Equity in the science classroom:
Assessing the attitudes of female science students towards alternative methods of assessment

by

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B.Sc., B.Ed. The University of British Columbia, 1993

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF MASTERS OF ARTS
in
THE FACULTY OF GRADUATE STUDIES
(Department of Curriculum Studies)

We accept this thesis as conforming
to the required standard

THE UNIVERSITY OF BRITISH COLUMBIA

June 1999
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Date July 19, 1999
Abstract

This study examines the attitudes of female high school science students towards alternative assessment strategies and probes the influence of alternative assessment on the students' attitudes towards science.

During one school year, ninety-three Science 9 students were exposed to three different methods of alternative assessment (i.e. portfolio-based assessment, drama-based assessment, and practical lab tests) as well as traditional assessment strategies (i.e. multiple choice and open-ended tests). Student questionnaires, teacher interviews, and classroom observations were completed in order to ascertain the attitudes and reactions of the students to the alternative methods of assessment.

The findings show that the students positively received the alternative methods of assessment. Students believed that these methods of assessment improved their connection with science, improved their ability to express themselves and their understanding of science, and made science less difficult and more enjoyable.
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Acknowledgements

I would like to thank my graduate adviser, Dr. Jolie Mayer-Smith, for her unending encouragement, support, and assistance through my entire graduate program. I would also like to thank Dr. Gaalen Erickson who so kindly served on my thesis committee and who inspired me to take alternative approaches to explaining the “black box” of science.

A special thank you must also be extended to my students who enthusiastically participated in my research. Their participation and understanding through this process made this study possible.

Finally, I would like to thank my family for all of their support. This one’s for you, Norm! Sorry you didn’t see it, but I hope I made you proud.
Science is Everything

Past, Present, Future
see, smell, touch, taste, feel science
Science all around

~ written by a Science 9 student
Chapter 1: Introduction

Background

As a female science teacher at an all-girls high school, I have always been concerned with turning my female students onto science. I hope by the time students have left my class, they have mastered skills, acquired knowledge, and developed an attitude that will allow them to enjoy a lifetime of scientific discovery.

Studies have shown that a disproportionately high number of female students have dropped out of science, particularly physical sciences, by the time they have reached senior high school (BCMEST, 1997). The question remains, “Why?” The typical responses to this question include “female achievement in science is below male achievement”; “female science students don’t have any female role models”; “females aren’t interested in science”; and “females have less personal experience with science than males”. While some of these claims may be true in particular situations, none of these claims fully explain the under-representation of females in science courses and science-related careers.

Recent statistics released by the government of British Columbia dispel the myth that boys out-perform girls on science achievement tests. While it is true that males have out-performed females on some science achievement tests (e.g. AAUW, 1992), males do not out-perform females on all science achievement tests. For example, in the 1996-97 school year, female Physics 12 students out-performed their male classmates on the provincial examination for that course (BCMEST, 1997). Thus, the gender gap in science achievement is debatable. Improving female students’ achievement in science may not, therefore, be the key to encouraging females to pursue science-related careers.

Efforts to introduce female role models and female-friendly examples and activities in science class have also been met with limited success (Kahle, 1996). These efforts do not seem to have a large impact on the number of females choosing to pursue advanced science education
Chapter 1: Introduction

or science-related careers. In spite of educator's best efforts, females are still choosing not to pursue science.

Unfortunately, what goes on in science class still appears to be turning females off science, rather than turning females onto science. Since females' ambivalence towards science does not appear until students reach middle school (Shemesh, 1990; Kahle & Lakes, 1983; Simpson & Oliver, 1985), it could be suggested that the school is the source of this ambivalence. We need to investigate what's occurring in our classrooms to generate this apathy towards science.

Research shows that women's talk differs from that of men (Gorman, as cited in Murphy, 1996); and feminine knowledge differs from masculine knowledge (e.g. Belenky, Clinchy, Goldberger & Tarule, 1997). In science classrooms, males and females are subjected to the same forms of instruction and assessment. And both males and females are forced to talk about and understand science in the same way. Historically, the nature of this scientific discourse has been determined by the dominant male voice. This study looks at altering the way we talk about science in the hope of allowing divergent voices to be heard.

To do this, the present study diverges from traditional studies which have investigated what we teach and how we teach it. This study takes a novel approach and focuses on the role of assessment on students' understanding and talk about science. The students in this study were exposed to alternative forms of assessment which may have allowed them to talk about science in new and unique ways.

What is Alternative Assessment?

When examining the issue of alternative assessment, a clear definition of the term "alternative" must first be given. Alternative assessment can be viewed as that form of assessment (as distinct from "traditional multiple-choice, standardized achievement tests") that
directly examines student performance on significant, relevant tasks (Worthen, 1993). These alternative assessment tasks can focus on students' processes (e.g. learning logs), products (e.g. portfolios), or performances (e.g. practical lab tests). Thus, alternative assessment goes beyond traditional paper-and-pen tests which are limited in their ability to assess a wide range of science process skills and problem solving abilities (Meng & Doran, 1990).

Many alternative assessment techniques allow students to explore topics, relate understandings to personal experiences, and use narrative to convey their understandings. Preliminary research into gender differences in assessment suggests that some methods of assessment (e.g. multiple choice tests) are more appropriate for boys while others are more appropriate for girls (e.g. open-ended tests) (Bolger & Kellaghan, 1990). Use of varied assessment techniques may improve female students' achievement in and attitudes toward science. The use of alternative assessment, thus, may be particularly beneficial to female students as it allows them to exploit their feminine ways of knowing and communicating.

Goals of the Study

The purpose of this study was to investigate the attitudes of female high school science students towards alternative assessment and examine the effects that alternative assessment had on the students attitudes towards science. This study looks specifically at five methods of assessment. These methods include traditional written tests (open-ended and multiple-choice questions included), portfolios, drama, practical lab tests, and student-directed assessment. Each of these assessments will be discussed more fully in the methodology section.

I hope that other science teachers will be able to use the findings of this study in order to establish gender-equitable classroom strategies. However, I realize that females are not the only students that can benefit from alternative assessment strategies. In fact, the use of alternative assessment may be beneficial to the majority of students, male and female. Although it would be erroneous to generalize these findings to other schools and other classrooms, these findings may
be useful in advocating the establishment of assessment practices that meet the needs of all students.

Research Questions

The major research questions to be answered in this study focus on female high school students' attitudes towards assessment in science. This study asks:

1. What are the attitudes of female high school students towards the use of alternative assessment in the science classroom?
2. Does the use of alternative assessment in the science classroom affect female high school students' attitudes towards science?

Answers to these questions were not limited to those given by the students. Rather, discussions with the teacher, questionnaires completed by the students, and my own classroom observations were analyzed to gain a more complete picture of the impact that alternative assessment had in this classroom.

Significance of this Study

Attempts to narrow the gender-gap in science classrooms have been focused on instruction and achievement and have been met with limited success (Kahle, 1996). Other methods towards encouraging the participation of females in science must be examined. One method that needs further examination is the use of alternative assessment in the science classroom. Very little research has investigated the impact that assessment may have on the attitudes and achievement of female students.

