in Mathematics	
3	I like the easy mathematics problems best.
8*	I would like to do some outside reading in mathematics.
14*	Sometimes I read ahead in our mathematics book.
32*	Sometimes I work more mathematics problems than are assigned in class.
37	I would rather be given the right answer to a mathematics problem than to work it out myself.
41	The only reason I'm taking mathematics is because I have to.
42*	It is important to me to understand the work I do in mathematics.
47*	I have a real desire to learn mathematics.

*Designates a reverse-scored item.