AN INVESTIGATION INTO THE EFFECT OF GENDER, BIOLOGY AVERAGE, AND PERSONAL AND PERCEIVED SCIENCE VALUES ON STUDENTS' PERSISTENCE IN BIOLOGY

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BY

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Abstract

This study investigated (i) whether the levels of academic integration and social integration of students who persist in biology differed from those of students who did not persist and, (ii) whether students' gender, academic performance, personal values and perceived values of scientists were predictive of persistence in, or attrition from, biology.

A random sample of 200 students was selected from the population of biology majors attending Memorial University of Newfoundland between 1988 and 1992. One hundred thirty-one of these people agreed to participate in the study.

Data were collected through the records of the Office of the Registrar at Memorial University and through the administration of a Science Issues Survey, and a Personal Information Survey. These data were then subjected to a series of statistical analyses, including Analyses of Variance, t-tests, and Regression Analysis.

It was found that students who persisted in biology or another science demonstrated greater academic integration with the Biology Department than students who chose to leave the study of science entirely. Students who persisted in biology did not demonstrate greater value integration with the Biology Department than students who did not persist in biology; degree of value integration appeared to vary with gender, rather than with persistence behaviour.

Students' sex, academic performance in biology, personal values in science, and perceived values of scientists, were found to be predictive of their persistence behaviour in biology and of their decision to leave science altogether. These factors did not accurately predict the persistence behaviour of students who chose to leave biology in order to study another science.

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Chapter 1

Introduction to the Problem

There was once a time when it was possible to possess all the knowledge western civilization had produced. For a brief period during the sixteenth century - just after the printing press came into common use, and just before that use resulted in an explosion of information - all who could read became privy to the world's collective knowledge (Burke, 1985). A person of wealth was capable of collecting the sum of that knowledge in one room (the personal library), and thus had access to this vast store of data whenever the need arose.

It is now four hundred years past that brief interval of time in which it was possible to know all that our society has to offer. Human learning has built upon the recorded achievements and pushed back the barriers to discovery until now, in the last decade of the twentieth century, the store of information is so extensive that even "experts" can possess only a portion of the sum of knowledge applicable to their field.

Canadians live in an advanced technological society. In many ways, the quality of people's lives is dependent upon their ability to cope with, and adapt to, the constantly-evolving technological world in which they exist. This presents a continual challenge, for science and technology are changing the society in which we live at an increasingly rapid pace.

As a consequence, the youth of the 1990s are subject to a relatively novel form of persuasion by their elders. They are pressed to obtain a post-secondary education in the sciences in order to prepare themselves to compete effectively in the technological world they are about to enter.

It would be naive, however, to assume that the pressure students feel to pursue the sciences stems totally from the altruistic notion that such an education will improve their lives. The pressure for students to pursue an education in the sciences derives from political, economic and scientific sources.

Politically, a science education is viewed as a path through which the transformation from a resource-based and industrial society to an information-based society (Crocker, 1989) can be effected. In the 1990s, both government and industry are promoting science education as the solution to Canada's poor performance in international trade.

To many industrialists, "a country's competitiveness starts in the classroom" (Iacocca, 1990, p. 31). The implication is that a greater number of scientists will result both in new and better technologies for use in the marketplace, as well as an ample supply of technologically competent industrial workers.

Finally scientists, particularly in universities, have a major interest in subject maintenance; that is, in the reproduction of the sciences as they in higher education define them (Fensham, 1988). To meet this requirement, a steady supply of student science majors is required.

Thus, the youth of the 1990s are subject to encouragement from many areas - government, industry, the scientific community, and educators - to obtain an education in science. Newfoundland students are accepting the challenge, with large numbers entering university expressing the intention of pursuing an education in one of the sciences (Crocker, 1989).

Unfortunately, a significant number of potential science majors subsequently decide that science is not for them, and either change their educational major or withdraw from college (Drew, 1992; Milem and Astin, 1992; Oliver, 1991; Levin and Wyckoff, 1990; Crocker, 1989; Hilton and Lee, 1988; Levin and Klindienst, 1983). In fact the most recent statistics available for Canadian universities indicate that, despite increasing societal pressure for students to enter the sciences, awards of Bachelor of Science degrees have been decreasing on a yearly basis (Statistics Canada, personal communication, October 8, 1993). (See Table 1.1).

This decline is also expressed differentially with regard to gender. Males tend to persist in the pursuit of an education in science to a greater degree than females (Head and Ramsden, 1990; Bateson and Parsons-Chatman, 1989; Boisset, Mackenzie, and Sidorenko, 1989; DeBoer, 1984a; Handley and

Table 1.1

Bachelor of Science Degrees, Granted by Province

1988-1990

Year	NF	PEI	NS	NB	QUE	ONT	MAN	SASK	ALTA	BC	TOTAL
1990	493	100	1379	693	7958	11173	1139	996	2771	2240	28942
1989	512	76	1481	735	7992	11507	1176	1102	2610	2100	29291
1988	456	56	1527	764	8183	11524	1222	1114	2801	2207	29854

NF = Newfoundland; PEI = Prince Edward Island; NS = Nova Scotia;

NB = New Brunswick; QUE = Quebec; ONT = Ontario; MAN = Manitoba;

SASK = Saskatchewan; ALTA = Alberta; BC = British Columbia

Morse, 1984; Betz and Hackett, 1983). The number of female students awarded a Bachelor of Science degree has steadily increased from 1988 to 1990, even as the number of male awards has decreased (Statistics Canada, personal communication, October 8, 1993). In 1988, 61.5% of Canadian Bachelor of Science degrees were earned by males; 38.5% by females. By 1990, the most recent year for which figures are available, 57.5% of Bachelor of Science degrees were awarded to males; 42.5% to females. (See Table 1.2).

A similar trend can be observed at Memorial University of Newfoundland where, from 1988 to 1990, the science faculty experienced an observable decline in its undergraduate population (Bessey, Bourne, Chancey, Gladney, and Stockley, 1992). While 1991 and 1992 science enrolments again approached 1988 levels, the societal goal of increased student participation in science had not been attained. (See Table 1.3). A comparable decline occurred in the number of Bachelor of Science degrees awarded by Memorial University from 1988 to 1992. (See Table 1.4). In 1988, 30% of students who graduated from Memorial University did so with a Bachelor of Science degree. By 1991, only 23% of graduates had completed an undergraduate degree in science. 1992 figures indicate that almost 28% of that year's graduating class had obtained a Bachelor of Science degree; the first increase in number in

Table 1.2

Bachelor of Science Degrees Awarded in Canada

1988 - 1990

(By Gender)

Year	Males	Percent of Total	Females	Percent of Total	Total
1990	16644	57.5%	12298	42.5%	28942
1989	17044	58.2%	12247	41.8%	29291
1988	17790	61.5%	12064	38.5%	29854

Table 1.3

Total Undergraduate Enrolment in Science Faculty

of Memorial University of Newfoundland

(Fall Semester)

1988 -1992

Year	1992	1991	1990	1989	1988
Number of Students	1278	1145	1065	1076	1225
Percent of Total Enrolled	7.9%	7.3%	7.0%	7.5%	8.4%

Table 1.4

Bachelor of Science Degrees Awarded by Memorial University of Newfoundland

1988 -1992

Year	1992	1991	1990	1989	1988
Number of Students	277	236	246	272	233
Percent of Total Graduates	27.7%	23.1%	25.7%	29.4%	30.0%

five years (Bessey, Bourne, Chancey, Gladney, and Stockley, 1992).

Students are making educational (and, therefore, career) choices outside the sciences, in spite of the efforts of their government, potential employers, and educators. If institutions of higher learning are to keep up with the demands for science graduates, this drain of science majors must be arrested. An understanding of the factors associated with student attrition from science is essential to this endeavour.

Initially, it would seem logical to assume that students do not enter post-secondary science, or leave its study, because they are not academically strong in this area. However, results of investigations on academic achievement and persistence in science at the college level are mixed. In other words, science ability alone does not predict persistence in the field. The majority of research in this area (Levin and Wyckoff, 1990; DeBoer, 1984b; Wollman and Lawrenz, 1984; Campbell and McCabe, 1982), however, utilized pre-college measures as predictors of persistence.

While students must certainly be academically competent in science in order to continue in its study, there are obviously other factors which affect their persistence. Investigation in this area has indicated that influences may include students' self-perceptions of competence, how they attribute their feelings of success or failure, their attitudes about science, and their feelings of "fit" within the science faculty. Clearly, the persistence behaviour of science students is a complex matter.

One aspect of persistence behaviour, inspired by feminist research into the nature of science, has not as yet been extensively investigated. This is the notion that the dominant values of science - its objectivity, rationality, analytical fragmentation and disinterestedness (Manthorpe, 1982) - serve as a selection mechanism within the discipline.

Some authors (Brush, 1991; Tobias, 1990; Keller, 1985; Manthorpe, 1982) suggest that science faculties share these values and look for them in their students. It has further been proposed (Tobias, 1990; Manthorpe, 1982; Gilligan, 1982) that people who do not possess these values (that is, those who cannot divorce themselves from holistic, ethical and moral considerations) will be less likely to persist in the sciences.

Adding to the intricacy of the matter is the consideration of students' gender. Lyons (1988), Gilligan (1982) and Manthorpe (1982) have suggested that there is a similarity between the perceived primary characteristics of science and the dominant stereotype of male values. They contend that the values which women could bring to science (for example, holistic, subjective and cooperative processes) are currently regarded as deviant within the discipline.

If these authors are correct, academically qualified students whose personal values do not match those of their science faculty may not persist in post-secondary science.

This idea is consistent with Tinto's (1987) Theoretical Model of Dropout Behaviour. In one component of this complex Model, Tinto (1987) indicates that students who are both academically and socially well-integrated with their chosen college system (i.e., meet the grade and value standards) are the ones most likely to persist.

The present study attempted to investigate that component of the Model with regard to the persistence/attrition behaviour of Biology Majors (1988 through 1992) of Memorial University of Newfoundland. That is, this research will sought to determine whether the levels of academic and social integration of Biology Majors (1988 through 1992) with the biology department of Memorial University of Newfoundland were predictive of students' persistence behaviour in Biology.

Social integration is, in itself, a complex element. Therefore, in keeping with the research cited above and for the purposes of this study, measurement of social integration was be limited to values expressed in moral issues in science.

Purpose of the Study

The first stage of this study investigated whether the levels of academic integration and social integration of students who persisted in biology differed from those of students who did not persist. Gender differences in both areas were also explored.

The second phase of this study considered whether students' gender, academic performance, personal values and perceived values of scientists were predictive of persistence in, or attrition from, biology.

Research Questions

Four research questions were considered:

1. Will Biology Persisters demonstrate greater academic integration with the Biology Department than students who do not persist in biology?

2. Will Biology Persisters demonstrate greater value integration with the Biology Department than students who do not persist in biology?

3. Do gender-based differences occur in the value judgements of students who persist, or discontinue, as biology majors?

4. Are the combined elements of biology students' sex, academic performance in biology, personal values in science, and perceived values of scientists predictive of persistence in, or attrition from, biology?

Hypotheses

The null hypotheses derived from these questions are:

Hypothesis 1: There will be no significant difference in the biology averages of Biology Persisters, $Nonpersisters_{(science)}$, and $Nonpersisters_{(other)}$.

Hypothesis 2: There will be no significant difference between the Value $Bias_{(self)}$, and the Value $Bias_{(science)}$ of Biology Persisters

Hypothesis 3: There will be no significant difference between the Value $Bias_{(self)}$, and the Value $Bias_{(science)}$ of $Nonpersisters_{(science)}$

Hypothesis 4: There will be no significant difference between the Value $Bias_{(self)}$, and the Value $Bias_{(science)}$ of $Nonpersisters_{(other)}$

Hypothesis 5: There will be no significant difference between male and female scores in Value $Bias_{(self)}$.

Hypothesis 6: There will be no significant difference between male and female scores in Value $Bias_{(science)}$.

Hypothesis 7: The factors of Value $Bias_{(self)}$, Value $Bias_{(science)}$, and biology average and sex will not predict persistence group membership with a probability which is any better than random chance.

Limitations of the Study

The population sampled in this study was limited to all persons who had registered as biology majors at Memorial University of Newfoundland during the period from 1988 to 1992. As a result, the findings of this study may not be generalizable to biology students in other universities, or even to other science students at Memorial University.

In addition, the restriction of sample selection to registered biology students introduces a degree of bias to the study. It is entirely possible that students who select biology as their subject major differ in significant ways from students who select other disciplinary majors in science.

A third liability in the research is that, although the subjects were selected at random, participation in the study was completely voluntary. This meant that the participants themselves exercised some degree of self-selection. There is no way of knowing whether students who agreed to take part in the study differed in any key ways from those who refused to take part.

Chapter 2

Related Research

Introduction

This section will critically investigate the research which has been carried out in the area of persistence in science at the college and university level. Naturally, pre-college characteristics which may affect subsequent behaviour (i.e., high school grades, number of mathematics and science courses taken prior to college entry) will be considered.

An understanding of the direction of research in science attrition behaviour is dependent upon some knowledge of the theoretical bases behind the various studies. A review of the work done this far revealed that three major theories point the direction of studies: Self-Efficacy Theory, Congruence Theory, and the Theoretical Model of Dropout Behaviour. Although all three theories initially described general attrition behaviour in students, workers in the field of science attrition have applied their concepts to that narrower educational domain.

Theories of Attrition Behaviour

Self-Efficacy Theory

Knowledge, ability and skill are all necessary, but not sufficient, for a person to perform competently in a given situation. People often do not behave at their optimum level despite complete knowledge of what is required of them and the capability to meet those requirements. This is because self-referent thought mediates the relation between knowledge and action (Bandura, 1977). People's self-efficacy expectations - beliefs about their ability to successfully perform a given task - will determine whether they will attempt to accomplish the task, how much effort they will expend, and how long they will sustain that effort if obstacles or aversive experiences present themselves (Lent, Brown and Larkin, 1984).

Efficacy involves a productive capability, one in which cognitive, social, and behavioral skills must be organized into an integrated course of action. Competence in any action requires people to be able to organize and implement a variety of subskills in order to cope with continually-changing conditions. Thus, a decision to take part in any activity must be partially governed by their operative capabilities. Perceived self-efficacy, people's own judgement of how well they can execute the required course of action, also governs the decision to engage in the activity (Bandura, 1982).

Bandura's concept of self-efficacy has direct relevance to the understanding of education-related behaviours. Successfully pursuing educational options requires a variety of coping mechanisms - the ability to make decisions and to take the initiative, as well as behaviours oriented toward the acquisition of important skills (Hackett and Betz, 1981). If individuals lack expectations of personal efficacy in the educational domain, behaviours critical to effective and satisfying choices, plans and achievements are less likely to be initiated. Even when initiated, these behaviours are less likely to be sustained when obstacles or negative experiences are encountered (Hackett and Betz, 1981). It is hypothesized that when difficulties arise, people who have serious doubts about their capabilities will lessen their efforts or give up altogether (Lent, Brown and Larkin, 1987). Alternatively, those with a strong sense of self-efficacy would be expected to exert greater effort to master the challenge (Bandura, 1982).

Bandura also contends that people's judgements of their capabilities influence their thought patterns and emotional reactions, both during anticipated and actual task experiences. Those who have a low self-assessment of their abilities are hypothesized as perceiving potential difficulties as unrealistically formidable. Such mistaken perceptions then create stress, and subsequently impair performance (Hackett and Betz, 1981), as attention is focused on failure anticipation rather than procedural concerns (Bandura, 1982). Those with a strong sense of self-efficacy are able to focus both attention and effort on situational demands; obstacles serve merely to increase effort (Lent, Brown and Larkin, 1987; Bandura, 1982).