In essence this study attempts to couple two areas of research that have remained relatively isolated from each other. Research that examines the attitudes and aspirations of female students has paralleled the investigation of alternative methods of assessment. However, rarely have the two areas of research been married. Those studies that have looked at gender
issues and science assessment have tended to focus on the disadvantages of multiple choice testing rather than investigating the possible advantages of alternative forms of assessment (e.g. Bolger & Kellaghan, 1990). This study takes a unique approach which brings gender research together with research in alternative assessment strategies. Thus, this study adds insight into the complexities of the gender differences that remain prominent in our science classrooms.
Science... hmmm...

Science
hmmm...
science...
beakers, test tubes, and flasks
i think science is confusing if anyone asks
so many equations 'n things to learn
people sitting around waiting for their marks
anxiously asking, "when is it my turn?"
and when in our lives will we ever need to incorporate cellular structures
so many questions to be asked
so many facts to be learned
having to learn 'n memorize these things is totally absurd
taking up my brain space
making me lose sleep
killing all my brain cells
i think my education is complete
tests, quizzes 'n exams
so many of them to study for
so little time to eat
science labs 'n experiments
now those are actually fun
the only thing that's wrong with them
is that we never do enough
although i may never be the best,

science is KINDA fun ...

~ written by a Science 9 student ~
Chapter 2: Literature Review

Introduction

Because this study attempts to integrate research on gender with research on alternative assessment strategies, the literature review section is broken into three components. The first component will ask the question, "What is feminine knowledge and how does it differ from masculine knowledge". This section will be followed by an examination of the research on gender differences in science and will attempt to answer the question, "What gender differences still exist in science classrooms?" The final component will attempt to synthesize these two components and relate them to alternative assessment practices. Essentially, the final component will probe the question, "Can alternative assessment practices incorporate feminine knowledge in a way that mitigates the gender differences present in the science classrooms?"

Component One: Feminine Knowledge

Most of us are keenly aware of the stereotypical differences of men and women. Physically, men are seen as big, strong, and tough; emotionally, men are seen as sensible, rational, problem solvers that are able to remove their feelings from a situation and focus on the facts. The opposite picture emerges of women. Physically, women are seen as weaker, smaller, and more fragile; emotionally, they are seen as sensitive, nurturing, and a little neurotic as they struggle to see facts through "veils of emotion". Men and women alike have struggled to break down these persistent images and remove gender labels and biases. But the images and labels persist. This persistence might be attributable to an element of truth in these exaggerated stereotypes. Instead of trying to remove gender differences, perhaps we should attempt to better understand gender differences. The section that follows discusses research that deals with the different ways men and women view the world and communicate their understandings.

Feminine Perspective

In general, women and men have different ways of viewing themselves and the world in which they live. Roychoudhury, Tippins, and Nichols (1995) argue that because knowledge is
Chapter 2: Literature Review

socially constructed within a "gender-stratified society", males and females will come to know and understand events in different ways. Essentially, the feminine perspective is contextual while the masculine perception is abstract.

Feminine knowledge is deeply concerned with people and real-life experiences (Belenky et al, 1997). This person-orientation provokes a feminine self-concept that is defined in terms of relationships and connections to other (Lyons, 1983) and a broader world-concept that is defined as a "complex web of inter-relationships" (Harding & Sutoris, 1987). This perspective leads women to view events as they apply to the lives and relationships of people. In keeping with this reasoning, Gilligan (1982) claims that females do not readily abstract events from their context. Context must, therefore, be an integral part of the education of females.

Males, on the other hand, are more likely than women to define themselves in terms of separation and autonomy. In contrast to her claims of the contextual knowledge of females, Gilligan (1982) claims that males are concerned with making sense of the world through abstract rules. The masculine concern with objects and rules fits more easily with the traditional objective and rational nature of science (Kelly, 1985).

Belenky et al. (1997) assert that, historically, pedagogy and curricula have been biased against women's more subjective ways of knowing in favour of males' more objective ways of knowing. This may be particularly true in the science classroom where pedagogy has focused on the memorization and application of abstract rules, formulas, and theories. To be successful in these classrooms, females have been encouraged to alienate themselves from their connected ways of knowing and develop a male perspective (Roychoudhury et al., 1995). Females have learned to adapt to the requirements of these removed, objective classrooms, and indeed many females have gone on to excel in science. However, regardless of how successful the female student is in the classroom, in terms of achievement, I am still left to wonder if her educational needs are being fulfilled.
To best meet the needs of female students, research suggests that an approach to teaching science that acknowledges female ways of knowing needs to be developed (e.g. Bentley & Watts, 1987). This feminine classroom science needs to incorporate women's connected ways of knowing by embracing the personal experiences, insights, and feelings of students. After studying 45 prospective elementary school teachers, Roychoudhury et al. (1995) found that females benefit from science teaching that embraces the real-life experiences of all students and connects those experiences with the classroom instruction. However, the inclusion of real-life experiences in classroom instruction is only the beginning. To fully meet the needs of female students, we need to change the prevailing paradigm for science education. A feminine perspective in science needs to emerge, recognizing "feelings, reactions, values, and intuitions (as) important starting points for the development of principles and theories" (Bentley & Watts, 1986a). The inclusion of this subjective knowledge (i.e. feelings, reactions, values, and intuitions) may allow female students to explore a science that is meaningful to them. Unlike males, females do not view science as a set of right answers, but rather as a means of solving society's problems and enhancing the quality of people's lives (Bentley & Watts, 1987).

The different perspectives of males and females also lead them to approach scientific problems in different ways. Harding and Sutoris (1987) have shown that when given identical problems, males and females employ different problem-solving strategies and arrive at different solutions. Thus, women may advance scientific theories that differ from the traditionally held scientific theories advanced by men (Bentley & Watts, 1987). Many examples could be given to support this point. For example, although the structure of DNA is attributed to the male scientists, Watson and Crick, it was the revolutionary work of Rosalind Franklin that formed the basis of the Watson-Crick model of DNA. Diverging from conventional methods for modeling DNA, Franklin used innovation and precision as she took X-ray photographs of DNA molecules. It was from these photographs that the now-accepted model of DNA was proposed. As scientific discovery relies on the advancement of new theories and insights, the development of a female perspective
in science would be invaluable. If this difference in approach has been shown to exist in the scientific field, it may also exist in the classroom. As such, male and female students may approach scientific problems posed in the classroom in very different ways.

**Feminine Language**

Thus far, I have limited my discussion to the need for the development of a feminine perspective in science classrooms. However, the development of scientific knowledge is not defined entirely by perspective. Lee (1997) argues that the development of scientific knowledge also involves “talking” science (i.e. engaging in scientific discourse and using scientific vocabulary). As such, language is an integral part of the development of scientific knowledge. But just as the perspective of females differs from the perspective of males, the language of females differs from the language of males. Gorman (as cited in Murphy, 1996) argues that girls prefer to communicate through “extended and reflective composition” while boys prefer “episodic, factual, commentative detail”. As males have historically dominated the field of science, this masculine style of communication has been the style that has dominated the scientific community. It may follow, then, that the alienation of female science students may be related, in part, to the use of masculine language.