Perceptions of personal efficacy are also thought to affect the choice of behavioral settings and activities (Lent, Brown and Larkin, 1987). People avoid activities they believe are beyond their capabilities, but they will confidently engage in those that they judge themselves capable of managing (Bandura, 1982).

Self-efficacy theory does not propose that people's judgements of their capabilities in an area are necessarily accurate. Indeed, it is quite possible to mistakenly believe in self-competence when none exists, or to reject ideas of efficacy when that efficacy is, in fact, present.

Whether accurate or not, Bandura postulates that there are four principal sources of information through which self-efficacy expectations are learned (Betz and Hackett, 1983). The most influential of these, because it is based on authentic mastery experience, is performance attainment. Successes in tasks are hypothesized to heighten perceived self-efficacy, while repeated failures lower it (Bandura, 1982). Thus students who consistently achieve A's on biology evaluations would be expected to have greater self-efficacy expectations in that subject than the students who consistently achieved D's.

Self-efficacy perceptions are not, however, completely dependent on personal achievements. Bandura (1982) also claims that self-efficacy expectations can be raised by vicarious learning; that is, by observing others performing a task which people judge they have the capabilities to perform. By the same token, observing others who are perceived to be of similar competence fail, despite high effort, may well lower observers' judgements of personal capability.

A third source of information which may influence self-efficacy expectations is verbal persuasion (Betz and Hackett, 1983). Limited in its power, persuasion can nevertheless contribute to self-efficacy expectations if the appraisal is within realistic bounds. Verbal encouragement and support from others may therefore have the greatest impact on people who have some reason (perhaps through previous performance attainments or vicarious experiences) to believe that they can produce effects through actions.

The final factor influencing self-efficacy expectations - emotional arousal - is seen by Bandura (1982) as a co-effect of self-efficacy expectations (Betz and Hackett, 1983). People's physiological state (i.e., their visceral arousal in stressful situations) is read by them as a sign of vulnerability to failure. High emotional arousal usually decreases performance (Bandura, 1982), whereas when self-efficacy expectations increase, anxiety should decrease (Betz and Hackett, 1983).

It would seem, then, that self-efficacy judgements are a crucial component of people's decisions to persist in an educational pursuit. Those who are confident of their ability will expend more effort, perform with greater confidence, and view obstacles as challenges instead of barriers. Those who judge their capabilities in an educational domain as lacking may tend to give up when aversive circumstance arise, or may even avoid entering that particular arena altogether.

Attribution Theory

The preceding discussion of self-efficacy theory suggests that how people perceive their competence is essential to their decision to enter and/or persist in a performance setting. This is not inconsistent with another theory pertaining to academic persistence: Attribution Theory.

Attribution theory may well be considered to be a corollary of self-efficacy theory. Like self-efficacy theory, attribution theory contends that students' feelings and beliefs about their ability to succeed are strongly related to their continued participation. These perceptions are based on information received about performance on achievement tasks. The explanations that people give for their success or failure in a given setting is similarly hypothesized to affect their emotional reaction. The combination of performance expectations and emotional reaction is then argued to affect subsequent achievement behaviours (Weiner, 1980; DeBoer, 1985).

However, attribution theory adds a component which self-efficacy theory does not possess. While both theories agree that feedback on performance influences students' perceptions of their competency in an area, attribution theory adds the dimension of perceived personal responsibility (Weiner, Russell, and Lerman, 1978).

Students do not uniformly attribute their success or failure in situations to their own efforts or academic abilities. Attribution theory suggests that individuals who believe their success or failure was caused by stable factors, such as their ability or intelligence, will expect the same outcome in the future, as these personal characteristics will not change. Success is therefore ascribed to ability, leading to feelings of self-competence; failure is ascribed to inability, and feelings of incompetence arise (DeBoer, 1985).

Success or failure may alternatively be attributed to other, less stable factors. Individuals who place outcome responsibility on such factors as the amount of effort they expended, or even luck, may anticipate future changes in performance (DeBoer, 1985). Thus success or failure is not necessarily indicative, in such circumstances, of personal competence.

Attribution theory predicts persistence behaviour is a function of whether people judge their abilities as being due to stable or unstable causes. People who attribute their failure to unstable causes, which may change, are more likely to persist than those who attribute their failure to stable causes, which will not change (Weiner, 1980).

Congruence Theory

Self-efficacy and attribution theory have been the basis for much of the research in the area of student attrition from post-secondary science. However, neither theory attempts to explain the behaviour of students who possesses high self-efficacy beliefs in a discipline, attribute success in that discipline to personal ability (a stable cause), and who, nevertheless fail to persist in their chosen course of study. Under such circumstances, it becomes necessary to consider alternative, or additional, contributors to the attrition process. It has been suggested that one such factor is a congruence between the values of the individual and those of the academic institution (Worthley, 1992).

Congruence theory, as proposed by Holland (1985) suggests that people can be characterized by their resemblance to each of six personality types: realistic, investigative, artistic, social, enterprising and conventional. The environments in which people live can similarly be characterized by their resemblance to six model types in the same categories.

Each individual's personality is hypothesized to be the product of a variety of personal and cultural forces. These forces include peers, parents, social class, culture and the physical environment. Out of interaction and experience with all of these components, people first learn (as a young children) to prefer certain activities; these later become strong interests which lead to a special group of competencies. Heredity also enters into the equation, as it determines people's ability to engage in certain activities (i.e., by virtue of their physical and/or mental capabilities). People's interests and competencies ultimately create a personal disposition that leads them to think, perceive, and act in particular ways (Holland, 1985).

Holland's (1985) six environments - realistic, investigative, artistic, social, enterprising and conventional - are each typified by circumstances which pose special problems and stresses. The investigative environment, for example, is characterized by investigation of physical, biological or cultural phenomena, while the social environment instead provides opportunities that entail the manipulation of others to inform, train, or cure. Each environmental type is dominated by its corresponding personality type (Holland, 1985).

The significance of this theory to the study of students' science persistence is found in Holland's (1985) contention that people search for environments which are congruent with their interests, competencies, and world view. In a congruent environment, people will feel free to exercise their skills and abilities, express their attitudes and values, and take on agreeable problems and roles. Such behaviours are likely to be inhibited by an incongruent environment - one which provides opportunities and rewards foreign to the person's preferences and abilities (Holland, 1985). Therefore, Congruence Theory holds that people's behaviour is largely determined by the interaction between their personality and the characteristics of the environment.

In the domain of science education, then, persistence should be attributable to the congruence between students and the academic environment of the scientific discipline (in this case, the investigative personality and the investigative environment). Similarly, attrition from science might be due to incongruence between personality type and environment (for example, an artistic personality in the investigative environment).

A Theoretical Model of Dropout Behaviour

At this point in the review of the theoretical bases of research in attrition from science it must noted that none of the theories described thus far attempts to account for all aspects of persistence/attrition behaviour. Each deals with some, but not all, of the factors which affect students' decisions to continue with their initial discipline choice, or to select other options. And, just as no preceding theory attempts to encompass every aspect of persistence behaviour, neither are the theories mutually exclusive. It is entirely conceivable that factors described by Self-efficacy and Congruence Theory operate simultaneously in any given educational persistence situation. Indeed, the final theory that this paper will consider, Tinto's (1987) Theoretical Model of Dropout Behaviour, contains features of both.

Tinto's theory has its roots in Durkheim's Theory of Suicide (Tinto, 1987). It also takes, from the field of economics of education, ideas concerning the cost-benefit analysis of individual decisions regarding investment in alternative educational activities (Tinto, 1975).

According to Durkheim (1951), the probability of suicide is increased when individuals lack value integration and collective affiliation with the rest of society. The lack of value integration is the result of people holding values which are highly divergent from society's; insufficient collective affiliation stems from inadequate personal interaction with other members of the community.

Tinto (1975) views college as a social system with its own values and social structures, and sees dropout from that social system as analogous to suicide in the wider society. That is, insufficient interactions with others in the college and insufficient congruency with the prevailing value patterns of the college social system will lead to a lack of integration and consequent low commitment. This will, in turn, increase the probability of dropout.

This Model, then, argues that dropout is a longitudinal process of interactions between individuals and the academic and social systems of the college. Tinto (1987) acknowledges that the interactions need not be on the scale of the entire college; they may occur within one faculty or department (for example, science or biology) within that institution. People's experiences during these interactions continually modify their goals and institutional commitments in ways that lead either to persistence or attrition.

It is possible, however, for the level of individuals' commitment to the goal of college completion and the level of commitment to the college to differ. The Model suggests that low commitment to either domain can lead to dropout. It also argues that, despite low commitment in one domain, sufficiently high commitment in the other may encourage persistence. For example, people who are highly committed to the goal of college completion may persist in studies despite low levels of commitment to the college itself. Thus it is the interplay between individuals' commitment to the goal of college completion and commitment to the institution that determines the persistence or dropout decision (Tinto, 1975).

As specified in the theory of cost-benefit analysis, individual decisions with regard to any form of activity can be analyzed in terms of the perceived costs and benefits of that activity relative to those perceived in alternative activities. This theory states that individuals will direct their energies toward activities that are perceived to maximize the ratio of benefits to costs over a given time perspective. With regard to staying in college, this perspective argues that people will withdraw from college upon the perception that an alternative investment of time, energies and resources will yield greater benefits, relative to costs, over time than will staying in college (Tinto, 1987).

Tinto's (1987) Model of Dropout suggests that these cost/benefit evaluations will be reflected in people's evolving commitments to the goal of college completion and to the institution itself. The commitments, he argues, which reflect their social- and academic-domain integration are themselves the results of individuals' perceptions of benefits (e.g., academic attainments, personal satisfaction) and the costs (e.g., financial, time, academic failures) of college attendance. Thus the theoretical Model takes account of the variety of external forces that may affect people's decisions to stay in college (e.g., good/poor job markets; probability of increased income on degree completion).

Finally, Tinto's (1987) Model accepts that, in both integration into the academic and social systems of the college, and in the evaluation of the costs and benefits of college and alternative activities, the perceptions of the individual are central. Persons of varying characteristics may hold differing perceptions of apparently similar situations; these perceptions will also be influences by the characteristics of the college, or departmental environment (Tinto, 1987).

To summarize, Tinto's theory hypothesizes that persistence is a function of the match between individuals' motivation and academic ability and the institution's academic and social characteristics. This match shapes two underlying personal commitments: Commitment to completing college (goal commitment), and commitment to the institution (institutional commitment). The stronger the commitment to these goals, the greater the probability of persistence (Cabrera, Castaneda, Nora, Hengstler, 1992).

Persistence Research

Academic Performance and Persistence

Students who have expressed an interest in pursuing a science degree may fail to persist for a variety of reasons. Individuals may lose interest in attending university, may develop greater interests in another area of academia, or may be unwilling (or unable) to meet the educational requirements of a scientific degree. Regarding the latter condition, Tinto (1987) has noted that the result of people's experiences in the academic domain may be a re-evaluation of educational expectations and a subsequent withdrawal decision.

The ability to predict who will persist in post-secondary science education has been the focus of a number of research studies. When considering college science, one is intuitively drawn to the thought that students who possess the necessary skills of the various disciplines upon entry (i.e., mathematics and science courses, high intellectual ability) would be those most likely to succeed and persist in their college science experience. If consistent relationships between student characteristics and continued participation in science could be found, educators would be better able to counsel students in their anticipated educational plans, and remediate those who lack the necessary strengths but posses the desire to pursue science (Oliver, 1991).

A study instituted by Campbell and McCabe (1982) is typical of several aimed at determining which factors of college students' backgrounds were significantly related to their persistence in a scientific discipline. Campbell and McCabe (1982) chose to look at all first-semester freshmen computer science majors (n=256) enroled in their first programming course for majors at a large midwestern American university.

Pre-college entrance data on each student was obtained from the registrar. This included SAT-mathematics and verbal scores; the percentile rank in the high school graduating class; the number of completed semesters; the average grade in each of high school mathematics, science and English; and gender.

Academic records of each student were reviewed in the middle of the sophomore year and the student's declared major was noted. The 256 freshmen computer science majors were then reclassified as sophomores into one of three groups: Computer Science, Engineering or Other Science, and Other. The means and standard deviations of the three groups and analysis of variance were used to compare the means of the three groups to each of the entrance variables. For no variable was the Computer Science group distinguishable from the Engineering and Other Science group; thus the comparison of interest was determined to be Computer Science+Engineering and Other Sciences versus Other.

A strong feature of this research design was its method of data collection. As the study was based on information readily available to the authors through the registrar's office, it became possible to sample the entire population of the freshman computer science class, with problems of subjects dropping out of the study, failing to respond to questions, or providing incorrect data eliminated.

However, the sampling technique used in the study was also the source of its major limitation. As the sample was drawn from only one college in only one semester, the results cannot be generalized to a larger population (i.e., students in other colleges), or past the sophomore year for the students in the study.

Nevertheless, the otherwise good design lends credibility to the results. Campbell and McCabe (1982) found that students who persisted in the sciences in their sophomore year had entered college with significantly higher SAT-math and SAT-verbal scores, had ranked higher in their high school graduating class, and had completed more semesters of high school math and science than did those students who left science for a dissimilar discipline.

The research also revealed gender differences in attrition, with 61% of males and only 39% of females persisting in scientific and engineering majors. Further analysis revealed that males had higher SAT-mathematics scores, had completed more semesters of high school science, ranked lower in their high school graduating class, and had lower grades in high school math and English than did females (all significant at $p<.05$ level). Although Campbell and McCabe's (1982) work is limited in its generalizability to other college populations, their results have been supported by subsequent research.

DeBoer (1984a) randomly sampled 30% of the graduates of one college from 1975 through 1977, using college and high school transcripts to determine the number of math and science courses, respective grades, numbers of years of high school math and science completed, average performance, SAT-mathematics and SAT-verbal scores. Data was obtained regarding each student's concentration in science, math, social science and humanities, and results were correlated through analysis of variance.

The results of this study support those of Campbell and McCabe (1982), in that the number of science courses taken in college was significantly related to the number taken in high school. DeBoer's (1984a) research also supports Campbell and McCabe's finding that men took significantly more high school math and science courses than women, but did not perform as well as women in either.

The two works disagree, however, on the relationship between SAT-mathematics scores and persistence in science courses. While both agree that high SAT-math scores are associated with continued participation, DeBoer (1984a) found the correlation significant only for men.

The argument over the value of SAT-math scores as a predictor of science persistence is further complicated by the work of other authors. Ware, Steckler and Leserman (1985) found, in a study similar to both DeBoer's and Campbell and

McCabe's, that achieving outstanding scores on the SAT-math significantly predicted continuation in science for <u>women</u> only, whereas the best predictor of male persistence was having high grades in freshman year science courses. In an attempt to identify student characteristics predicting persistence in engineering, Levin and Wyckoff (1990) utilized admissions records to obtain the SAT-math, SAT-verbal, high school grade point averages and gender of the entering freshman class at the College of Engineering at Pennsylvania State University. Transcripts and registration information provided data on enrolment status after one year. These authors found that grade point average and math and science grades (<u>not</u> SAT-math scores) were significant indicators of persistence in future engineering courses (Levin and Wyckoff, 1990).

Gender differences appear to influence both the type and number of science courses students bring with them to college. As already noted, both Campbell and McCabe (1982) and DeBoer (1984a) found that males entered college with significantly more high school science courses than women. This is further supported by the work of Marion (1988) in investigating gender differences in selecting undergraduate majors. Marion (1988) found that males took an average of 0.2 standard deviations more advanced science courses than females.

DeBoer (1984a) found that gender differences in science participation could be attributed primarily to differential entry into physics, which was taken by 71% of the male science students in his study but only 41% of female science students. A study by Lips (1988) agrees that males are more likely to enter university with physics credits, but found that females were more likely than males to enter with credits in math, chemistry and biology.

The difficulty in using previous educational experience and standard measures of achievement (e.g., high school courses taken, percentile rank, SAT-math scores) to predict who will persist in science is highlighted by two studies on dropouts from college physics classes. Wollman and Lawrenz (1984) found that neither records of past performance (grade point average, high school percentile rank, ACT scores) nor a measure of math reasoning items and math skills given as a pretest before a physics course were helpful in distinguishing characteristics of completes and dropouts.

Hudson (1986) similarly found that three math instruments - a test of math skills, one of proportions and one of word problem symbols - were not useful as indicators of completes and dropouts in a college physics course.

In both studies the researchers administered math pretests to all students entering the freshman physics course at their respective universities (Hudson, n=152; Wollman and

Lawrenz, n=483). All instruments were subjected to validation by other faculty members. Upon completion of each physics course the respective authors compared the degree of correlation between math ability (as indicated by pretest results) with each student's course persistence behaviour.

Both of theses studies appear to call into question the importance of math skills in predicting persistence in physics. However, both the Wollman and Lawrenz (1984) and the Hudson (1986) research possess a flaw which calls their results into question. The alpha reliability of the Wollman and Lawrenz instrument was only 0.5; Hudson's three instruments showed Kuder-Richardson reliabilities of 0.87 (math skills), 0.59 (proportions) and 0.48 (word problems). Such low reliability scores on three out of the four testing instruments in question call both authors' conclusions about the lack of association between math skills and physics persistence into question.

Attitudes and Persistence

As the preceding section has shown, pre-college measures of academic ability, as well as tests devised to assess the mathematical skills considered essential for persistence and success in science, have provided mixed results as indicators of students' continued participation. While certainly a factor in persistence, academic ability must be considered as only one part of a continuum of student characteristics which influence their relationship with science education.

Student attitudes have also been considered as contributors to persistence or attrition behaviour within the sciences. This student characteristic appears to be particularly subject to gender differences; all the studies surveyed for this document found it necessary to differentiate between male and female attitudes toward various aspects of the science education experience.

Neither gender identifies science as an exclusively male activity (Hough and Piper, 1982; Lyson and Brown, 1982); however, females tend to be less stereotypic in their attitudes toward science (Levin and Klindienst, 1983). Men tend to view science as a male domain to a much greater extent than do women (Steinkhamp and Maehr, 1984; Levin and Klindienst, 1983).

While both men and women appear to agree that science is open to all, some research implies that both sexes may have preconceptions about which sciences males and females are best suited to enter. Lips (1988) found that significant gender differences ($p<.05$) existed for perceived encouragement in science among same-sex peers. Females perceived more same-sex encouragement to enter biology, whereas males received more encouragement from same-sex peers to enter computer science, math, and physics. Lips (1988) also noted that females perceived more encouragement from their opposite-sex peers to engage in the study of biology.

This research tends to suggest that subtle forces may be at work regarding the direction males and females take in their future studies in science. Students appear to be differentially supporting entry into specific science disciplines on the basis of gender. There is also evidence to suggest that the perception of the degree of difficulty experienced in science is gender-specific.

This evidence comes from a well-designed study by Lips (1988), in which data were collected from 253 female and 235 male randomly-selected first year university students. Students completed a questionnaire which measured intent to enrol in science and mathematics courses, a number of attitudes related to math and science, as well as demographic information. Data on high school academic background, as well as subsequent information on course credits received during first year, and courses attempted during second year were also obtained for these participants. These data were used to examine gender differences in a number of math- and science-related attitudes.

Lips (1988) discovered that the female students in her study were more likely than the men to have entered university with entrance-level credits; an ANOVA found no gender differences in achievement or self-rated performance in math in high school. Yet male students had significantly higher self-expectations for performance.

Similarly, Drew (1992) used student's scores on the quantitative portion of SAT as a measure of math ability and discovered that, among high-aptitude women, only 32.6% considered themselves in the top ten percent; 53.5% of high-aptitude men correctly placed themselves at this level.

In a study by Boisset, Mackenzie and Sidorenko (1989) female students, both persisters and non-persisters, had a significantly higher overall average than their male counterparts. Yet the reason for transferring out of science - "failure" or "not doing well" - was cited by 83.4% of female transferees. Only 68.9% of male transferees cited these reasons, despite data which showed that, on the average, females had higher grades than males at the time of their transfers out of science.

The results of the studies by Lips (1988), Drew (1992) and Boisset, Mackenzie and Sidorenko (1989) appear to indicate that females are more critical judges of their personal abilities in math and science. They are less likely than men to rate themselves as among the top achievers (even when evidence exits to support such claims), and may judge their academic performances more harshly than men do their own.

Hackett and Betz (1981) have argued that students' beliefs about their math/science capabilities are important influences on their decisions to persist in a science concentration. The significance of the findings of Lips (1988), Drew (1992) and Boisset, Mackenzie and Sidorenko (1989) is that prospective women science majors may be facing a demand to prove themselves capable in an area where their abilities will be repeatedly challenged. It has been suggested that these women may subsequently develop extremely high standards for themselves as a prerequisite for staying in science, and that their beliefs about the level of ability and performance required for success in science are inflated (Ware, Steckler and Leserman, 1985).

Self-Efficacy and Persistence

A major component of students' attitudes about science is their personal belief about their ability to cope effectively with the demands that such a challenging educational choice will place on them. According to self-efficacy theory (Bandura, 1982), beliefs about personal competence may determine the level of persistence expressed when a difficult course of action is undertaken. In their extension of this model Hackett and Betz (1981) have specifically hypothesized that efficacy expectations are related to the degree of persistence in college science majors.

To test this hypothesis, Betz and Hackett (1983) conducted a study which measured the math self-efficacy expectations, attitudes towards math, and sex-role orientations of 114 undergraduate students through three instruments: a math self-efficacy scale; a revised Fennema-Sherman Mathematics Attitude Scale; and the BEM Sex Role Inventory. A questionnaire requesting information concerning math background and college major was also administered, while American College Test Math Usage scores were obtained from university records.

A stepwise multiple regression analysis of the data indicated that students reporting stronger self-efficacy expectations were significantly ($p<.05$) more likely to select science-based college majors than were students reporting weaker expectations with regard to math (Betz and Hackett, 1983). Additionally, the math self-efficacy expectations of college females were found to be consistently and significantly weaker than those of males in all areas looked at in the study (i.e., math tests, college courses, and math problems) (Betz and Hackett, 1983).

These findings represent an important contribution to the understanding of students' persistence in the sciences. Although the results are not generalizable due to the sample selection (i.e., one segment of the undergraduate population of one college) they could, if supported by further studies, begin to explain some aspects of science attrition. That is, students who have high self-efficacy expectations regarding math may not avoid the prerequisite coursework necessary for continuation in the sciences. Extending this idea, the finding that women have lower math self-efficacy expectations may partially explain why this gender appears to favour work in the biological sciences when science is chosen as a major. The biological sciences may be perceived as generally less math-based than the physical sciences.

These, however, are speculations. The results of Betz and Hackett's (1983) work demand that further research be carried out in the study of the relationship between self-efficacy and science persistence, both to respond to these speculations and to provide support for the research already performed. Support is especially important in light of one weakness; Betz and Hackett utilized only volunteer subjects, all of whom were enroled in introductory psychology courses, and who were paid for their participation. Such obviously biased sampling of the university population would suggest that the results of this study are to be relied upon only cautiously.

Support for the relationship between self-efficacy expectations and science persistence does, however come from other researchers. A 1984 study by Lent, Brown and Larkin found that students who reported high self-efficacy expectations regarding their ability to complete scientific majors persisted longer in those majors than students who reported low ratings. These results, however, cannot be relied upon with any certainty, again because of the sampling technique. Lent, Brown and Larkin (1984) tested only 42 students, and twice as many males as females (i.e., 28 males, 14 females).

Further support for the results of both preceding studies can be obtained from a 1987 work of Lent, Brown and Larkin in which a much larger sample (105 people) was used. Again it was determined that self-efficacy expectations were powerful predictors of persistence in scientific and technical majors over a one year period.

When self-efficacy expectations are examined, it must be acknowledged that students are not academically identical. Their aptitudes and abilities differ, just as do their self-efficacy expectations. A moderate, but significant, correlation between objective measures of academic ability (e.g., SAT-Math scores, high school rank) and self-efficacy scores has been observed by some researchers (Lent, Brown and Larkin, 1984; Betz and Hackett, 1981). The strength of students' beliefs in their ability to succeed in a variety of science and engineering studies has been found to affect the persistence of low aptitude students. Lent, Brown and Larkin (1988) found that people with low aptitude/low self-efficacy expectations persist in science and engineering majors for significantly less time than low aptitude/high self-efficacy individuals.

If high self-efficacy expectations can enhance persistence in academically weak students, one would expect that enhancing the self-efficacy beliefs of academically qualified students would promote their increased persistence in science. Although no studies supporting this hypothesis were found in this review of the literature, such a determination might prove especially important with regard to gender and persistence in science.

Women and men show distinct differences in both their levels of persistence and their self-efficacy expectations in science. Women terminate their quest for a science education in greater numbers than men, despite equal or superior abilities (Boisset and Sidorenko, 1989; Lips, 1988; McDade, 1988; DeBoer, 1984a).

The two genders also differ in what might be considered as another component of self-efficacy - the attribution of success or failure to internal or external causes. Both men and women perceive science and math as difficult (Ware, Steckler and Leserman, 1985). Men, however, tend to place the responsibility for the difficulties they experience outside themselves (i.e., citing difficult course materials or poor instructor performance as the reason for their problems). Women, alternatively, fix the blame internally, citing lack of ability as the reason for perceived poor achievement (Boisset, Mackenzie and Sidorenko, 1989; McDade, 1988; Ware, Steckler and Leserman, 1985; Kahle, 1983). As these attributions are not based on empirical evidence (i.e., differential test scores between men and women), it becomes important to explore the form attribution-based attrition experiences take in the minds of male and female students leaving science.

One study which did just this was a qualitative research project carried out by Laurie McDade in 1988. Thirty science dropouts from one university were extensively interviewed. The students were asked to talk about their high school and college experiences and the event of their attrition. These interviews were coded to defined anthropological descriptors for domain analysis, a standard ethnographic technique (Gay, 1987).

McDade's (1988) findings are in agreement with previously cited quantitative studies on self-efficacy and attribution. All the female science-leavers she interviewed had been high achievers in high school, but their college grade point average was significantly lower than that of the graduating college group. All identified their poor performance as a challenge to their self-image; they saw their self-selected attrition as evidence of their personal inability to achieve in science.

Men, in contrast, did not see their lack of success in science as a striking statement of their overall competence. They interpreted their decision to leave science as a process of self-development and assessment of their own potential (McDade, 1988). In other words, men did not feel they were leaving science because of failure; they merely felt they would have more opportunities for success in another field of endeavour.

Although these results are not generalizable to the science populations of other universities, they do concur with the findings of the preceding quantitative studies (Lent, Brown and Larkin, 1984, 1987; Betz and Hackett, 1983). Further support also comes from the results of a descriptive questionnaire submitted by Boisset, Mackenzie and Sidorenko (1989) to all science entrants in a small Quebec college. Of those who, on follow up, indicated they were transferring out of science, "not doing well" was the reason cited by 83.4% of females and 68.9% of males. More females (19.4%) than males (5.4%) attributed this condition to a lack of personal ability.

Congruence and Persistence

Certainly, self-efficacy expectations explain much of the persistence behaviour of students in science. However they do not account for science students who, although academically well-prepared and in possession of high self-competence beliefs, make a decision to leave the study of science. In such cases it is possible that individuals' decisions about persistence in science is affected by the degree of their integration into the social system of the scientific discipline.

Science faculties create an academic environment which is not like that of other disciplines. The culture is characterized as being very competitive and task-oriented (Becher, 1987). This competitive nature of science practice may serve to exclude many students who might otherwise be attracted to the discipline (Rosser, 1990). Indeed, McDade (1988) found that female non-persisters strongly believed that the atmosphere of competition greatly contributed to their decision to leave their science majors.

In a 1992 study, Milem and Astin examined the similarities and differences between science, math, and engineering faculties and the faculties of other (non-science) disciplines. The research drew upon information with regard to demographics, as well as the roles, classroom practices, personal goals, attitudes, and behaviours of members of each faculty. The data were collected as part of a U.S. national survey of 432 colleges during the fall and winter of 1989. Of 91,000 faculty surveyed, a response rate of 55% was achieved.

In comparing science faculties with those in other fields Milem and Astin (1992) found that science faculty exhibited a greater degree of authoritarianism and hierarchical approaches in their classroom behaviours. They were less likely to be student-centred in their pedagogy and were more likely to be interested in research than teaching. They were also more likely than members of other faculties to feel that the quality of students is poor.

The results of the Milem and Astin (1992) work, generalizable due to the scope of the sample, are supported by more limited studies. Tobias (1990) found that members of scientific faculties tend to possess shared values and look for certain behavioral attitudes in students. They tend to believe it is their responsibility to teach students the perspectives peculiar to their discipline and to provide them with regular feedback on the degree to which their work meets institutional standards (Belenky, Clinchy, Goldberger and Tarule, 1986).

Thus science departments may be considered unique subsets of the total college social system. These micro-systems possess their own standards, values and expectations - consequences of the common attributes of the faculty members. There are grounds to suggest that the attrition behaviours of many academically qualified students may be the result of an incongruence between the intellectual values that characterize the individual and those of the various members of the science faculty (Tinto, 1987). Gender differences are of particular interest in this area, as many researchers postulate that males and females differ in cognitive styles and values

(Worthley, 1992; Head and Ramsden, 1990; Lips, 1985; Gilligan, 1982; Yanico and Hardin, 1981).

Females are reported to be more global, holistic thinkers, while males tend toward serial, analytical patterns (Head and Ramsden, 1990). In general, the cognitive style of male students is more like that found in science workers; female styles tend to differ (Head and Ramsden, 1990; Gilligan, 1982).

In a 1982 study Gilligan demonstrated that, when confronted with a science-based moral dilemma, males tended to make a direct approach to the problem and depended on a rule or procedure to provide the basis for their decision. Females, however, had difficulty in making a decision, as they felt that they had an inadequate understanding of the situation. They desired further information in order to ascertain that all possibilities had been considered.

These results have been disputed by Friedman, Robinson and Friedman (1987) who found, in a test of Gilligan's hypothesis, that neither gender nor sex-differentiated personality attributes could reliably be associated with the type of moral judgements that individuals make. The generalizability of their experimental process, however, can be questioned on the basis of their sample selection: 101 psychology students drawn from one liberal arts and one community college. This narrow demographic segment makes it conceivable that their results are indicative of characteristics unique to psychology students. At any rate, the results are not generalizable to either the general college population, nor even to other science students.

In contrast, a study on persistence and congruence of science values was conducted by Worthley (1992). The author selected all students enroled in one college who had a 630 minimum SAT-Math score, 7.5 minimum high school math/science courses, and who had indicated an interest in a major in science. Of two hundred forty seven students contacted, one hundred seventy-three agreed to participate in the study.

Worthley administered an adapted Science Issues Survey to the students. They were asked to complete two identical versions of the measure - one from their own point of view, and one as they believed a scientist would. Students rated their endorsement of a "care" or "justice" solution to science-based moral dilemmas along a seven point scale. Declared science major at the time of testing was used to divide the sample into persisters and nonpersisters.

The results support the hypothesized association between value congruence and science persistence. All students believed that "justice" was the dominant perspective in science. Non-persisters of both genders exhibited a prominent personal "care" perspective - one that is incongruent with the "justice" bias attributed to science. Persisters demonstrated congruence, but this congruence was achieved differentially for men and women.