The alienation in females, however, is not the only problem that arises from the reliance on masculine language in the science classroom. Because females are more comfortable using narrative descriptions than analytical expositions filled with technical language, they may have trouble expressing their understanding of science in the conventional way (i.e. traditional assessment strategies). Traditional assessment techniques in science (e.g. multiple choice tests, technical lab reports, etc.) do not employ narrative descriptions and may, therefore, prevent educators from seeing the true nature of the understanding of female students.

As both perspective and language contribute to the development of scientific knowledge, both need to be considered when examining the nature of gender differences in science.
Historically, both feminine perspective and language have been ignored in schools and in the scientific community. Many of the gender differences that appear in science education and science-related careers may be explained by the exclusion of feminine knowledge and language from scientific curricula.

Component Two: Gender Differences in Science

As a teacher in an all-girls school, I felt it was necessary to examine the literature on gender differences in science before conducting any research in my classroom. Without teaching male students, my ideas about gender differences in the classroom were developed mainly through personal experiences as a student and discussions with my colleagues. However, after an extensive examination of the literature, I became convinced that gender differences still exist in many science classrooms.

Gender Differences in Self-Concepts

Even before they enter school, boys and girls have very different self-concepts and well-defined ideas about gender roles. The masculine self-concept includes toughness, aggression, activity, and disdain for girls, while the feminine self-concept includes timidity, conscientiousness, deference, person orientation, and a concern for appearance (Kelly, 1985). When they enter school, socialization inside and outside the classroom reinforces these stereotypical views of males and females.

Because the conceptions of male and female characteristics are so dramatically different, the presumed roles of males and females in society are also drastically different. Feminine traits are seen to lend themselves to nurturing careers such as motherhood and nursing. Masculine traits are seen to lend themselves to analytic, competitive careers such as careers in business, science and technology. When high school science students are asked about the roles of men and women in society, many males, and to a lesser extent females, reveal very traditional and
rigid attitudes (Kelly, Whyte & Smail, 1987). These attitudes remain steadfast in the minds of students even after exposure to men and women in non-traditional fields (e.g. female machinists and male nurses).

As seen in the work of Kelly, Whyte & Smail (1987), science is viewed as a male domain. In a review of literature on gender issues in science, Kahle and Meece (1994) assert that both males and females consider science to be more appropriate for boys than girls. In addition, they found that traits of scientists (e.g. independence, practical ability, and self-confidence) are more often associated with masculinity than femininity. This stereotype persists, as girls are not socialized at home or at school to develop these traits (Jones & Wheatley, 1988). From an early age, it is more socially acceptable for boys to show an interest in and disposition towards science-related toys, games, and activities (Kahle, 1990). By adolescence, many females who do display an interest in science experience gender-role conflict as they struggles between what it means to be female and what it means to be a scientist (Kelly, 1987). Girls choosing science tend to have low self-esteem in terms of being socially and sexually attractive (Head, 1987). These stereotypes and prejudices that exist from early childhood through adolescence discourage many females from pursuing science and technological education and careers.

Gender Differences in Self-Confidence

Even before they reach school, differences in the socialization of males and females may affect their levels of self-confidence. Once in the classroom, these socially constructed differences in the self-confidence of male and female children may be magnified by differences in the school experiences of male and female students. Many studies have shown that girls and boys in the same classroom do not have the same learning experiences (eg. Jones & Wheatley, 1990; Jones & Wheatley, 1989). These classroom differences can be seen in student-teacher interactions, student-student interactions, and classroom behaviour.
Chapter 2: Literature Review

Student-teacher interactions.

Although few teachers would admit to treating their male and female students differently, research suggests that such differential treatment does exist in classrooms. Often unknowingly, teachers place different expectations on boys and girls and treat these students differently (Spear, 1987a). Even exemplary teachers have been observed to exhibit gender biases in instruction and assessment.

Gender biases can be seen, for example, in the amount of attention that teachers pay to male and female students. Females, on the whole, demand and receive less attention than their male classmates. Becker, Jones, and Sikes (as cited in Jones, 1991) have observed that females receive less praise, direct questions, and behavioural warnings from their teachers. In a more recent study, Jones and Wheatley (1990) documented additional gender differences in classroom interactions. They observed that females were asked less frequently than males to carry out demonstrations and use scientific equipment. In addition, females called out less often in class and asked fewer procedural questions. From this research, it could be argued that girls have less opportunity to voice their insights, have their ideas heard, and clear up uncertainties. These instructional prejudices experienced by female students may result in lower levels of confidence and achievement.

Gender biases can also be observed in the assessment practices of teachers. In general, teachers evaluate male students and female students differently, regardless of the quality of work. Spear (1987a) found that secondary school science teachers rate boys' work higher than the identical work from a girl. When girls' work was praised, it is more likely to be praised for neatness while boys' work was more likely to be praised for its content. Overall, boys tend to be praised for performance and criticized for behaviour while girls tend to be praised for behaviour and criticized for performance. Dweck (as cited in Kelly, 1987) has shown that these differential patterns of criticism and praise promote an increase in self-confidence among boys and a decrease in self-confidence among girls.
Although few teachers acknowledge these differences, research has clearly shown that male and female science students receive different treatment from their teachers. The question that remains is "Why do science teachers treat male and female students differently?" The difference may be due, in part, to the high school science teachers' belief that science is more suitable for boys than girls (Spear, 1987a) and more important to the lives of boys than to the lives of girls (Spear, 1987b). It seems logical to expect these beliefs to become apparent to female students and to affect their self-concepts and self-confidence so that they too fail to see the importance of science in their daily lives. Research would support this inference. For example, Kelly (1987) has shown that boys over-emphasize the importance of science in their lives while girls under-emphasize it.

Student-student interactions.

The erosion of self-confidence of adolescent females may, thus, be affected by interactions between students and teachers. However, the interactions between students and their classmates may be equally damaging. Through observations of British high school classes, Kelly (1985) found that adolescent boys are scornful of girls, are reluctant to assist girls in classroom work, and attempt to exert dominance over girls in whole group, small group, and lab settings. Tobin (1996) conducted similar research in the United States and found that American high school boys dominate science lab activities and equipment. Girls in mixed-sex lab groups were merely left to watch their male classmates conduct the experiment; girls in all-female groups were often left without adequate scientific equipment to conduct the experiment. Consequently, girls in these classrooms had limited learning opportunities due to their passive involvement and limited apparatus. Thus, male-female interactions within the classroom may further diminish the self-confidence of female students.
Chapter 2: Literature Review

Classroom behaviour.

This lack of confidence of female students is manifested in their classroom behaviour as females adopt a more passive role in the classroom. For example, in observations of 200 high school science classes, Tobin and Garnett (1987) found that, while in mixed sex groups, girls are less likely than boys to engage in interactions with their peers. Unfortunately, girls are also less likely to engage in interactions with their teachers and demand less teacher attention (Kahle & Meece, 1994). Because females seem less inclined to interact with their teachers or peers in the classroom, the opportunities to have their voices heard may be unduly limited.

Female students' lack of self-confidence is also reflected in their attitudes towards their schoolwork. Compared to males, females are more conscientious about their schoolwork. This high degree of conscientiousness demonstrates the low level of self-confidence held by these female students. Conscientiousness has been linked to low self-confidence as highly conscientious students tend to be more concerned about making mistakes (Kelly, 1987). Even when females experience success, they are more likely than boys to attribute their success to luck. Boys, on the other hand, are more likely to attribute success to ability (AAUW, 1992). These attribution patterns again demonstrate the gender differences in self-confidence among male and female students.

Thus, the classroom experiences of female students may further diminish female students' already low levels of self-confidence. Research suggests that this inference may be valid, as gender differences in self-confidence tend to become prevalent among adolescent students. In a study conducted by the American Association of University Women (1992), females experienced a dramatic decrease in self-esteem and confidence from childhood to early adolescence. By adolescence, females, in general, lack the confidence of their male classmates (Kelly, 1987). These changes in self-confidence may have significant effects on career and educational choices as they occur during the age that females are formulating their gender identities and career aspirations (AAUW, 1992).
Gender Differences in Science Achievement

Coupled with the emergence of gender differences in self-confidence are gender differences in science achievement. Research shows that gender differences in science achievement emerge in middle school grades and become strong by the time students reach their senior year in high school (Linn & Hyde, 1989; AAUW, 1992). Using nationally representative data from the United States, eighth-grade female students do not differ from their male classmates in science achievement tests or grades (Catsambis, 1995). However, by the time these students reach senior high school, gender differences favouring males emerge and are strongest in the areas of physics, chemistry, earth science, and space science (AAUW, 1992). It is important to note, however, that the male and female students used in these studies did not display the same patterns of course enrollment or the same exposure to extra-curricular activities. The effects that enrollment in science courses and exposure to extra-curricular activities may have on achievement is considered in a set of studies described in the following sections.

Gender differences in course enrollment.

One only has to walk into a Physics 12 classroom to become aware of the alarming disparity between the number of girls and boys enrolled in advanced physical science courses. Generally, almost everyone in the room (students and teacher) is a male. Numerous studies (e.g. Shemesh, 1990; Kahle & Lakes, 1983; Simpson & Oliver, 1985) have confirmed the obvious, finding that by middle school, females are much less interested in science than their male classmates. Females' lack of interest in science is reflected in enrollment patterns. By the time most students reach senior high school, advanced science and mathematics courses are optional, and discrepancies in science and mathematics enrollments exist. For example, in British Columbia in 1997, female high school students were much more likely to enroll in Biology 12 than their male classmates; male students were much more likely to enroll in Physics 12 and to a lesser extent Math 12 than their female classmates (BCMEST, 1997). In general, enrollment patterns show that women are more likely to enroll in "feminine" science courses (e.g. nursing...
and social science) and less likely to enroll in "masculine" courses (e.g. engineering, physics, and chemistry) than their male counterparts (Kahle & Meece, 1994).

I have often heard students and parents refer to biology as "an easy science" while physics is referred to as a "hard science". These generalizations suggest that female students may be dropping out of the masculine sciences because they perceive these as too hard. However, the gender difference in enrollment patterns cannot be explained by gender differences in achievement. Although female students, in general, lag behind their male classmates in terms of science achievement in the area of physical science (AAUW, 1992), the reverse finding may be true if the sample is limited to students enrolled in advanced physical science courses. For example, in British Columbia in 1997, although there were fewer females than males enrolled in Physics 12, those females that did enroll outperformed male students on the Physics 12 provincial examination (BCMEST, 1997). These findings suggest that the gender gap in science achievement may be due to the differential enrollment patterns of students, and not due to the abilities of male and female students.

Similar to the discrepancy found between achievement and enrollment in physical sciences, a discrepancy between achievement and enrollment may also be found in the biological sciences. Keeves and Kotte (1996) showed that females are more likely than males to take biology even though they generally did less well than males on biology tests. 1996-97 statistics from the British Columbia Ministry of Education support this finding. These statistics show that while there were more females than males taking Biology 12, males outperformed females on the Biology 12 provincial examination.

This disparity between enrollment and achievement in science suggests that the limited participation of females in senior high school courses must be related to factors other than achievement. Citing a number of European and North American studies, Kelly (1985) argues that the masculine image of science is the main factor preventing girls from enrolling in optional
science courses. She asserts that the participation in science courses is seen to enhance a boy’s masculinity while diminishing a girl’s femininity. Kelly’s assertions are supported by a report by the AAUW (1992) that states that negative peer interaction often prevents female students from enrolling in advanced science classes because such classes are viewed as more appropriate for males.

It seems evident, then, that gender differences in enrollment patterns cannot be fully explained by gender differences in science achievement. However, the corollary of this statement, gender differences in science achievement cannot be fully explained by gender differences in enrollment patterns, is equally true. Although the limited participation of females in senior high school science courses explains a substantial part of gender differences in science achievement test (Jones, 1987), it cannot explain all of the gender gap in science achievement. The gender gap in science achievement has been shown to increase during middle school grades although most males and females are enrolled in similar courses during those years (Kahle & Meece, 1994). As such, the average female student may still lag behind the average male student in terms of science achievement.

Gender differences in extra-curricular activities.

From an early age, boys are more likely to be exposed to science-related activities that can later serve to enhance their interest and success in science (Greenfield, 1996). A number of studies have shown that childhood toys, hobbies, and pastimes of boys are more likely to involve science and technology than those of girls (e.g. Murphy, 1996; Kelly, 1987). As a result, boys have greater connection and experience with science and technology even before they reach the classroom.

Once they reach school, boys are also much more likely than girls to participate in relevant science-related extra-curricular activities (Catsambis, 1995; Kahle & Lakes, 1983). This may create a gender gap in science achievement as students with greater exposure to relevant
extra-curricular activities tend to have higher science proficiency scores (Kahle & Lakes, 1983). For example, Olson (as cited in Greenfield, 1995) has shown that participation in science competitions has positive effects on science attitudes and achievement. As boys enter science competitions with greater frequency than girls (Jones, 1991), a gender gap in science attitudes and achievement may develop.

The nature of science-related extra-curricular activities also differs between boys and girls. For example, when females do participate in science competitions, they are more likely than boys to submit a display project on life science (Greenfield, 1995) and to attend to the social aspects of a science problem rather than aspects of experimental methodology (Martinez, 1992). In this way, female students' participation in extra-curricular activities related to physical science and technology is particularly limited.

Evidence, therefore, shows that the gender differences in participation in science-related pastimes and extra-curricular activities persist from childhood through adolescence. Consequently, females have fewer personal experiences with science and technology from which to draw and less opportunity to develop their science interests. It would seem obvious, then, that this lack of experience may have a negative effect on the female students' achievements, attitudes toward science, and future career aspirations.

Gender Differences in Career Aspirations

Historically, males have dominated the fields of science and technology. This trend continues even today. Jones (1991) asserts that significantly more males than females continue to enter physical science and engineering careers. Unfortunately, an examination of Canadian statistics indicates that this trend will apparently continue as we head into the next century. Statistics show that females are still dramatically under-represented among graduates obtaining degrees in engineering, applied science, physical science, and mathematics from Canadian
universities (Statistics Canada, 1997). When women do choose science-related careers, it tends to be in the biological sciences or medical-related fields (Statistics Canada, 1997; Jones, 1991).