Male persisters appeared congruent with science in the shared value bias toward "justice"; female persisters showed a value perspective for both self and science that is not overwhelmed by either "justice" or "care" concerns. That is, female persisters did show a personal bias toward "care" and attributed a bias toward "justice" to science. However, compared with other groups, the degree of bias in both perspectives is small (Worthley, 1992).

The limitations of the sample prevent generalization to all academic institutions. However, the results do suggest that students whose values are congruent with their perceived values of science, or those whose values do not strongly conflict, are more likely to persist in this discipline.

Summary of Research

Attrition Theory

The three theories outlined in this paper are by no means the only theoretical explanations of student attrition behaviour. Tinto (1987), Bandura (1977) and Holland (1985) have, however, provided the basis for most of the research reviewed here. Hence they are featured in some detail.

The theories proposed by these three workers are not mutually exclusive. All make inferences about the theoretical relationship between the student and the educational institution, and participation in that institution. Bandura, for example, proposed that perceptions of personal efficacy will cause people to select environments in which they will be competent. Holland similarly argued that people search for environments which are congruent with their interests, attitudes, competencies and world view. Tinto hypothesized that persistence is a function of the match between an individual's motivation and academic ability, and the institution's academic and social characteristics. Thus, all three theorists related academic dropout behaviour to the degree of "fit" between the individual and the educational institution.

Although Tinto, Bandura and Holland addressed their theories to the wider concern of student college attrition, workers in the area of student participation in science have been able to apply these authors' work to this narrow domain. As the literature review revealed, the majority of studies which addressed the issue of student persistence in science made inferences from the observed relationships between students' characteristics and their participation in science (Oliver, 1991).

Academic Performance and Persistence

Results of investigations into the relationship between the degree of student ability in science and mathematics upon entering college and their subsequent persistence in a science major were mixed. Math ability appeared to be a common predictor of subsequent college persistence (Levin and Wyckoff, 1990; Ware, Steckler and Leserman, 1985; DeBoer, 1984b; Campbell and McCabe, 1982), although differences existed among authors as to whether this ability was best measured by SAT-math scores or high school math grades.

Results on math ability/persistence predictors by gender were inconclusive. Some studies found SAT-scores were predictive of persistence only for males (DeBoer, 1984b), while others found them predictive only for females (Ware, Steckler and Leserman, 1985). There was also some indication that the number of science courses taken in high school was significantly related to later science persistence in college (DeBoer, 1984b; Campbell and McCabe, 1982); that females entered university with significantly fewer courses in science than males (Marion, 1988; Campbell and McCabe, 1982); and that females would be more likely than males to lack physics credits in particular (Lips, 1988; DeBoer, 1984b).

Attitudes and Persistence

Male and female students did not differ in their belief that scientific domains are open to both genders. However, differential peer encouragement indicated that students had gender-specific attitudes as to which science was appropriate. Males were encouraged to enter physics, computer science and math; females to enter biology.

With regard to attitudes toward ability in science, males tended to possess a higher self-perception of their performance than did women, in spite of equal or superior actual performance by females.

Self-Efficacy and Persistence

High self-efficacy expectations in math and science appeared to be correlated with a greater degree of student persistence in science (Lent, Brown and Larkin, 1987, 1984; Betz and Hackett, 1983) even among lower-aptitude students (Lent Brown and Larkin, 1988, 1984; Betz and Hackett, 1981). Female students had lower self-efficacy expectations than male students in science and were more likely to attribute their perceived lack of competence to inability (Boisset, Mackenzie and Sidorenko, 1989; McDade, 1988; Ware, Steckler and Leserman, 1985; Kahle, 1983).

Congruence and Persistence

It had been suggested that the characteristics of members of science faculties - their values, attitudes and expectations - have created an academic environment which is incongruent with the intellectual values of some individuals (Tobias, 1990; Tinto, 1987; Belenky, Clinchy, Goldberger and Tarule, 1986). Some research showed results which supported the hypothesis that incongruence between student values and the perceived values of the science discipline discouraged science persistence for those individuals (Worthley, 1992; Gilligan, 1982).

Chapter 3

Method

Introduction

The preceding review of the literature has touched upon many of the factors which may affect students' college persistence decisions. Some of these factors (self-efficacy expectations and attribution behaviour, for example) are largely internally developed characteristics of each student and therefore *may* be relatively independent of influence by the students' faculty of choice. Others, such as academic and value integration, are dependent upon the interaction between students and their chosen faculty. As this study focused on the persistence behaviour of students within the biology faculty of Memorial University, the decision was made to centre research upon those components which the social system (Tobias, 1990) the students have entered may demand: academic and value integration. It is acknowledged that the choice not to consider self-efficacy and attribution in the analysis may have somewhat limited the ultimate degree of prediction of persistence behaviour. However, these are factors which may certainly be assessed in any future work by this author.

In order to obtain the data required for this study, three separate measures were utilized for each student: (a) a record of academic achievement in biology; (b) an assessment of personal values and perceptions of scientists' values in science-based moral issues and; (c) information regarding gender, year of study, and persistence (or intention to persist) towards the completion of a biology degree. Definitions of terms used in the study, as well as descriptions of the selection of participants, the instruments used and the methods employed are included in this chapter.

Definition of Terms

Academic integration.

According to Tinto (1987), students' academic integration within an institution is a function of the match between their academic ability and the institution's academic characteristics. He also states that this match need not be on the scale of the entire college; it may occur within one faculty or department (Tinto, 1987). Additionally, within the Theoretical Model of Dropout Behaviour, academic performance is considered as an indicator of academic integration (Cabrera, Castaneda, Nora and Hengstler, 1992; Tinto, 1987).

For the purposes of this study, academic integration of Biology majors of Memorial University of Newfoundland with their Biology Department has been defined within the parameters of Tinto's (1987) Model. That is, students' academic performance in biology will be considered as an indicator of their academic integration within the Biology Department.

Therefore, academic integration will be measured by the average biology scores students have attained during their time as biology majors at Memorial University (i.e., while they were within their "chosen college system"). Higher average scores will be considered indicative of greater academic integration and lower average scores as an indication of diminished academic integration with Memorial University's Biology Department.

Value integration.

Value integration will be defined with reference to Worthley (1992), who uses the term "congruence", as the relation between students' personal values regarding science-based moral issues and their perceptions of these values within the faculty of Memorial University's Biology Department. Students whose personal values do not conflict with their perceived values of scientists will be considered well-integrated with the Biology Department; students whose expressed personal values are divergent from their perceptions of scientists' values will be considered poorly integrated.

Science.

The definition of "science" will include the fields of mathematics, physical or biological sciences, computer science, engineering, architecture, and agriculture. This categorization is consistent with the fields of study that the National Science Foundation considers as science (Hilton, 1988).

Persistence Behaviour.

It must be acknowledged that the declaration of a biology major is, for some students, an interim measure while waiting to enter another area (for example, medicine, nursing, or pharmacy). There is also evidence to suggest that science students, as a group, differ from students who pursue non-science interests (Campbell and McCabe, 1982). Because of these factors, persistence behaviour will be defined in three ways:

1. Biology Persisters - students who have persisted long enough to obtain their biology degree, or biology undergraduates who intend to persist long enough to do so.

2. $\text{Nonpersisters}_{(\text{science})}$ - students who have dropped, or intend to drop biology in favour of another science

3. $\text{Nonpersisters}_{(\text{other})}$ - those who have left, or intend to leave biology and the sciences completely.

Academic Year.

Memorial University recognizes only five academic years; students who persist in their studies any longer than this remain classified as Year 5 by the Institution. In this investigation, academic year is defined as year of study as identified by the student. As such it includes the categories of Graduated and Dropped Out (for students who are no longer attending the University).

Participant Selection

The population from which this study's sample was drawn consisted of all the 1044 Memorial University students who had declared a biology major during the five year period between 1988 and 1992. From this group, the Office of the Registrar selected a random sample of 200. A list of these students' names, permanent addresses and telephone numbers was subsequently provided to this researcher.

The initial approach to prospective participants was made by telephone. From the original group of 200, 135 people were actually contacted. Fifty-five potential participants either could not be reached after several telephone attempts, had moved without forwarding addresses, or had changed their telephone numbers from the "permanent" record held by the Registrar's Office. The families of a further ten students responded that these people were working out of province during the period of the study and could not be reached.

During the initial telephone communication students were informed of their random selection, given a brief outline of the purpose of the research, and asked if they would be willing to participate. Of the 135 people contacted by telephone, 131 agreed to participate in the study. Four people refused.

Data Collection Instruments

Academic Records

The record of each student's academic achievement in biology was provided by the Office of the Registrar of Memorial University. Upon submission of the student identification numbers of those who had agreed to participate in the research project, transcripts of final grades in each biology course completed were released. To ensure student confidentiality, all results were identified only by student number. Individual's biology grades were then averaged in order to provide an indication of their academic integration with the requirements of the biology department.

Science Issues Survey

The second measure utilized in this research was the Science Issues Survey - an instrument developed by J. S. Worthley (1992) to assess individuals' personal values regarding science-based moral issues, as well as their perceptions of scientists' values in these same dilemmas. It was used in this context, with the author's permission, to evaluate each participant's social integration within the biology department of Memorial University.

The Science Issues Survey consists of six dilemmas based on current issues in contemporary science: genetic engineering, the Challenger disaster, euthanasia, limiting access to medicare, AIDS research, and Star Wars research.

Each dilemma is followed by six decision items. Three of these reflect Gilligan's "care" perspective (Gilligan, Ward and Taylor, 1988; Gilligan, 1982) , and are therefore focused on responsiveness, avoidance of harm, subjectivity, and interdependence in making choices (Worthley, 1992). The remaining three decision items are based on Kohlberg's (1981) description of moral development, and focus on rights, rules, objectivity, and autonomy of choice (Worthley, 1992). Worthley has called these three items "the justice orientation".

Reliability of the "care" and "justice" perspectives was established by Worthley at 90%. Internal consistency, determined by Cronbach's alpha for each of the four self/science X justice/care combinations across the six dilemmas, was high. The alphas were reported as .88 (self/care), .79 (science/care), .87 (self/justice), and .88 (science/justice) (Worthley, 1992).

The complete Survey incorporates two identical sections of the six dilemmas, each with a separate instruction sheet. In one section, a cover sheet asks participants to consider the dilemmas and decision items from a personal point of view; in the other section they are asked to think about the issues as they feel a scientist would. In this study, half of the Surveys were constructed with the "personal" point of view as the first response section while the rest were constructed so that the "scientist" point of view began the Survey. This was done in order to control for potential variations in responses due merely to the position of the "personal" or "scientist" section in the questionnaire (Gay, 1987).

Students were asked to rank their response to each decision item on a seven point scale, with #1 corresponding to "Very Unimportant", #4 being neutral, and #7 classified as "Very Important". (See Appendix 1). Each position on this continuum had an associated score value. The neutral attitude was assigned a score of 0, the "unimportant" attitudes negative scores, and the "important" attitudes positive scores.

The mean ratings for the eighteen care items and the eighteen justice items were obtained separately for the "personal" and "scientist" perspectives. This resulted in a mean for "care" and a mean for "justice" in the personal, or Self Perspective, as well as a mean for "care" and a mean for "justice" in the Science Perspective. These were used to compute two different scores (care - justice): one for the Self Perspective, and one for the Science Perspective. A positive value was considered indicative of a "care" bias; a negative value indicated a "justice" bias. The strength of either bias corresponded to its distance from the neutral value of 0. These scores will hereafter be referred to as Value Bias$_{(self)}$ and Value Bias$_{(science)}$.

With the permission of the author, changes were made in the dilemmas (where appropriate) to put them in a Canadian context. For example, the genetic engineering dilemma was placed in a Canadian, rather than an American university. Similarly, references to Medicare and the Cancer foundation mention the Canadian equivalent of the American institutions named in the original work. No other modifications were made in the instrument. The Science Issues Survey may be found in Appendix 1.

Personal Information Survey

The third measure used in this study, a personal information questionnaire, was placed between the "personal" and "scientist" sections of the Science Issues Survey each student received. This one-page survey gathered important individual data; details which allowed each participant to be categorized by gender, academic year, and persistence in biology.

Two questions in this section were key in determining whether or not the student was considered as "persistent" in biology. Question 4 requested the respondent's current academic major, and thus allowed Biology persisters and nonpersisters to be immediately identified. It was possible, however, for a biology major to have recently made a decision to pursue another path. Question 5, therefore, asked if the participant *intended* to continue in the current major. This allowed the classification of those who were listed as biology majors, but who had made a decision to withdraw, as nonpersisters.

The questionnaire also asked students to give their subjective ranking of their own academic standing in biology (question #6), their perception of the standing of their biology classmates (question #7), and their satisfaction with their academic standing (question #8). Responses were made on a seven point scale, with #1 indicating a low mark or displeasure with academic standing, #4 being neutral, and #7 a high mark or pleasure with academic standing. Students were also given (in question 9) the opportunity to express, in their own words, why they had chosen the level of academic satisfaction indicated in question 8. The Personal Information Survey is found in Appendix 2.

<u>Survey Administration</u>

Administration of the Science Issues Survey took place during the Spring semester of 1993. As this was a time period when many full-time university students had returned to their homes for the summer and as the sample included students from all over the Province of Newfoundland and Labrador, it was necessary to conduct the Survey through the mail.

A Science Issues Survey "package" was mailed to each of the people who had agreed to participate in the study. This package consisted of four components. A cover letter explained the purpose of the study and the extent of the student's involvement, stressing that participation was voluntary and could be withdrawn at any time. In addition, the letter provided information which allowed the student to contact the researcher (in case of questions or a late withdrawal decision). The Science Issues Survey (with inserted personal information questionnaire) was accompanied by a stamped, return-addressed mailing envelope. Finally, a "Request for Study Summary Form" was provided, to allow the researcher to compile a mailing list of those who wished to receive information on the results of the study on its completion.

Fifty Science Issue Surveys were returned within the first two weeks of sendout. After this period, a "return reminder" telephone call was placed to all participants, and twenty-eight more Surveys were received during the second two-week period.

While seventy-eight Surveys were returned, not all could be utilized. Two participants returned their Surveys with the message that they had decided to withdraw from the study. Five students completed only the first half of the Survey (these results were subsequently discarded). Consequently, data from seventy-one 1988-1992 declared biology majors was available for the ensuing statistical analyses. As thirty subjects are considered to be the minimum needed to establish the existence or nonexistence of a relationship for a correlational study of this kind (Gay, 1987), the sample should prove to be adequate.

Chapter 4

Data Analysis and Discussion

Introduction

The purpose of this chapter is to present, interpret and discuss the results of the statistical analyses of the data collected in the light of the underlying theory and stated hypotheses. Several statistical procedures were used. First, descriptive statistics were generated for the number of persisters/nonpersisters, student distribution by year of study, students' personal perception of average mark, perception of others' average marks, and personal satisfaction with mark.

Second, two-way analysis of variance (gender X persister) was used to determine whether or not differences existed in the average biology marks of Biology Persisters, $\text{Nonpersisters}_{(\text{science})}$, and $\text{Nonpersisters}_{(\text{other})}$. Two-way ANOVA was also used to assess the differences between male and female students (Biology Persisters, $\text{Nonpersisters}_{(\text{science})}$ and $\text{Nonpersisters}_{(\text{other})}$) on the scores of Value $\text{Bias}_{(\text{self})}$ and Value $\text{Bias}_{(\text{science})}$. In analysis of variance, the variability of the observations within the group (around the mean) and the variability between the group means were observed in order to determine whether the between-group variance was significantly greater than the within-group variance (Borg and Gall, 1983).