Although there must be a number of influences affecting students' educational and career aspirations, achievement in advanced high school courses does not appear to have a strong influence over these aspirations. Female students with exceptional academic preparation and achievement in science are still choosing science-related careers in disproportionately low numbers (AAUW, 1992). Hewitt and Seymour (as cited in AAUW, 1992) found that instead of crediting past success, many women who decided to pursue scientific fields after high school credit the encouragement provided by their teachers as an important deciding factor.

The influence of science teachers on students' educational and career aspirations cannot, therefore, be overlooked. Science teachers may need to pay particular attention to the influence they have over female students. Female students' self-concept and lack of self-confidence may make them particularly sensitive to the treatment they receive in the classroom. Although these students may be in great need of praise and attention, science teachers have been found to give less praise and pay less attention to female students as compared to male students (Becker, Jones, & Sikes as cited in Jones, 1991). Consequently, science teachers may, through their lack of encouragement, be unwillingly excluding female students from advancement in the field of science and technology.

Summary of Gender Differences in Science Classrooms

This component has examined a number of the gender differences prevalent in our science classrooms. From this examination, it appears that gender-biased socialization starts at an early age and persists through a student's education. This socialization affects the confidence and self-concept of females and limits their view of women in science. Specific to the science classroom, females have been shown to have less positive classroom interactions with teachers and classmates and fewer educational opportunities. It would seem logical to assume, then, that
these gender biases affect female students' attitudes towards science as well as their educational and career aspirations. In this way, gender differences that exist in our classrooms may be discouraging females from participating in science courses and science-related activities. Ultimately, the disproportionately low number of females in science-related careers may stem, in part, from the gender differences at school.

Component Three: Gender Differences and Alternative Assessment

As my grade nine science students arrive to the first day of class, they already believe that some of them "get science" while others simply don't. They appear to make this judgement based on their personal experiences with science exams and tests. For the unfortunate students that struggle through science, science tests are a form of cruel and unusual punishment. Regardless of how hard these students study, they seem incapable of doing well on traditional science tests.

Differences in student performance on traditional assessments may be largely attributed to personality traits (Rowley, 1974) and gender (Harding, 1981; Kahle & Lakes, 1983) rather than knowledge and understanding of the context being examined. As a result of these findings, many educators have called for educational assessment reform and the use of alternative methods of assessment. The term "alternative assessment" has been given to non-traditional forms of assessing student understanding. Alternative assessment tasks can include drama, creative writing, practical lab tests, and portfolios, to name just a few. Many studies have examined these various forms of alternative assessment (e.g. Daws & Singh, 1996; Worthen, 1993). Some of this research has suggested that traditional assessment strategies (i.e. multiple choice and open-ended pen-and-paper tests) put some students at an advantage over others. Many of the students who do poorly on traditional science tests may succeed when allowed to present their knowledge in formats that diverge from these traditional forms of assessment.
Alternative assessment techniques allow students to explore topics, relate understandings to personal experiences, and use narrative to convey their understandings. The use of alternative assessment may, thus, be particularly beneficial to female students as it allows them to exploit their contextual way of knowing and communicating. These varied assessment techniques may improve female students' achievement in and attitudes toward science.

Preliminary research into gender differences in assessment does suggest that some methods of assessment are more appropriate for boys while others are more appropriate for girls (Bolger & Kellaghan, 1990; Meng & Doran, 1990). The gender biases that arise through the use of various assessment techniques will be examined in the following sections.

**Gender Differences and the Purpose of Assessment Tasks**

Murphy (1996) explains that students often fail to understand the purpose of assessment tasks because teachers often fail to emphasize it. Too often, teachers assume the purpose to be "implicit and unproblematic". Female students often feel alienated from traditional assessment techniques (Murphy, 1996) that appear devoid of purpose and direction. In order for female students to connect with and understand the content of the problem, the purpose of the assessment task must be made clear. To a greater extent than boys, girls assign purpose to tasks that differ from the purposes of the instructor. As a result, the strategies taken to complete that task and the results obtained are often at odds with those envisioned by the instructor. This dichotomy may ultimately lead to the underachievement of female students.

Unlike the traditional forms of assessment, alternative assessment strategies can be given real life applications and may improve the connection that female students have with the task. As such, both the purpose and the direction of the task become more readily apparent to the students.
Gender Differences and the Role of Assessment Tasks

The role of assessment in the classroom, whether formative or summative, can also contribute to the development of gender differences in achievement. The primary goals of formative and summative assessment are vastly different. Formative assessment aims to further learning by encouraging pupils to (i) reflect on their learning, (ii) engage in discourse with their teachers regarding their progress, and (iii) become more competent in the process of learning (Daws & Singh, 1996). In contrast, summative assessment aims to compare pupils in a norm-referenced way for selection, placement or reporting purposes (Daws & Singh, 1996).

After developing and validating the Attitude toward Science in School Assessment (ATSSA), Germann (1988) found a relationship between middle school students' success on formative evaluation tasks and positive attitudes towards science. As many alternative assessment techniques are useful for formative assessment, the use of alternative assessment may also promote the development of positive attitudes towards science.

The use of alternative assessment activities for formative assessment purposes may be particularly beneficial to female students. Murphy (1996) asserts that formative assessment could reduce the “alienation of girls from science and may narrow the gender gap in science achievement”. Two studies conducted by Kahle (1985, 1987) would support this assertion. Kahle found that teachers who had a high proportion of girls continuing to enroll in advanced science courses tended to emphasize formative assessment techniques such as lab work, discussion groups, and weekly quizzes. Thus, using alternative assessment as a means of formative assessment might not only help mitigate the gender gap in science achievement, but they may also help improve females' attitudes towards science.

Language and Alternative Assessment

As female students are less likely than their male classmates to actively participate in mixed sex groupings (Kelly, 1985; Kahle & Meece, 1994), they are also less likely to be heard.
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The dominance of the male voice may be especially problematic in the science classroom as girls are reluctant to engage in scientific discourse and more apt to passively observe such discourse (Kelly, 1985). Boys, on the other hand, are more willing to discuss science topics and use scientific vocabulary they do not understand.

Alternative assessment may give female students the opportunity to become more comfortable engaging in scientific discourse and using scientific vocabulary. Learning logs, for example, allow students to explain their understanding of scientific concepts and give students an opportunity to practice scientific vocabulary in a low-risk environment. The low-risk nature of this assessment may encourage students to actively engage in scientific discourse. Through the use of alternative assessment techniques, female students may gain proficiency and confidence in their abilities to talk about science.

Attitude and Alternative Assessment

Some alternative assessment activities allow students to explore areas of science that are of particular interest to them. In addition, these activities empower students to draw upon their unique strengths and personal experiences to explain topics in science. In a study conducted by Roychoudhury et al. (1995), student teachers were given the opportunity to explore personal interests and experiences in science. The female student teachers, in particular, relished the opportunity to explore personal interests and felt that their views were legitimized. In this way, alternative assessment may be useful in developing positive attitudes in students.

Two alternative assessment techniques, in particular, have been found to enhance learning and foster positive attitudes among females. Bentley and Watts (1987) found self-assessment to be an important feature in the learning of females. However, they found that to be effective, these self-assessments needed to be valued and taken into account by teachers. Similarly, Bentley and Drobinski (as cited in Murphy, 1996) found that the adoption of problem-solving assessment strategies improved the attitudes of female students towards science. Thus,
alternative assessment strategies may have positive influences on the attitudes of female science students.