Two-way ANOVA is suitable for analysis of data from studies which give rise to more than one dependent variable (Haase and Ellis, 1987) as it simultaneously measures the effects of two independent variables as well as the interaction of the variables (Coldeway, 1989).

Third, the differences in Value Bias$_{(self)}$ and Value Bias$_{(science)}$ scores of Biology Persisters, Nonpersisters$_{(science)}$ and Nonpersisters$_{(other)}$ was evaluated. A repeated-measures ANOVA (persister group X value bias) was completed to find the MSerror for the repeated measure. That MSerror was then used to calculate the t-statistic comparing Value Bias$_{(self)}$ to Value Bias$_{(science)}$ for Biology Persisters, Nonpersisters$_{(science)}$ and Nonpersisters$_{(other)}$. The repeated measures design removes the variability due to individual differences from the estimate of experimental error (Coldeway, 1989)

Finally, Discriminant Function Analysis was used to determine the relationship among the dependent variables of Biology Persisters, Nonpersisters$_{(science)}$, and Nonpersisters$_{(other)}$ -- and the independent variables of sex, average biology mark, Value Bias$_{(self)}$, and Value Bias$_{(science)}$. Discriminant analysis is a statistical procedure related to regression which uses a number of predictor variables to classify subjects into two or more distinct groups. The procedure results in an equation where the scores on the predictors are multiplied by weights to permit classification of subjects into groups (Ary, Jacobs and Razavieh, 1990).

Results and Interpretation

Descriptive Statistics

Seventy-one of the contacted 136 biology majors participated in the study. The random selection procedure used in this study drew its sample from the pool of students who had been registered as biology majors during the period from 1988 to 1992. At the time the sample was taken, thirty-eight of the original seventy-one students had persisted, or had declared an intention to persist, in biology. Sixteen of the original seventy-one students had changed their academic major to another science; and sixteen students had made the decision to leave the sciences altogether (See Table 4.1). These three groups will hereafter be referred to as Biology Persisters, $\text{Nonpersisters}_{(\text{science})}$, and $\text{Nonpersisters}_{(\text{other})}$, respectively.

Thirty-nine of the study participants were male; thirty-two were female. Twenty males and eighteen females were identified as Biology Persisters, ten males and six females as $\text{Nonpersisters}_{(\text{science})}$, and eight males and eight females as $\text{Nonpersisters}_{(\text{other})}$ (See Table 4.1).

The academic year of the participants ranged from Year 2 to Year 9. The greatest number of Biology Persisters (ten)

Table 4.1

Number of Male and Female Biology Persisters, Nonpersisters$_{(science)}$, and Nonpersisters$_{(other)}$

	Biology Persisters	Nonpersisters (science)	Nonpersisters (other)	Total
Male	20	18	8	38
Female	18	6	8	32
Total	38	24	16	70

Number of missing observations: 1

were found in years 3, 4, and Graduated; Nonpersisters$_{(science)}$ (five), in year 5; and Nonpersisters$_{(other)}$ (three), in years 3 and 4. Data on academic year is contained in Table 4.2.

Students were also asked to rate their perceptions of their own and others' biology averages on a 7 point scale (from very low to very high), as well as their level of satisfaction with their own biology averages. Biology Persisters and Nonpersisters$_{(science)}$ tended to perceive their own biology averages at the high end of the 7 point scale (i.e., above 4). Nonpersisters'$_{(other)}$ ratings were inclined to cluster in midscale - neither high nor low. Data on students' personal perceptions of their biology averages is found in Table 4.3.

All groups - Biology Persisters, Nonpersisters$_{(science)}$, and Nonpersisters$_{(other)}$ - perceived other students' biology averages equally between the midrange and high end of the seven point scale. Data on students' perceptions of others' biology averages is found in Table 4.4.

Finally, in their ratings of personal satisfaction with their biology averages, all three groups of students showed a marked division between the high and low ends of the satisfaction scale. Both Biology Persister and Nonpersister$_{(science)}$ groups, however, contained more students who

Table 4.2

Number of Biology Persisters, $\text{Nonpersisters}_{(science)}$, and $\text{Nonpersisters}_{(other)}$ in Each Academic Year

Academic Year	Biology Persisters	Nonpersisters (science)	Nonpersisters (other)
2	4		1
3	10	2	3
4	10	2	3
5	3	5	2
6	1	1	2
7		2	1
8		1	
9		1	
Graduated	10		2
Dropped Out		2	2
Total:	38	16	16

Number of missing observations: 1

Table 4.3

Biology Persisters', Nonpersisters'$_{(science)}$, and Nonpersisters'$_{(other)}$

Perceptions of Personal Biology Average

Perception of Average	Biology Persisters	Nonpersisters $_{(science)}$	Nonpersisters $_{(other)}$
1			1
2	1		
3	2	3	3
4	10	4	8
5	17	4	2
6	8	4	2
7		1	
Total	38	16	16

Number of missing observations: 1

Students' Perception of Personal Biology Average was rated on a seven point scale: 1 = very low perceived biology average; 4 = neutral; 7 = very high perceived biology average

Table 4.4

Biology Persisters', Nonpersisters'$_{(science)}$, and Nonpersisters'$_{(other)}$

Perceptions of Others' Biology Average

Perception of Mark	Biology Persisters	Nonpersisters $_{(science)}$	Nonpersisters $_{(other)}$
1			
2			
3	1	2	1
4	18	6	8
5	11	6	6
6	8	1	1
7		1	
Total	38	16	16

Number of missing observations: 1

Students' Perception of Others' Biology Average was rated on a seven point scale: 1 = very low perceived biology average; 4 = neutral; 7 = very high perceived biology average

Table 4.5

Biology Persisters', Nonpersisters'$_{(science)}$, and Nonpersisters'$_{(other)}$

Satisfaction with Personal Biology Average

Level of Satisfaction	Biology Persisters	Nonpersisters (science)	Nonpersisters (other)
1	4	1	3
2	6	4	6
3	4	1	4
4	3		
5	14	2	1
6	7	5	1
7		3	1
Total	38	16	16

Number of missing observations: 1

Students' Satisfaction with Personal Average was rated on a seven point scale:

1 = very dissatisfied with biology average; 4 = neutral; 7 = very satisfiec with biology average

were highly satisfied with their biology averages, while the Nonpersister$_{(other)}$ group exhibited a greater number who were highly dissatisfied with their biology averages. Data on students' ratings of their satisfaction with their biology averages is found in Table 4.5.

Hypothesis 1:

The first hypothesis tested using the two-way Analysis of Variance concerned the relationship between students' average biology scores and their persistence in biology. The null hypothesis was:

Hypothesis 1: There will be no significant difference in the biology averages of Biology Persisters, Nonpersisters$_{(science)}$, and Nonpersisters$_{(other)}$.

This hypothesis was tested for the group as a whole, and by sex. The two-way ANOVA indicated a significant ($p = 0.006$) main effect (see table 4.6). This significant main effect occurred because of a significant ($p = .002$) effect of persister group on biology grades. A value of $p = .9893$ indicates no effect of sex on biology grades.

It was therefore appropriate to conduct separate analysis of variance on persistence groups and biology average, followed by the Student-Newman-Keuls procedure, in order to determine where the differences in biology grades occurred (Borg and Gall, 1983). The Student-Newman-Keuls procedure

Table 4.6

Two-Way ANOVA to Determine Significant Differences in Biology Averages of Male and Female Biology Persisters, Nonpersisters$_{(science)}$, and Nonpersisters$_{(other)}$

Source of Variation	S.S.	df	M.S.	F	p
Main Effects	868.010	3	289.337	4.53	0.006
Persistence Group	867.549	2	433.775	6.79	0.002
Sex	1.176	1	1.176	0.02	0.893
2-Way Interactions (Persister Group, Sex)	94.937	2	47.468	0.74	0.480

S.S. = Sum of Squares; df = Degree of Freedom; M.S. = Mean Square; F = F Ratio; p = probability

Descriptive Statistics: Biology Average

Persister Group	Mean	Standard Deviation
Biology Persisters	71.000	6.107
Nonpersisters *(science)*	72.500	7.294
Nonpersisters *(other)*	63.188	11.566
Total	69.557	8.556

Table 4.7

ANOVA to Determine Significant Differences in Biology Averages of

Persisters, $\text{Nonpersisters}_{(science)}$, and $\text{Nonpersisters}_{(other)}$

Group	Number of Students	Biology Averages	S.D.	S.E.	df	F	p
Biology Persisters	38	71.000	6.107	.991	2,67	6.940	0.002
Nonpersisters (science)	16	72.500	7.294	1.824			
Nonpersisters (other)	16	63.187	11.566	2.891			

S.D. = Standard Deviation; S.E. = Standard Error; df = Degree of Freedom;

F = F Ratio; p = probability

Student-Newman-Keuls Procedure Ranges for the .050 level: 2.83 3.39.

Biology Persisters and $\text{Nonpersisters}_{(science)}$ differ significantly from $\text{Nonpersisters}_{(other)}$

indicated that Biology Persisters and $\text{Nonpersisters}_{(\text{science})}$ achieved significantly higher averages in biology (71.0 and 72.5, respectively) than $\text{Nonpersisters}_{(\text{other})}$ (63.2) (see Table 4.7). A significant difference *does* exist between the biology averages of Biology Persisters and $\text{Nonpersisters}_{(\text{science})}$, and those of $\text{Nonpersisters}_{(\text{other})}$.

Hypotheses 2, 3, and 4

Hypotheses 2, 3, and 4 were tested through repeated-measures ANOVA. These hypotheses were related to social integration (as defined previously in this paper) and the persistence of students in biology. The null hypotheses state:

Hypothesis 2: There will be no significant difference between the Value $\text{Bias}_{(\text{self})}$, and the Value $\text{Bias}_{(\text{science})}$ of Biology Persisters

Hypothesis 3: There will be no significant difference between the Value $\text{Bias}_{(\text{self})}$, and the Value $\text{Bias}_{(\text{science})}$ of $\text{Nonpersisters}_{(\text{science})}$

Hypothesis 4: There will be no significant difference between the Value $\text{Bias}_{(\text{self})}$, and the Value $\text{Bias}_{(\text{science})}$ of $\text{Nonpersisters}_{(\text{other})}$

These hypotheses were tested both by persister groups as a whole and by sex. The repeated-measures ANOVA showed that, overall, a significant difference existed between the scores

Value Bias$_{(self)}$ and Value Bias$_{(science)}$ (significance: .000). (See Table 4.8). There was no significant interaction between persister group and value bias, indicating that each persister group reacted to each value bias in approximately the same way. There was, however, a significant interaction between sex and value bias. This indicates that the pattern of value bias varies by sex across the various persister groups. This is discussed later in this paper under Hypotheses 5 and 6.

These results indicated that it would be appropriate to conduct separate repeated-measures t-tests (Value Bias$_{(self)}$ x Value Bias$_{(science)}$) for each persister group (Biology Persisters, Nonpersisters$_{(science)}$ and Nonpersisters$_{(other)}$), in order to determine precisely where differences in Value Bias$_{(self)}$ and Value Bias$_{(science)}$ occurred.

Repeated-measures t-tests revealed significance levels of .000, .001, and .001 for Biology Persisters, Nonpersisters$_{(science)}$ and Nonpersisters$_{(other)}$, respectively (Tables 4.9, 4.10, 4.11). In each instance, the mean of Value Bias$_{(self)}$ was significantly higher than the Value Bias$_{(science)}$, indicating a higher "caring" perspective in students' personal value judgments on science issues. Null Hypotheses 2, 3, and 4 were rejected at the .05 level. A significant difference did exist between the Value Bias$_{(self)}$, and the Value Bias$_{(science)}$ among students in all persistence groups.

Table 4.8

Repeated-Measures ANOVA to Determine Significant Differences between Value Bias$_{(self)}$ and Value Bias$_{(science)}$ of Male and Female Biology Persisters, Nonpersisters$_{(science)}$, and Nonpersisters$_{(other)}$

Source of Variation	S.S.	df	M.S.	F	p
Within Cells	25.16	63	.40		
Value Bias	42.07	1	42.07	105.35	.000
Persistence Group x Value Bias	.66	2	.33	.83	.442
Sex x Value Bias	3.37	1	3.37	8.43	.005

S.S. = Sum of Squares; df = Degree of Freedom; M.S. = Mean Square; F = F Ratio;

p = probability that Value Bias$_{(self)}$ is different from Value Bias$_{(science)}$

Table 4.9

Repeated-Measures t-test to Determine Significant Differences in Value Bias$_{(self)}$ and Value Bias$_{(science)}$ Among Biology Persisters

Value Perspective	Number of Students	Mean	S.D.	S.E.
Value Bias$_{(Science)}$	37	-0.092	0.910	0.150
Value Bias$_{(Self)}$	37	1.015	0.571	0.094

Mean (Difference)	S.D.	S.E.	Corr	2-tail prob	t value	df	2-tail prob
- 1.107	.836	.137	.438	.007	- 8.05	36	.000

S.D. = Standard Deviation; S.E. = Standard Error; Corr = Correlation; Prob = Probability;

df = Degree of Freedom

Table 4.10

Repeated-Measures t-test to Determine Significant Differences in Value Bias$_{(self)}$ and Value Bias$_{(science)}$ Among Nonpersisters$_{(science)}$

Value Perspective	Number of Students	Mean	S.D.	S.E.
Value Bias$_{(Science)}$	16	-.399	1.344	0.336
Value Bias$_{(Self)}$	16	1.021	0.616	0.154

Mean (Difference)	S.D.	S.E.	Corr	2-tail prob	t value	df	2-tail prob
- 1.420	1.343	.336	.231	.390	- 4.23	15	.001

S.D. = Standard Deviation; S.E. = Standard Error; Corr = Correlation;

Prob = Probability; df = Degree of Freedom

Table 4.11

Repeated-Measures t-test to Determine Significant Differences in Value Bias$_{(self)}$ and Value Bias$_{(science)}$ Among Nonpersisters$_{(other)}$

Value Perspective	Number of Students	Mean	S.D.	S.E.
Value Bias$_{(Science)}$	16	-0.264	0.919	0.230
Value Bias$_{(Self)}$	16	0.712	0.643	0.161

Mean (Difference)	S.D.	S.E.	Corr	2-tail prob	t value	df	2-tail prob
- 0.976	.973	.243	.263	.324	- 4.01	15	.001

S.D. = Standard Deviation; S.E. = Standard Error; Corr = Correlation;

Prob = Probability; df = Degree of Freedom

Hypotheses 5 and 6

Null Hypotheses 5 and 6 were tested through a separate two-way ANOVA. These hypotheses were related to male and female value judgements in science, and were stated as follows:

Hypothesis 5: There will be no significant difference between male and female scores in Value $\text{Bias}_{(\text{self})}$.

Hypothesis 6: There will be no significant difference between male and female scores in Value $\text{Bias}_{(\text{science})}$.

The two-way analysis of variance for male and female persistence group scores in Value $\text{Bias}_{(\text{self})}$ permitted the acceptance of null Hypothesis 5. There is no meaningful relationship among sex, persistence group and value $\text{bias}_{(\text{self})}$ (significance level: .287). No significant difference in Value $\text{Bias}_{(\text{self})}$ among persistence groups (significance level: .249) or between males and females (significance level: .407) was found to occur. Finally, the two-way ANOVA has revealed that Value $\text{Bias}_{(\text{self})}$ is not significantly related to the gender of the persistence group (significance level: .469). The positive group means of Biology Persisters, $\text{Nonpersisters}_{(\text{science})}$, and $\text{Nonpersisters}_{(\text{other})}$ indicate that students within all the persisters groups exhibited a personal "care" perspective in judging science-based moral issues. (See Table 4.12; Figure 4.1).