**Gender Differences and Achievement**

Traditionally, science achievement has been measured through standardized achievement tests that rely heavily on multiple choice questions. The reliance on this form of assessment may generate gender differences in achievement, as the nature of the assessment may be more suitable for boys than for girls. Research into gender differences in assessment supports this inference. Preliminary research indicates that females experience greater success on open-ended, essay-type tests than they do on multiple-choice tests (Bolger & Kellaghan, 1990; Harding, 1981) while males tend to score higher on objective tests (Kahle & Lakes, 1983). For example, Bolger and Kellaghan (1990) tested a large sample of Irish high school students across a number of subjects (Irish, English, and mathematics) and found that males perform relatively better than females on multiple choice tests while females do relatively better than males on free response methods. Therefore, the reliance on multiple choice questions may create, rather than uncover, gender differences in science achievement.

The gender differences in response to assessment techniques may be due, in part, to the differences in the ways in which male and female students obtain and express their knowledge. As argued in component one, males and females have different ways of perceiving and learning about the world in which they live. It follows, then, that the expression of that knowledge may also differ. Female students' lack of proficiency in writing multiple choice tests has been attributed to two inherent features of the tests themselves; (1) the need to take risks and (2) the need to remember facts in isolation.

**Risk-taking.**

Multiple choice tests require self-confidence as they necessitate the selection of one correct answer (Harding & Sutoris, 1987). Similarly, when the answer is unknown, multiple
choice tests require students to take risks (Rowley, 1974). Because adolescent females lack self-confidence (Kelly, 1987; Harding, 1981), they are less comfortable selecting one response or answering questions they are unsure of. For example, in the previously mentioned study conducted by Bolger and Kellaghan (1990), males were more likely than females to guess the answers to multiple choice test questions while females were more likely than males to leave questions unanswered. Because female students lack the confidence to guess and tend to leave more unanswered questions, they will likely be outperformed by male students who possess the same knowledge of scientific content. Open-ended tests, on the other hand, afford the student the opportunity to explain the answer and allows room for qualification and hesitation (Harding, 1981). Thus, the very nature of the multiple choice test itself may result in some of the gender differences in achievement.

Isolation of the problem.

The nature of multiple choice tests also require students to recall facts in isolation without allowing them to examine the context in which the scientific content is useful (Smail, 1987a). These tests rarely allow students to explore the complexity of the problem (Harding & Sutoris, 1987). Boys may, therefore, have an inherent advantage over females in completion of traditional assessment tasks as boys tend to approach issues in isolation (Murphy, 1996). To illustrate this point, Murphy cites the work of Sorensen (1990) which investigated grade 7 students as they built model homes complete with working electrical circuits. When wiring their model houses, many seventh grade boys successfully completed the electric circuits but positioned the light switches on the outside of the house. The location of the light switches, although important in real-life, seemed irrelevant to the boys as they conducted the task. In contrast, the models built by girls showed careful attention to the design of the house. The position of light switches, home furnishings, and home decorations were deemed as important to the task as was the wiring of the electric circuits. This study exemplifies the value girls place on the context of a problem (Murphy, 1996). In order for the assessment activity to be meaningful to female students, the context of
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the problem seems essential. Open-ended assessments allow students to explore and explain the complexity of the problem and may appeal to females' connected ways of knowing.

Thus, use of alternative assessment activities may narrow (if not close) the gender gap in science achievement by allowing female students to explore and explain their understanding of scientific concepts. Traditionally, the gender differences in science achievement that have been observed have often been measured with conventional assessment techniques. These conventional techniques may be more suitable for assessing boys' knowledge (abstract, object-based) than girls' knowledge (contextual, person-oriented). Consequently, females may perform poorly on these assessments due to the nature of the test, and not due to their understanding of the concepts. As such, traditional assessment techniques may indicate gender differences in achievement even when gender differences in student understanding do not exist.

Summary of Gender Issues Related to Alternative Assessment

Alternative assessment strategies can be designed to embrace the contextual knowledge of female students. These tasks give females greater freedom to explore scientific topics in a way that is meaningful to them. The tasks allow females to relate the topics to personal experiences and insights, enabling students to probe their personal connection with science. In this way, alternative assessment may lend itself to the feminine view that sees science as a means of solving society's problems and enhancing the lives of people.

Similarly, alternative assessment activities may involve the narrative, reflective language preferred by many female students. Because students are not forced to regurgitate the technical language of scientific theories, alternative assessment activities allow students to explain concepts using the language they are comfortable with. In this way, these tasks can give female students the opportunity to gain confidence in their abilities to talk about science.
By incorporating feminine knowledge and language, alternative assessment tasks may improve the achievement, attitude, and confidence of female science students. This improvement may then lead to increases in the number of females who pursue science-related education and careers. Thus, the implementation of alternative assessment in the science classroom may expedite the shift in the view of science from that of a male domain to that of a gender-neutral domain.

While alternative assessment may benefit students by fostering achievement, positive attitude, and confidence, it may also pose some challenges for instructors. While the freedom to explore personal interests and exploit individual talents enables students to tackle problems in different ways, it may lead to varied results (Murphy, 1996). Evaluation of student work may, therefore, be difficult. Instructors must keep in mind that student work can be different without necessarily being wrong (Murphy, 1996).

Conclusion

The research indicates that male and female students differ in achievement in science (AAUW, 1992; Catsambis, 1995), enrollment in advanced science courses (BCMST, 1997; Kahle & Meece, 1994; Kelly, 1985), and participation in science-related careers (Statistics Canada, 1997; Jones, 1991). This may be due, in part, to the nature of science instruction and science assessment. Traditionally, science instruction has been objective, impersonal, and abstract. The personal nature of science and its meaning to the lives of people have been largely ignored. Not surprisingly, science assessment has also been objective, impersonal, and abstract, relying heavily on the recollection of isolated facts on multiple choice tests.

However, these traditional methodologies for the instruction and assessment of science may be incongruent with female students' preferred ways of knowing. For science to be important and meaningful for females, the feminine perspective needs to be respected. Science
instruction must embrace real problems that are important to the lives of people. To be meaningful to female students, the context in which scientific facts are important cannot be overlooked.

Similarly, assessment strategies in the science classroom need to be expanded to measure feminine knowledge. Assessment techniques need to enable students to explore the social and political importance of the scientific issues, including the feelings and emotions associated with the issue. While doing so, assessment techniques should allow students to express their insights confidently, using the modes of communication they are most comfortable with. For females, these modes of communication may include detailed descriptions and narratives.

Female students have historically been excluded from the advanced education and careers in the field of science. This exclusion may be due, in part, to the omission of feminine knowledge and language from science classrooms. Perhaps it is women's different way of knowing and communicating that is at the root of the gender gap in science. Recent interventions have been successful in reducing the gender gap in mathematics achievement, but not the gender gap in science achievement. One possible explanation might be the more verbal nature of science tests as compared to math tests (Greenfield, 1996). Because women have a different way of knowing and a different style for expressing that knowledge, it may be more difficult for women to communicate their knowledge of science as compared to math. The expression of mathematical knowledge, unlike scientific knowledge, does not rely heavily on language and may not be as sensitive to different language styles.