Analysis of variance for male and female persistence group scores in Value $\text{Bias}_{(\text{science})}$ revealed there is no significant relationship between sex, persistence group and Value $\text{Bias}_{(\text{science})}$ (significance level: .079). A significant relationship between value bias and sex was determined to exist (significance level: .022); however this is not immediately interpretable because of the significant interaction effect of gender and persister group on Value $\text{Bias}_{(\text{science})}$ (see Table 4.13). This interaction effect indicates that the pattern of scores for Value $\text{Bias}_{(\text{science})}$ differs for males and females across the three persistence groups. Graphing the means of the scores by gender (see Figure 4.1) suggests that the significant interaction and difference by sex occurs because the means for the males and females are similar for Biology Persisters and $\text{Nonpersisters}_{(\text{science})}$ but differ for $\text{Nonpersisters}_{(\text{other})}$.

To test this, separate analyses of variance (gender x Value $\text{Bias}_{(\text{science})}$) were performed for Biology Persisters, $\text{Nonpersisters}_{(\text{science})}$ and $\text{Nonpersisters}_{(\text{other})}$. As expected, these analyses revealed no significant differences in Value $\text{Bias}_{(\text{science})}$ scores of male and female Biology Persisters or $\text{Nonpersisters}_{(\text{science})}$ (significance levels: .386 and .541,

Table 4.12

Two-way ANOVA to Determine Significant Differences in Value Bias$_{(self)}$ of Male and Female Biology Persisters, Nonpersisters$_{(science)}$, and Nonpersisters$_{(other)}$

Source of Variation	S.S.	df	M.S.	F	p
Main Effects	1.396	3	.465	1.285	.287
Persistence Group	1.030	2	.515	1.423	.249
Sex	.252	1	.252	.696	.407
2-Way Interactions (Persister Group, Sex)	.555	2	.278	.767	.469

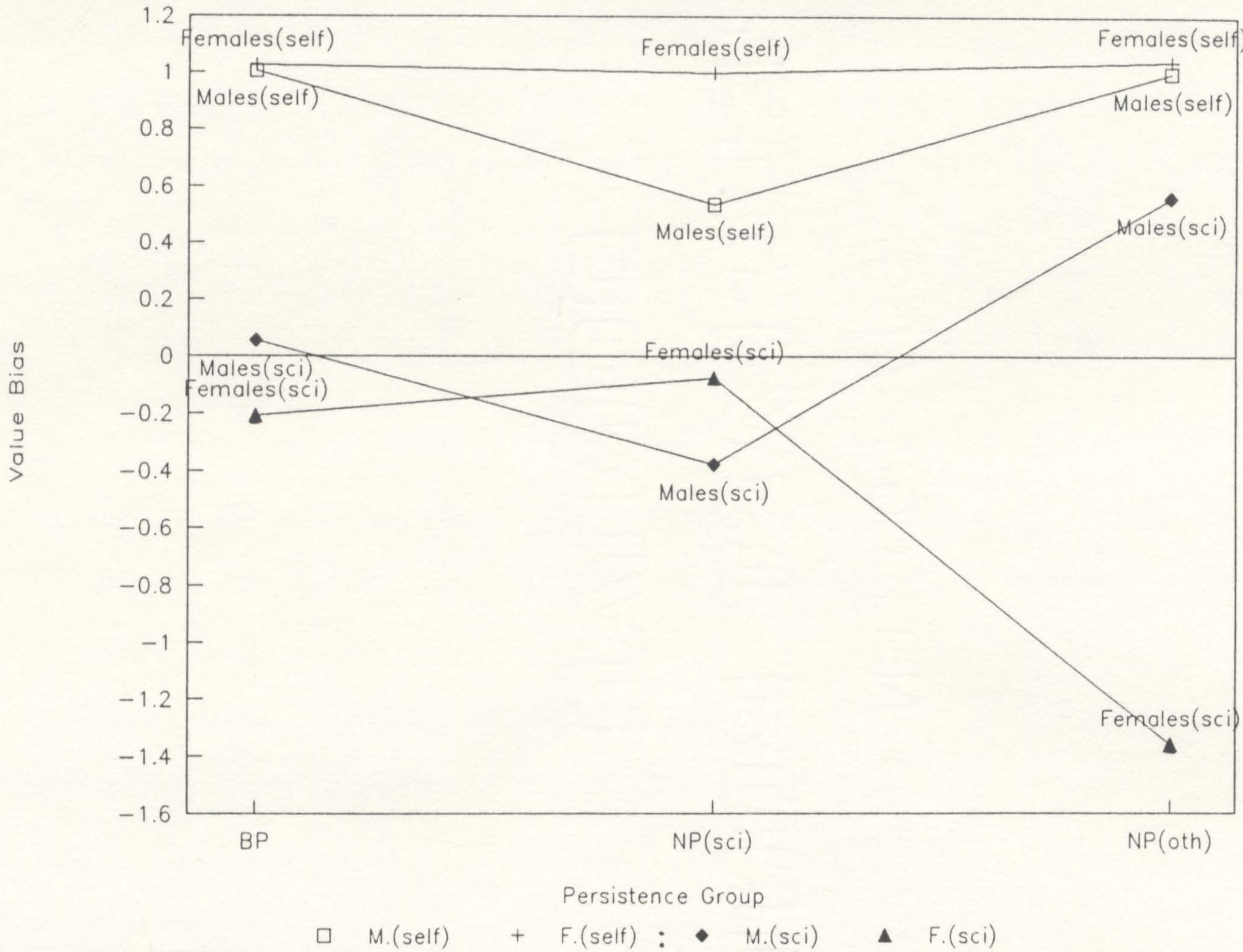
S.S. = Sum of Squares; df = Degree of Freedom; M.S. = Mean Square; F = F Ratio; p = probability

Descriptive Statistics: Value Bias$_{(self)}$

Persister Group	Mean	Standard Deviation
Biology Persisters	1.015	0.571
Nonpersisters$_{(science)}$	0.712	0.642
Nonpersisters$_{(other)}$	1.021	0.616
Total	0.946	0.603

Figure 4.1

The Interaction of Male and Female Biology Persisters, Nonpersisters$_{(science)}$ and Nonpersisters$_{(other)}$ in Value Bias$_{(self)}$ and Value Bias$_{(science)}$



BP = Biology Persisters; NP(sci) = Nonpersisters$_{(science)}$; NP(oth) = Nonpersisters$_{(other)}$;

M.(self) = Males, Value Bias$_{(self)}$; F.(self) = Females, Value Bias$_{(self)}$;

M.(science) = Males, Value Bias$_{(science)}$; F.(science) = Females, Value Bias$_{(science)}$

Table 4.13

Two-way ANOVA to Determine Significant Differences in Value Bias$_{\text{(science)}}$ of Male and Female Biology Persisters, Nonpersisters$_{\text{(science)}}$, and Nonpersisters$_{\text{(other)}}$

Source of Variation	S.S.	df	M.S.	F	p
Main Effects	6.052	3	2.017	2.373	.079
Persistence Group	1.404	2	.702	.826	.443
Sex	4.708	1	4.718	5.549	.022
2-Way Interactions (Persister Group, Sex)	11.067	2	5.534	6.508	.003

S.S. = Sum of Squares; df = Degree of Freedom; M.S. = Mean Square; F = F Ratio; p = probability

Descriptive Statistics: Value Bias$_{\text{(science)}}$

Persister Group	Mean	Standard Deviation
Biology Persisters	- 0.092	0.910
Nonpersisters$_{\text{(science)}}$	- 0.264	0.919
Nonpersisters$_{\text{(other)}}$	- 0.399	1.344
Total	- 0.203	1.019

respectively) (see Table 4.14 and 4.15), with male and female Nonpersisters$_{(other)}$ differing significantly in their scores on Value Bias$_{(science)}$ (significance level: .001). (Table 4.16).

There is clearly a difference in the pattern of scores for Value Bias$_{(science)}$ across persistence groups, with the scores being roughly the same for males and females who persist in some area of science, but differing by gender for persons who leave the sciences completely. Overall, students in the three persistence groups exhibited a "justice" perspective when judging science-based moral issues from the perspective of a scientist (see Table 4.13). Male Nonpersister$_{(other)}$ students exhibited a "care" Value Bias in the judgement of science issues, whereas female Nonpersisters$_{(other)}$ displayed a "justice" Value Bias. As stated, null Hypothesis 6 can be rejected on the basis of the scores of the Nonpersisters$_{(other)}$ group ($p = .001$).

Hypothesis 7

The preceding statistical analyses tested the relationship between several independent variables (Value Bias$_{(self)}$, Value Bias$_{(science)}$, biology average and sex) and the persistence behaviour of students registered as biology majors. While some significant results were determined from these analyses, two-way and repeated measures ANOVAs were limited in that they could not attempt to predict persistence

Table 4.14

ANOVA to Determine Significant Differences Between Male and Female Biology Persisters, in Value Bias$_{(science)}$

Group	Number of Students	Mean Value Bias (Self)	S.D.	S.E.	df	F	p
Males	20	.053	.835	.187	1,36	.771	.386
Females	18	-.207	.987	.233			

S.D. = Standard Deviation; S.E. = Standard Error; df = Degree of Freedom; F = F Ratio; p = probability

Table 4.15

ANOVA to Determine Significant Differences Between Male and Female Nonpersisters$_{(science)}$, in Value Bias$_{(science)}$

Group	Number of Students	Mean Value Bias (Self)	S.D.	S.E.	df	F	p
Males	10	-.378	.968	.306	1,14	.393	.541
Females	6	-.074	.882	.360			

S.D. = Standard Deviation; S.E. = Standard Error; df = Degree of Freedom; F = F Ratio; p = probability

Table 4.16

ANOVA to Determine Significant Differences Between Male and

Female Nonpersisters$_{(other)}$, in Value Bias$_{(science)}$

Group	Number of Students	Mean Value Bias (Self)	S.D.	S.E.	df	F	p
Males	8	.562	.844	.298	1,14	16.865	.001
Females	8	-1.361	1.021	.361			

S.D. = Standard Deviation; S.E. = Standard Error; df = Degree of Freedom;

F = F Ratio; p = probability

group membership on the basis of the combined variables. In order to perform this evaluation Discriminant Function Analysis was the method of choice. The null hypothesis states:

Hypothesis 7: The factors of Value $Bias_{(self)}$, Value $Bias_{(science)}$, average biology mark, and gender will not predict persistence group membership with a probability which is any better than random chance.

Discriminant function analysis provided two functions that can be used to predict group membership. The first of these functions (Table 4.17) predicts 86% of the variance accounted for and correlates very highly (0.865) (Table 4.18) with student grades. The second function predicts a much smaller percentage of the variance (13.7%), correlates weakly with grades but strongly with Value $Bias_{(self)}$, Value $Bias_{(science)}$ and sex, with correlations of 0.914, 0.418, and 0.388 respectively. Because of the very high correlation with Value $Bias_{(self)}$ this function can be thought of as being comprised mostly of the Value $Bias_{(self)}$ score. Thus we have two quite different functions, one of which accounts for most of the variance.

Together, these factors composed of biology average, Value $Bias_{(self)}$, Value $Bias_{(science)}$, and gender accurately predicted

Table 4.17

Canonical Discriminant Functions for Variables Affecting Persistence Group

Function	Eigenvalue	Percent of Variance	Cumulative Percent	Wilk's Lambda	Chi Squared	D.F.	Significance
1	0.278	86.320	86.32	0.749	18.613	8	0.017
2	0.044	13.680	100.00	0.958	2.783	3	0.426

D.F. = Degree of Freedom

Standardized Canonical Discriminant Function Coefficients

Variables	Function 1	Function 2
Value $Bias_{(self)}$	- 0.032	0.790
Value Bias $_{(science)}$	0.539	0.295
Average	0.977	0.173
Sex	0.049	0.378

Table 4.18

Pooled Within-Groups Correlations Between Discriminating Variables and Canonical Discriminating Functions

Variables	Function 1	Function 2
Average	0.865	0.047
Value Bias$_{(self)}$	- 0.204	0.914
Value Bias $_{(science)}$	0.176	0.418
Sex	- 0.106	0.388

Variables ordered by size within function.

62.3% of students' persistence group membership (see Table 4.19). This is considerably better than the chance value of 54% (Betz, 1987) that would have occurred if we had assigned all of the people to the most probable group, and much better than the 48% chance classification (Betz, 1987) that would have occurred had we randomly assigned persons to groups in the proportion assigned by the discriminant analysis.

These factors were particularly valuable in the prediction of biology persisters, with 89.2% of students accurately placed. They predicted Nonpersisters$_{(other)}$ reasonably well (43.8%), and predicted Nonpersisters$_{(science)}$ weakly (18.8%). Chi square analysis revealed that these results differed significantly ($p < .01$) from those which would have been expected by chance. We may therefore state that biology average appears to be the most important determining factor in the prediction of students' persistence behaviour.

The linear discriminant function minimizes the probability of miscalculation if the covariance matrices for all groups are equal (Norusis, 1990). In order to test the equality of the group covariance matrices, Box's M Test was performed. The result of this procedure indicated that the covariance matrices were *not* equal (significance: 0.038) (Table 4.20). While this initially seems to indicate that

Table 4.19

Classification Results Using a Discriminant Function to Predict Biology Persistence

Actual Group	Predicted Group: Biology Persisters	Predicted Group: Nonpersisters (science)	Predicted Group: Nonpersisters (other)
Biology Persisters:			
Number	33	2	2
Percent	89.2%	5.4%	5.4%
Nonpersisters (science)			
	13	3	0
	81.3%	18.8%	0.0%
Nonpersisters (other)			
	9	0	7
	56.3%	0.0%	43.8%
Ungrouped cases			
	1	0	0
	100.0%	0.0%	0.0%

Percent of grouped cases correctly classified: 62.32%

Table 4.20

Test of Equality of Group Covariance Matrices Using Box's M

Group	Rank	Log Determinant	Box's M	Approximate F	D.F.	Significance
Biology Persisters	4	0.659	36.525	1.630	20, 6865.7	0.038
Nonpersisters (science)	4	0.555				
Nonpersisters (other)	4	2.137				
Covariance Matrix	4	1.524				

The ranks and natural logarithms of determinants printed above are those of the group covariance matrices.

Analysis should not be executed, Discriminant Function Analysis performs quite well for groups with small numbers even if the covariance matrices are somewhat different (Norusis, 1990). It was therefore decided that the Discriminant Function Analysis would be included. It is also important to note that results from the discriminant analysis should be validated by being used to predict group members for a new population. This has not been done in this case.

Discussion

Academic Integration

The research question, "Will Biology Persisters demonstrate greater academic integration with the Biology faculty than students who do not persist in biology?" cannot be answered with a simple "yes" or "no". As previously noted, academic integration was measured by the average biology scores students attained as biology majors at Memorial University. Higher average scores were considered indicative of greater academic integration; lower average scores of diminished academic integration with Memorial University's Faculty of Science.

Using the above measure, it is apparent that students who had chosen to persist in the study of biology, and students who had chosen to leave biology to study another science, exhibited a significantly higher level of academic integration with the biology department than those students who had left the sciences altogether.

Both the former and the latter groups of students performed as Tinto (1987, 1982) suggested they might. That is, Biology Persisters were academically well-integrated with their chosen college system, and remained within that system. $\text{Nonpersisters}_{\text{(other)}}$, who were poorly academically integrated with the biology department, had made the decision to withdraw from that area of study. The $\text{Nonpersister}_{\text{(other)}}$ group also demonstrated a rather large variability in their mean biology scores (standard deviation within this group was 11.6) as compared to the variability in the mean scores of the Biology Persisters and $\text{Nonpersisters}_{\text{(science)}}$ (standard deviations of 6.1 and 7.3, respectively).

Students who had left the biology department to pursue study in another area of science ($\text{Nonpersisters}_{\text{(science)}}$), however, exhibited high levels of academic integration with the biology department. These levels were not significantly different from those shown by students who had chosen to persist in biology. Such results are not unlike those of Campbell and McCabe (1982), who found no significant academic differences between Computer Science and Other Science students taking part in their research.

At this point, it must be stated that the results of academic integration for Nonpersisters$_{(science)}$ were not supportive of the theory underlying this research. However, these results also hint at the possibility of other mitigating factors in academic integration and biology persistence.

It is entirely possible that students who left biology for other sciences differed from biology persisters in their academic integration with those non-biology sciences. Could, for example, students who left biology to study engineering have attained significantly higher marks than Biology Persisters in math or physics? As this study tested only for academic integration with the biology department, such questions are beyond its scope. Research into the relationship between academic achievement in all science disciplines encountered and students' subsequent persistence behaviour would help resolve this question.

When the academic integration of male and female students within the persister groups was assessed, no gender differences in the data became apparent. The results thus indicate that gender is not a factor in the academic integration of these students.

Value Integration

As with academic integration, the research question, "Will Biology Persisters demonstrate greater value integration with the Biology faculty than students who do not persist in biology?" does not lend itself to a simple answer. The review of the theory and research on values in science had led this researcher to expect that students who persisted in biology (and, perhaps, who left biology for other sciences) would exhibit some degree of self/science value integration. Students who left the sciences completely were expected to show value incongruence. The research literature also suggested that males would exhibit a "justice" perspective in personal values; a perspective which students would associate with the values maintained by scientists. These expectations were not realized.

Students from all persister groups demonstrated a lack of value integration, with significant differences between their mean Value $Bias_{(self)}$ and Value $Bias_{(science)}$ scores. It is also worth noting that all students possessed personal science values in the "caring" perspective and perceived scientists as having science values in the "justice" perspective.

Gender Differences/Value Integration

The third research question of this study, "Do gender-based differences occur in the value judgements of students who persist, or discontinue, as biology majors?" can be answered in the affirmative. The discussion will now centre on the occurrence and significance of these disparities.

As has been previously reported, all students possessed a personal "care" perspective in judging science-based moral issues. When science-based moral issues were assessed as students believed scientists would, however, gender differences began to appear. Male students who had chosen to leave the sciences completely ($\text{Nonpersisters}_{(\text{other})}$) viewed scientists as having a "caring" perspective in decision making; females determined that scientists possessed a "justice" perspective. The gender distinction between the perceived value bias of scientists was quite pronounced for $\text{Nonpersisters}_{(\text{other})}$, and was statistically significant.

For the most part, these results did not support the suggestions of Lyons (1988) and Gilligan (1982, 1977) that male and female conceptions of morality differ. This study has discovered significant gender differences in moral judgement only among the perceived value perspectives of scientists in the $\text{Nonpersisters}_{(\text{other})}$ group.

These differences are quite interesting, for they suggest that females who leave the study of science completely do so for reasons which differ from those of males. It is possible that the perceived *degree* of scientists' "justice" perspective is a key in interpreting these women's persistence behaviour in biology. Could, for example, female attrition from all sciences be linked to the perception that scientists are likely to make moral decisions in science from a noncaring (i.e., "justice") perspective? Alternatively, is a relatively large difference between a persons' self/science Value Bias correlated to a greater extent with science attrition than a small, but significant, Value Bias difference? Research into the relationship between the degree of perceived Value $Bias_{(science)}$ and persistence, and into self/science Value Bias disparities and persistence behviour in biology students would help answer these questions.

Predictions

Research carried out thus far indicates that the degree of both academic and value integration may vary among Biology Persisters, $Nonpersisters_{(science)}$ and $Nonpersisters_{(other)}$. It has also been noted that gender differences occur in the academic and value integration of all these groups. Females appear to leave biology when they perceive a different value climate or receive poor grades; males when they obtain poor academic scores.

The second phase of this study investigated whether students' gender, academic performance, personal values and perceived values of scientists were predictive of with persistence in, or attrition from, biology.

Discriminant function analysis revealed that biology students' sex, academic performance in biology, personal values in science, and perceived values of scientists could be used to predict 62.3% of students' membership in one of the three persistence groups. Greatest predictive success (89.2%) was achieved for students who chose to persist in biology; least predictive success (18.8%) occurred with students who moved from biology to another science.

The fact that 81.3% of Nonpersisters$_{(science)}$ were erroneously classified as Biology Persisters is not surprising when it is acknowledged that Function 1, which predicted 86% of the variance, was highly correlated with biology average. As already discussed, Biology Persisters and Nonpersisters$_{(science)}$ did not differ significantly on their biology means. The high correlation of academic mean and persistence is also consistent with the correct prediction of 43.8% of students who chose to leave the sciences altogether. As previously noted, this group exhibited significantly lower biology means that both Biology Persisters and Nonpersisters$_{(science)}$.

The combined values of Value Bias$_{(self)}$, Value Bias$_{(science)}$, and sex were most highly correlated with Function 2 in the Discriminant Analysis. As such, they mostly accounted for 13.68% of the variance. Thus, while these values were certainly contributors to the process, the biology average of students would appear to be the determining factor in the prediction of students' persistence groups. This makes the

$\text{Nonpersisters}_{(science)}$ very difficult to predict, as they are academically like the Biology Persisters.

Hence the fourth and final research question: "Are the combined elements of biology students' sex, academic performance in biology, personal values in science and perceived values of scientists predictive of persistence in, or attrition from, biology?" may be answered, partially in the affirmative. It may be stated that these factors may accurately predict the persistence behaviour of 62.3% of students, with the students' biology average as the determining factor in this prediction.

These results indicate that an assessment of the preceding factors in students members of a Biology Faculty may be valuable in identifying both those who will most likely complete their program of study and those who will leave the sciences completely. In the case of potential science dropouts, such identification could be utilized to instigate interventive procedures which might encourage some of the reluctant potential scientists to persist.

Chapter 5

Summary, Conclusions and Recommendations

Summary of the Study

The purpose of this study was to investigate whether the levels of academic integration and social integration of students who persist in biology differ from those of students who do not persist, and to consider whether students' gender, academic performance, personal values and perceived values of scientists were predictive of persistence in, or attrition from, biology.

A random sample of students was selected from the population of biology majors attending Memorial University of Newfoundland. Data were collected through the records of the Office of the Registrar at Memorial University and through the administration of a Science Issues Survey, and a Personal Information Survey. These data were then subjected to a series of statistical analyses, including MANOVA, repeated-measures ANOVAs and t-tests, and discriminant function analysis. Findings emerging from the study may be briefly summarized as follows:

(i) Students who persisted as biology majors, and students who left biology to pursue another science major exhibited significantly higher academic integration with the Biology Department of Memorial University than students who left the study of science completely.

(ii) Gender differences did not exist in academic integration.

(iii) Students from all persister groups demonstrated a lack of value integration. Students also exhibited a "caring" perspective when assessing science-based moral issues from a personal perspective, and a "justice" perspective when making decisions on science-based moral issues from the perspective of a scientist.

(iv) Significant gender differences appeared in the value integration of students in the Nonpersister$_{(other)}$ group. Males who had chosen to leave the sciences completely viewed scientists as possessing a "caring" perspective in science-based moral issues whereas females from this group determined that scientists possessed a "justice" perspective.

(v) The combined elements of biology students' sex, academic performance in biology, personal values in science and perceived values of scientists may accurately predict the persistence of 62.3% of students. Biology average is the determining factor in this prediction.

Conclusions

The results of the study allow the following conclusions to be drawn:

Academic Integration

Students who persisted in biology demonstrated greater academic integration with the Biology Department than students who chose to leave the study of science entirely. Both the persistence behaviour of the academically well-integrated students, and the attrition behaviour of students with poor academic integration, were consistent with Tinto's (1987,1982) Theoretical Model of Dropout Behaviour. Students who persisted in biology did not demonstrate greater academic integration with the Biology Department than students who chose to leave the study of biology for another science.

Gender is not a factor in the academic integration of students.

Value Integration

Students who persisted in biology did not demonstrate greater value integration with the Biology Department than students who did not persist in biology. Students from all persister groups demonstrated a lack of value integration, with significant differences between their mean personal judgements of science-based moral issues (Value $Bias_{(self)}$) and their perceptions of scientists' judgements on these same issues (Value $Bias_{(science)}$).

All students possessed personal science values in the "caring" perspective and perceived scientists as having science values in the "justice" perspective.

Value Judgements and Gender

Significant gender differences in value judgements occurred only in the perceptions of scientists' value perspectives by students who left the study of science completely. No other significant differences in value judgements between the genders were found. This is neither consistent with the premise of Lyons (1988) and Gilligan (1982) that male and female conceptions of morality differ, nor with that of Gilligan (1982) and Worthley (1992), that males tend to demonstrate a personal "justice" perspective.

Prediction of Attrition

Students' sex, academic performance in biology, personal values in science, and perceived values of scientists, are predictive of their persistence behaviour in biology and of their decision to leave science altogether. These factors are not accurately predictive of the persistence behaviour of students who choose to leave biology in order to study another science.

Recommendations for Future Research

This study focused on the persistence behaviour of students who occupied only one Department within the Science Faculty of Memorial University of Newfoundland. The results of this study lead to some interesting questions about the persistence behaviour of science students in general, some of which may be considered in future research. These may include:

1. Students' intradisciplinary and interdisciplinary academic integration might be correlated with their persistence behaviour in a particular science specialty. For example, are students who achieve high marks in sciences outside their subject major more or less likely to persist in that major than students who achieve lower marks in non-major sciences? Research into the relationship between students' academic achievements in all sciences encountered in college and their subsequent persistence behaviour would help resolve this question.

2. Students' own and perceived moral values in science may be correlated with the discipline they have chosen. Do, for example, students who choose to enter biology possess personal and perceived science value perspectives which are similar to students who choose to enter chemistry? Research

into the existence of a correlation between the value perspectives of students majoring in various science disciplines would help resolve this question.

3. The possibility exists that students who persist in a particular science discipline are those who either possess value perspectives which are congruent with those of their chosen Department upon entry, *or* whose personal value perspectives *become* congruent with those of their chosen Department. Research into the stability of students' personal and science value perspectives over time, correlated with persistence behaviour would be indicated.

4. This study has ignored those students who entered university with the purpose of pursuing a biology degree, but who changed that goal before applying for entry into the Faculty of Science. Do these students differ academically or in self/science value perspective from those who subsequently choose to pursue a biology degree? Research into the correlation between pre-science students' academic/value integration with the Science Faculty and their subsequent persistence decision would help resolve this question.

5. Students will mature, both academically and socially during the period they are engaged in their post-secondary education. As a result, their academic and social integration with the science faculty may vary during their time at university. These variations may be correlated with students'

decisions to persist or leave their original science major at certain points during their degree program. A longitudental study which monitored students' academic and value integration with their chosen science faculty throughout their time at university, and which correlated these factors with students' persistence decisions in science would be helpful in further understanding the process of science attrition at the university level.

References

Ary, D., Jacobs, L.C., and Razavieh, A. (1990). Introduction to research in education. Fourth Edition. Toronto: Holt, Rinehart and Winston, Inc.

Bandura, A. (1982). Self-efficacy mechanisms in human agency. American Psychologist, 37, 122-147.

Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavioral change. Psychological Review, 84, 191-215.

Baruch, R. and Nagy, J.N. (1977). Females and males in the potential science pool: A study of the early college years. Hanover: Dartmouth College.

Bateson, D.J. and Parsons-Chatman, S. (1989). Sex-related differences in science achievement: A possible testing artifact. International Journal of Science Education, 11, (4) 371-385.

Becher, T. (1987). The disciplinary shaping of the profession. In B.R. Clark (ed). The academic profession. Berkeley: University of California Press.

Belenky, M., Clinchy, B., Goldberger, N., and Tarule, J. (1986). Women's ways of knowing. New York: Basic Books.

Bessey, J., Bourne, G. Chancey. P. Gladney, R. and Stockley, K. (1993). Memorial University of Newfoundland Factbook for the Year 1992. Newfoundland: Memorial University.

Betz, N.E. (1987). Use of discriminant analysis in counselling psychology research. Journal of Counselling Psychology, 34, (4) 393-403.

Betz, N.E., and Hackett, G. (1983). The relationship of mathematics self-efficacy expectations to the selection of science-based college majors. Journal of Vocational Behaviour, 23, (3) 329-345.

Betz, N.E., and Hackett, G. (1981). The relationship of career-related self-efficacy expectations to perceived career options in college women and men. Journal of Counselling Psychology, 28, 399-410.

Blanc, R.A., DeBuhr, L.E., and Martin, D.C. (1983). Breaking the attrition cycle. Journal of Higher Education, 54, (1) 80-89.

Boisset, A., Mackenzie, J., and Sidorenko, C. (1989). Persistence in science: Gender and program differences. Final Report. Sainte Anne de Bellevue, Quebec: John Abbott College.

Borg, W.R., and Gall, M.D. (1983). Educational Research Fourth Edition. London: Longman Press.

Brush, Stephen G. (1991). Women in science and engineering. American Scientist, 79, September-October 404-419.

Burke, J. (1985). The day the universe changed. Toronto: Little, Brown and Company.

Cabrera, A.F., Castaneda, M.B. Nora, A., Hengstler, D. (1992). The convergence between two theories of college persistence. Journal of Higher Education, 63, (2) 143-164.

Campbell, P.F., and McCabe, G.M. (1982). Factors relating to persistence in a computer science major, Technical Report #82-15. Indiana: Purdue University.

Coldeway, A.E. (1989). Using basic statistics in the behavioral sciences. Ontario: Prentice-Hall Canada, Inc.

Crocker, R.K. (1989). Towards an achieving society. Newfoundland: Government of Newfoundland and Labrador.

DeBoer, G.E. (1985). Success and failure in the first year of college - effects on expectations, affect, and persistence. Journal of College Student Development, 26, (3) 234-239.

DeBoer, G.E. (1984a). Factors related to the decision of men and women to continue taking science courses in college. Journal of Research in Science Teaching, 21, (3) 325-329.

DeBoer, G.E. (1984b). A study of gender effects in the science and mathematics course-taking behaviour of a group of students who graduated from college in the late 1970s. Journal of Research in Science Teaching, 21, (1) 95-103.

Drew, D.E. (1992). The attitudes of college students about science and research. A paper presented at the American Educational Research Association 1992 Annual Meeting, San Francisco, California.

Durkheim, E. (1951). Suicide. Glencoe: The Free Press. In Tinto, V. (1987). Leaving college: Rethinking the causes of student attrition. Chicago: University of Chicago Press.

Fensham, P.J. (1988). Approaches to the teaching of STS in science education. International Journal of Science Education, 10, (4) 346 - 354.

Friedman, W.J., Robinson, A., and Friedman, B. (1987). Sex differences in moral judgements? A test of Gilligan's theory. Psychology of Women Quarterly, 11, 37-46.

Gay, L.R. (1987). Educational research. Toronto: Merrill Publishing Company.

Gilligan, C., and Attanucci, J. (1988). Two moral orientations. In Gilligan, C., Ward, J.V., and Taylor, J.M. (eds). (1988). Mapping the moral domain. Cambridge: Harvard University Press.

Gilligan, C., Ward, J.V., and Taylor, J.M. (eds). (1988). Mapping the moral domain. Cambridge: Harvard University Press.

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

Haase, R.F., and Ellis, M.V. (1987). Multivariate analysis of variance. Journal of Counselling Psychology, 34 (4) 404-413.