The inclusion of feminine perspective and language through the use of alternative assessment strategies in the science classroom may impact students' achievement and attitudes. As past interventions have tended to focus on instruction and achievement in science and have been met with limited success (Kahle, 1996), my research will focus on the attitudes of students.
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Specifically, my research will investigate the impact that these alternative assessment strategies have on female students' attitudes towards science and science-related careers.
It's hard for women to strive to be the best in this male-dominated world.

We have strong beliefs as women to be the best.

Female achievers... We should name more females every day.

When asked who role models are, some students name other women.

Quick! Name your role model?
Chapter 3: Methodology

Introduction

Research indicates that adolescent girls have less positive attitudes towards science and aspire less often to science-related careers (AAUW, 1992). Although many studies have looked at ways of improving the attitudes of female high school students toward science, few have looked at the effects that assessment may have on these attitudes. In general, there is a lack of formal research investigating the implementation of alternative assessment strategies in the classroom (Kamen, 1996). The study described here investigates the attitudes of female high school students towards the use of alternative assessment in the science classroom, in particular, and science, in general.

Alternative assessment includes a number of different strategies and has been given a variety of names. Thus, I felt it was necessary to begin this study by defining "alternative assessment" and selecting some alternative assessment strategies that were appropriate for use in the secondary science classroom.

In order to achieve these goals I conducted a pilot study in my classroom a year prior to conducting this research. During the pilot study, I explored the use of ten different assessment techniques with my female Science 9 students. After exposure to the assessment strategies, each student was asked to fill out an anonymous questionnaire, to determine her reaction to each form of assessment. Responses on the questionnaires indicated that the students that participated in the pilot study had a strong affinity for the various alternative assessment techniques. The pilot study, however, only examined student attitudes towards alternative assessment and did not include student attitudes towards science in general. In addition, attitudes were surveyed only at the end of the study. Thus, no comparison could be made between attitudes before and after the implementation of alternative assessment strategies. To address these limitations my present research includes an examination of changes in student
attitudes toward science and science-related careers. A copy of the pilot study can be found in Appendix A.

The present study expanded the scope of the original pilot study as it investigated, not only how students perceived alternative assessment, but also how this alternative assessment may have altered students' perceptions of science. The study investigated the following two research questions:

1. What are the attitudes of female high school students towards the use of alternative assessment in the science classroom?

2. Does the use of alternative assessment in the science classroom affect female high school students' attitudes towards science?

The research methodologies used in the present study were primarily qualitative. Qualitative research embodies a “naturalistic-phenomenological” philosophy which assumes that reality is socially constructed, and strives to understand the social phenomenon leading to such constructs (McMillan & Schumacher, 1997). As the development of attitudes is one such socially constructed phenomenon, qualitative research was deemed more suitable for this study. The qualitative methodologies used allowed the students to give descriptive accounts of their feelings and insights, providing a richer understanding of their attitudes towards assessment and science.

Qualitative research embodies multiple methodologies to develop a richer understanding of the socially constructed phenomenon (Denzin & Lincoln, 1994). This study made use of three separate methodologies which enabled the researcher to view the students' reactions to alternative assessment from three vantage points: the students', the teacher's, and the researcher's. As individuals are seldom able to give full explanations of their thoughts and deeds (Denzin & Lincoln, 1994), the synthesis of the three viewpoints provided a more complete picture.
To support the anecdotal comments obtained through qualitative methodologies, simple statistical data was collected and analyzed using a Chi-square test to determine the significance of the shift in students' attitudes towards science. Analysis of the statistical data provided another lens through which student attitudes could be viewed and another method to aid understanding of the context of student attitudes.

Site Selection

The study was conducted in an all-girls' private school in Vancouver. As a teacher at this school, I felt that my familiarity with the students and the staff would allow me to have a greater understanding of the context of student responses and classroom observations.

A second reason I chose to conduct my research at this school was my belief that the all-female environment would provide a low-risk setting in which female students would feel free to participate in the alternative assessment activities. The use of some forms of alternative assessment requires students to take some risks. For example, drama-based assessment is risky for many students as it forces the students to speak in front of the class. Thus, I felt it was desirable to conduct this research in a supportive environment. Research has shown that adolescent boys are scornful of and less willing to help their female classmates (Kelly, 1987). In addition, male students tend to dominate classroom interactions (Jones & Wheatley, 1989). Assuming these findings to be true, I believed that an all-girls setting would offer the female students the support they needed to participate freely in the required activities.

Teacher Selection

When asked to participate in this study, Jennifer was a new teacher who had just finished her year of teacher education. Her only prior teaching experience was as a student-teacher
during her practicum. As a recent graduate from the teacher education program, Jennifer had received some instruction in the alternative forms of assessment used in the study. Among the forms of assessment used, she had limited experience with the use of portfolios, testing, and drama. Based on her initial exposure, Jennifer believed that the use of alternative forms of assessment could benefit all students. In particular, she believed that alternative assessment strategies allow students to make use of individual talents and strengths to explain their understanding of a topic. In addition, she expressed her belief that these forms of assessment should be incorporated into all science classrooms. Her initial receptiveness to the techniques made this teacher a good candidate.

When approached about the study, Jennifer was enthusiastic about participating. I felt that this enthusiasm was going to be crucial to the success of the study due to the degree of commitment required. I felt that I needed to enlist the help of a teacher dedicated to the successful implementation of alternative assessment largely due to the time required to develop, administer, and score alternative assessment activities. I further believed that teacher support was necessary to ensure that the students approached the alternative assessment strategies with an open mind. If the teacher was skeptical of the assessment techniques, the students would likely be aware of this skepticism and might adopt this position. Without teacher support, successful implementation of these methods would be difficult, if not impossible.

Student Selection

Grade 9 students were chosen because it is at this age that gender differences in science emerge (AAUW, 1992) and females' begin to heavily question their self-concepts (Kelly, 1987). Moreover, one instructor taught all Science 9 students at the school. Although student volunteers
were in three separate classes, according to homeroom placement, all received the same
instruction and assessment throughout the study. I introduced the study to the grade 9 students
during a brief in-class presentation. A formal letter of introduction was then given to students
inviting them to participate in the study. All ninety-two Science 9 students agreed.

Role of the Researcher

As a teacher at the school, I was familiar with the school community and had previously
established a rapport with the student participants. For a period of four weeks prior to the onset
of the study, I had taught science to all of the students participating in the study. However, the
study itself was conducted while I was on a leave of absence from the school. Because the
familiarity between the students and me could influence student responses, all student feedback
was collected on an anonymous basis. Although this anonymity may not have completely
eliminated my influence on the students, it may have allowed students to answer questions more
comfortably and freely.

Alternative Assessment Strategies

The three alternative assessment strategies that were used in the study included
practical lab tests, drama-based assessment, and portfolios. These strategies were chosen, as
they each require the students to use different skills to express their understandings of a scientific
concept. Practical lab tests require students to use science process skills as they manipulate
scientific apparatus and materials. While labs themselves are not "alternative", lab assessments
of the type used in this study are rarely used in high school classrooms. Drama-based
assessment allows students to explore their connections with science while requiring them to
express these connections in front of an audience. Finally, portfolios oblige students to explain
scientific concepts in their own, non-technical language. As such, portfolios prevent students
from hiding behind scientific vocabulary. Thus, each of these assessment strategies goes
beyond the traditional paper-and-pen tests which often tend to assess student knowledge rather than understanding.