Hackett, G., and Betz, N.E. (1981). A self-efficacy approach to the career development of women. Journal of Vocational Behaviour, 18, 326-339.

Handley H.M., and Morse, L.W. (1984). Two-year study relating adolescents' self-concept and gender role perceptions to achievement and attitudes toward science. Journal of Research in Science Teaching, 21, (6) 599-607.

Head, J., and Ramsden, J. (1990). Gender, psychological type and science. International Journal of Science Education, 12, (1) 115-121.

Hilton, T.L., and Lee, V.E. (1988). Student interest and persistence in science. Journal of Higher Education, 59, (5) 510-526.

Holland, J.L. (1985). Making vocational choices: A theory of careers. Englewood Cliffs: Prentice-Hall.

Hudson, H.T. (1986). A comparison of cognitive skills between completes and dropouts in a college physics course. Journal of Research in Science Teaching, 23, (1) 41-50.

Hough, L.W. and Piper, M.K. (1982). The relationship between attitudes toward science and science achievement. Journal of Research in Science Teaching, 19, (1) 33-38.

Iacocca, L. (1990, Summer). Schools need to work on customer satisfaction. Inside Canada, 31.

Janis, I.L., and Mann, L. (1977). Decision making: A psychological analysis of conflict, choice, and commitment. New York: Free Press.

Kahle, J.B. (1983, October). Factors affecting the retention of girls in science courses and careers: Case studies of selected secondary schools. A paper presented at the National Association of Biology Teachers.

Keller, E.F. (1985). Reflections on gender and science. London: Yale University Press.

Kohlberg, L. (1981). The philosophy of moral development: Moral stages and the idea of justice. New York: Harper and Row.

Lent, R.W., Brown, S.D., and Larkin, K.C. (1988, August). Effects of self-efficacy - aptitude incongruence on career behaviour. A paper presented in K.M. Taylor (Chair), Recent applications of self-efficacy theory to career behaviour. Symposium conducted at the 96th meeting of the American Psychological Association, Atlanta, GA.

Lent, R.W., Brown, S.D., and Larkin, K.C. (1987). Comparison of three theoretically derived variables in predicting career and academic behaviour: Self-efficacy, interest congruence, and consequence thinking. Journal of Counselling Psychology, 34, (3) 293-298.

Lent, R.W., Brown, S.D., and Larkin, K.C. (1984). Relation of self-efficacy expectations to academic achievement and persistence. Journal of Counselling Psychology, 31, (3) 356-362.

Levin, J., and Fowler, H.S. (1984). Sex, grade and course difference in attitudes that are related to cognitive performance in secondary science. Journal of Research in Science Teaching, 21, (2) 151-166.

Levin, J., and Klindienst, D. (1983). Differences in attitudes between academic continuing and academic terminal secondary science students. A paper presented at the Annual meeting of the national Association for Research in Science Teaching, Dallas, Texas.

Levin, J., and Wyckoff, J. (1990). Identification of student characteristics that predict persistence and success in an engineering college at the end of the sophomore year: Informing the practice of academic advising. A paper presented at the Annual Meeting of the American Educational Research Association, Boston, Massachusetts.

Lips, H.M. (1992). Gender-related and science-related attitudes as predictors of college students' academic choices. Journal of Vocational Behaviour, 40, (1) 62-81.

Lips, H.M. (1988). The role of gender, self- and task-perceptions in mathematics and science participation among college students. Ottawa: Social Sciences and Humanities Research Council of Canada.

Lips, H.M. (1985). Self-schema theory and gender-related behaviours: Research on some correlates of university women's participation in mathematics, science and athletic activities. Final report for the Social Sciences and Humanities Research Council of Canada.

Lyons, N. P. (1988). Two perspectives: On self, relationships and morality. In Gilligan, C., Ward, J.V., Taylor, J.M. (eds). (1988). Mapping the Moral Domain. Cambridge: Harvard University Press.

Lyson, T.A., and Brown, S.D. (1982). Sex-role attitudes, curriculum choice, and career ambition - A comparison between women in typical and atypical college majors. Journal of Vocational Behaviour, 20, (3) 366-375.

Manthorpe, C. A. (1982). Men's science, women's science or science? Some issues related to the study of girls' science education. Studies in Science Education, 9, 65-80.

Marion, S.F. (1988). Gender differences in selecting undergraduate science majors. A paper presented at the annual meeting of the New England Educational research Organization, Rockport, ME.

McDade, L.M. (1988). Knowing the "Right Stuff": Attrition, gender and scientific literacy. Anthropology and Education Quarterly, 19, 93-113.

Mervis, J. (1991). Educators rally to salvage science dropouts. Scientist 5, (4) 1.

Milem, J.F., and Astin, H.S. (1992, April). Science faculty: Culture, roles, and pedagogy. A paper presented at the Annual meeting of the American Educational research Association, San Francisco, California.

Norusis, M.J. (1990). SPSS/PC+ ADVANCED STATISTIC 4.0. Chicago: SPSS Inc.

Oliver, J.S. (1991). Participation in school science: A synthesis of recent research. A paper presented at the Annual Meeting of the National Association for Research in Science teaching, Lake Geneva, WI.

Rosser, S.V. (1990). Female friendly science: Applying women's studies methods and theories to attract students. New York: Pergamon.

Schoenberger, A.K. (1988). _College women's persistence in engineering and physical science: A further study_. A paper presented at the Annual Meeting of the American Educational Research Association, New Orleans, LA.

Sollimo, V.J. (1988). _A retention study at Burlington County College in general college chemistry_. Pemberton: Burlington County College.

Steinkamp, M.W., and Maehr, M.L. (1984). Gender differences in motivational orientations toward achievement in school science: A quantitative synthesis. _American Educational Research Journal_, _21_, (1) 39-59.

Tinto, V. (1987). _Leaving college: Rethinking the causes and cures of students attrition_. Chicago: University of Chicago Press.

Tinto, V. (1982). Limits of theory and practice in student attrition. _Journal of Higher Education_, _53_, (6) 687-700.

Tinto, V. (1975). Dropout from higher education: A theoretical synthesis of recent research. _Reviews of Educational Research_, _45_, (1) 89-125.

Tobias, S. (1990). _They're not dumb. they're different: Stalking the second tier_. Tuscon: research Corporation. In Milem, J.F. and Astin, H.S. (1992). _Science faculty: Culture, roles and pedagogy_. A paper presented at the Annual Meeting of the American Education Research Association, San Francisco.

Ware, N.C., Steckler, N., and Leserman, J. (1985). Undergraduate women: Who chooses a science major? Journal of Higher Education, 56, 73-84.

Weiner, B. (1980). Human motivation. New York: Holt, Rinehart and Winston.

Weiner, B., Russell, D., and Lerman, D. (1978). Affective consequences of causal attributions. In DeBoer, G.E. (1985). Success and failure in the first year of college - Effects on expectation, affect, and persistence. Journal of College Student Personnel, 26, (3) 234-239.

Wollman, W., and Lawrenz, F. (1984). Identifying potential "dropouts" from college physics classes. Journal of Research in Science Teaching, 21, (4) 385-390.

Worthley, J.S. (1992). Is science persistence a matter of values? Psychology of Women Quarterly, 16, 57-68.

Worthley, J.S. (1992). Science Issues Survey. Personal copy.

Yanico, B.J., and Hardin, S.I. (1981). Sex-role self-concept and persistence in a traditional vs nontraditional college major for women. Journal of Vocational Behaviour, 18, (2) 219-227.

Appendix 1

Science Issues Survey (Worthley, 1992)

All of the questions included in this Survey are answered by the students on a seven-point scale which follows each response item. The form of the scale is:

Very Unimportant	1	2	3	4	5	6	7	Very Important

For purposes of brevity, the scale has been omitted from the Science Issues Survey presented below.

Students received one of two Surveys, the only difference being the order in which they answered the questionnaire. Half the respondents received Surveys which asked them to respond first as they would personally; then as they believed a scientist would. The order of response was reversed for the remaining respondents. The two sets of instructions required are therefore included at the beginning of this inclusion of the Science Issues Survey (students, of course, received only the instructions applicable to their own response).

Instructions(A)

This questionnaire is aimed at understanding how people think about science and scientists. All of us have different ideas about science; we are interested in how you think about science rather than in any "right" answers to the questions.

On the pages which follow, there is a series of stories about problems faced by scientists. For this part of the questionnaire, it is important that you take the role of a **scientist**, and answer the questions **as you believe a scientist would**. Please begin with a careful reading of the story, then rate each item beneath the question according to how important that item would be **to a scientist** in deciding "yes" or "no".

Instructions(B)

This questionnaire is aimed at understanding how people think about science and scientists. All of us have different ideas about science; we are interested in how you think about science rather than in any "right" answers to the questions.

On the pages which follow, there is a series of stories about problems faced by scientists. For this part of the questionnaire, it is important that you answer the questions **from your own point of view**. Please begin with a careful reading of the story, then rate each item beneath the question according to how important that item would be **to you** in deciding "yes" or "no".

THANK YOU FOR TAKING PART IN THIS STUDY

Science Issues Survey

Dilemma 1

A biologist at Queen's University has applied to the Canada Council for grant money to support three years of recombinant DNA research involving the chemical synthesis of pieces of DNA. This controversial research is monitored by Health and Welfare Canada whose guidelines set standards for procedures, materials, and safety in DNA research. One obvious danger with this research is the possibility that pathogens could be released into the environment, with unpredictable results for human and other populations. On the other hand, results from the proposed research could lead to a cure for genetic diseases like diabetes, or to the reversal of genetic defects like dwarfism.

Decision Items

Whether the laboratory located in a residential neighbourhood

Whether it is the right of qualified scientists to pursue basic research without outside interference

Whether it is only fair to support this research since other scientists in places like University of Toronto have received Canada Council grants for equally controversial research

Whether the odds of a mishap harming people and the environment will be calculated and made public by the university

Whether government agencies like the Canada Council have the right to use their funds to regulate research conducted in university laboratories

Whether the introduction of this research will produce tensions between the university and residents of its surrounding neighbourhoods

Dilemma 2

The loss of the space shuttle Challenger revives debate over NASA policy on the use of humans in deep space exploration. Few people doubt that human exploration of space will continue, but information from the investigation of the Shuttle disaster has moved the President's commission to ask for a one-year suspension of flights carrying humans while NASA and the public evaluate shuttle program goals and NASA'S launch procedures. Those who want a suspension claim that vulnerabilities in the technology and economic pressures on launch schedules expose crews to unacceptable risks. Those who disagree want the program to continue with minimal interruption; they argue that shuttle flights are essential to national security, that astronauts are indispensable on missions involving communications hardware, and that overall, the program has a good safety record.

Decision Items

Whether the panel's investigation reveals that NASA's procedures during the Challenger launch followed space agency regulations

Whether the panel investigation shows that NASA shared with the Challenger crew information related to the safety of the January 28th launch

Whether it can be shown that NASA provides long-term support to families of astronauts killed on duty including reducing benefits for the care of the terminally ill and the elderly.

Decision Items

Whether reducing medical benefits to the terminally ill elderly will result in neglect and abandonment of the aged in the last year of life

Whether the rights of the young, who are embarking on life, take precedence over the rights of the very old, whose lives are nearly over

Whether guaranteed minimums in health care contribute to the psychological well-being of the elderly

Whether it is the duty of the young and able in society to provide care for the disabled elderly

Whether the decisions we make in middle age about the care of our parents' generation will be used as a model by our own children in caring for us

Whether cutbacks in health services to the elderly will weaken the ties between generations as mid-aged adults are caught between caring for their children and their aging parents

Dilemma 4

Research on AIDS (acquired immune deficiency syndrome) is being conducted worldwide, often through collaboration among researchers. However, the visibility of the research and the pressure for a breakthrough create a climate of competition, motivating some researchers to keep a result secret until it's in print and they are credited with the discovery. Recently, researchers at the Canadian Cancer Foundation discovered that a drug now used against protozoan blood parasites suppresses the AIDS virus. It's not a cure, but the drug produces remissions and may provide information about the failure of AIDS patients' antibodies in combatting opportunistic diseases. This discovery, however, divides scientists at the Cancer Foundation: Some are eager to call a press conference to announce their finding; others, who want to shield their research, are bitterly opposed to such a move.

Decision Items

Whether it is a violation of scientific principles to release this information to the press before it appears in a science journal

Whether the release of this information will raise false hopes among AIDS victims

Whether the unwritten rules in science justify secrecy, because scientists who are the first to a discovery are most rewarded in science

Whether releasing this information will promote exploitation of AIDS victims through "underground" dissemination of the drug

Whether the rights of the scientists who want to protect their research take precedence over the rights of the scientists who want to share the discovery

Whether announcing this finding will promote or hinder future collaborations involving Cancer Foundation scientists and other AIDS researchers

Dilemma 5

The proposed Strategic Defence Initiative ("Star Wars") calls for the development of sophisticated remote sensing devices along with new types of "kill mechanisms" including lasers and "smart rocks" designed to track and destroy incoming weapons. Contracts for "Star Wars" research are awarded to many university researchers, each one working on a bit of the technology crucial to the development of the Strategic Defence Initiative. Recently, the American Association for the Advancement of Science met to consider whether "Star Wars" research violates the 1972 antiballistic missile treaty in which the U.S. and Russia agreed "not to develop, test or deploy antiballistic missile systems." The issue facing the AAAS is: Does laboratory research on the Strategic Defence Initiative violate the intentions of the antiballistic missile treaty, even though "Star Wars" now exists only on the drawing boards? Following a debate, hundreds of scientists will vote on an official AAAS recommendation on its members' participation in "Star Wars" research.

Response Items

Whether academic research on "Star Wars" violates specific provisions of the antiballistic missile treaty

Whether academic scientists have a responsibility to examine the social outcomes of their work

Whether embarking on "Star Wars" research harms the chances for trust between the two nations

Whether AAAS is infringing on members' rights to professional independence by taking an official position on "Star Wars" research

Whether it would be a violation of scientific principles for AAAS to take an official position on a matter of foreign policy

Whether pursuit of "Star Wars" research harms our prospects for mutual arms' reductions in the future

Dilemma 6

A physician is treating a patient with incurable cancer who has no more than six months to live. The patient, who is alert and responsive, but already in constant pain and unable to breathe without automated equipment, has asked to be removed from the respirator. The patient's family refuses to allow the respirator to be removed, claiming that the patient is not competent to make such a request. The hospital's case review committee will meet to consider whether the physician can honour the patient's request.

<u>Decision Items</u>

Whether the doctor considers the patient a partner in the treatment

Whether the doctor is obligated by rules of practice to use all available measures to sustain life

Whether the rights of the family or the rights of the patient take precedence in making the decision

Whether the act of helping to end another's life is balanced by the alleviation of pain and suffering

Whether the hospital has the right to continue life-support measures when a patient no longer wants to live

Whether cooperation with the patient's request will alienate the patient's family

Appendix 2

Personal Information Survey

Student Information

Student Number: ______________________________

Sex: M ______ F ______

Academic Year: ______

Academic Major: ______________________________

Do you plan to continue in this major? Yes ___ No ___

Why/why not?

____

____

Please indicate where you would consider your average mark in biology to stand by circling the appropriate number on the following scale (#1 would indicate you think your average is very low; #4 would indicate midrange; #7 is very high).

(low) 1 2 3 4 5 6 7 (high)

How do you think the average marks of other biology students stand?

(low) 1 2 3 4 5 6 7 (high)

Are you pleased or displeased with the average mark you've achieved in biology? Please indicate your level of satisfaction by circling a number on the scale below (#1 - very displeased; #4 - neutral; #7 - very pleased).

(displeased) 1 2 3 4 5 6 7 (pleased)

Can you explain the above rating?

____