To assist Jennifer with the implementation of alternative assessment strategies, I provided her with sample assessment activities that I had developed and refined during my pilot study. Although I designed these sample activities to be used with the Science 9 curriculum, Jennifer was free to use, modify, or abandon these activities to suit her classroom needs. The following section summarizes the types of alternative assessment activities given to the students during the course of the study. A more detailed description of the assessment activities used in this study can be found in Appendix B.

**Practical Lab Test**

This form of assessment included a number of stations at which students were asked to perform various laboratory skills (e.g. make observations of a novel chemical reaction, take measurements, design and perform a controlled experiment using a variety of apparatus). Unlike regular laboratory exercises in which students work in small groups, the students worked independently during the practical lab test. Each student had a specific amount of time at each station and was then asked to rotate around the class until all stations had been visited.

**Drama-based Assessment**

Drama-based activities were widely used in the classroom throughout the study for assessment. Students were often asked to form groups and create skits to explain a particular scientific concept. Each group was usually assigned a different concept to present. Skits could be based on material covered in class or on library research and could be presented live or on video. The format of the skits varied greatly between groups. Some skits involved the students preparing a written script with roles that were acted out by the various group members. Other
skits involved the students physically displaying their knowledge of a narrow scientific concept, with or without words. These skits involved such things as the manipulation of props, mini-dialogues, and interpretative dances with running commentaries.

The teacher assessed these drama-based activities and assigned students a mark based on pre-established criteria. These criteria varied, depending on the activity, but always included marks for both creativity and scientific content. The primary role of these activities was to determine student understanding.

Portfolios

This form of assessment involved the students' establishing a folder of written work to document their learning during the year. The portfolio assessment activities involved a number of approaches during the course of the study. Initially, the students were asked to maintain a portfolio, but were not given much direction regarding what work should be included or how it was going to be assessed. After a number of weeks, most students had made very little use of their portfolios. During the second attempt at implementing portfolio assessment, students were challenged to use their portfolios to express their understanding of a unit. Students were free to include any work they wanted in their portfolios. Again, students were given little direction and made only sparse use of the portfolios. During the final attempt at implementing portfolio assessment, the students used their portfolios as learning logs. The logs consisted of their daily reflections on their learning and were used as a means of open communication with the teacher. Students frequently asked questions in their logs and received prompt answers from the teacher. All three attempts to use portfolios took place during the biology unit of Science 9 which deals with human physiology.
Traditional Assessment Strategies

In addition to using alternative assessment strategies, Jennifer continued to use traditional tests (i.e. multiple choice and short answer questions) as another means of assessing student understanding. Tests included a range of questions that attempted to evaluate knowledge, understanding, and application of concepts. Tests were given at the end of each chapter, unit, and term.

Student-Directed Assessment

At the end of the study, as students prepared for the final exam, students were given the opportunity to "display their knowledge" of any topic covered in Science 9 using any of the assessment techniques they had been exposed to during the study. For this activity, students were free to work individually or in groups.

Data collection

Three separate data collection techniques were used in the study to chart student attitudes. The multi-method approach included a survey of student attitudes, a number of interviews with the teacher, and a series of observations of classes in which alternative assessment strategies were being used. Each technique is explained in more detail in the sections that follow.

Student Attitudes

In order to assess student attitudes towards alternative assessment, students were surveyed using four separate questionnaires that were distributed over the course of one school year (September 1997 to June 1998). Questionnaires primarily contained open-ended, anecdotal questions concerning the students' attitudes towards science and the use of various alternative assessment practices. In addition, the questionnaires contained a small number of closed-
response questions that permitted a quantitative analysis comparing student attitudes toward
science before and after the study.

The questionnaires were completed four times during the school year. The first
questionnaire was completed at the start of the school year (Early September), prior to any
exposure to the use of alternative assessment techniques in a secondary science classroom.
When asked, by a show of hands, which students had used these alternative assessment
techniques in elementary school, a small minority of students indicated prior exposure to
alternative assessment (particularly portfolio assessment). However, as I am very familiar with
the instructional and assessment strategies at this school, I know that none of the students had
used any of the alternative assessment techniques in high school science courses. The second
questionnaire was completed immediately after students had participated in a practical lab exam
at the end of the chemistry unit. The third questionnaire was completed after students had
submitted a number of portfolio entries and participated in a number of drama exercises. The
final questionnaire was completed at the end of the school year. All questionnaires were
completed during science classes while I was present to enable me to answer any questions
posed by the students or the teacher.

Questionnaires were chosen to survey student attitudes to for two reasons. Firstly, the
use of questionnaires provided an efficient means of collecting data as they allowed a greater
number of students to be surveyed in a shorter period of time. Secondly, the design of the
questionnaires allowed for anonymity. As I was familiar with the students, I felt that students
might not be truthful in their responses unless their anonymity was ensured. Thus, each student
participating in the study was assigned a random student number. Student responses were
identified only through these student numbers.
Chapter 3: Methodology

Teacher Response

The study also investigated the reactions of the teacher who was working to implement alternative assessment. Teacher feedback was obtained through a number of ethnographic interviews I conducted with the teacher. Data was collected via notes made during these interviews, as the teacher did not wish to be audio-taped. Interview notes were read back to the teacher to ensure accuracy.

The interviews were semi-structured and conducted informally, allowing the teacher and I to engage in open discourse. Although interview questions were constructed prior to the interview, the interviews often strayed from these interview questions. This semi-structured format enabled the teacher to ask questions and receive feedback regarding the implementation of alternative assessment techniques. The informal nature of the interview also gave me new insights as the teacher identified and discussed topics that she felt were important, a number of which were not included in the interview questions.

Classroom Observations

I observed twenty-four classes (8 classes with each homeroom) during the course of the study. My observations served two roles. Firstly, I observed a number of classes to ascertain how the alternative assessment activities were being implemented in the classroom. To do this, I observed the teacher as she gave directions to the students, observed the students as they participated in the activities, and reviewed the evaluation criteria used by the teacher during these activities. As the teacher was inexperienced with many of these assessment activities, my observations were made to assist her in implementing these activities. Secondly, I observed the student-student interactions and the student-teacher interactions during the alternative assessment activities. Observational field notes were made during these classes and shared
assessment activities. Observational field notes were made during these classes and shared with the teacher at the end of each class. Informal discussions between the teacher and me stemmed from these observational periods.

Limitations

This study was undertaken to provide insight into the impact that alternative assessment strategies can have on female high school science students. However, the findings of this study are very contextual, and may not be applicable to other school settings.

The sample of students used in this study is unique and is not necessarily representative of the population at large. Although the sample of students represents a range of different racial and ethnic groups, the socio-economic backgrounds of the students are less diverse. In spite of the fact that the socio-economic backgrounds of the students in the study varies greatly, the majority of the students come from middle class to upper-middle class families. One or both parents of many students are educated professionals. Thus, the students selected for the study may have different familial expectations than other students of their age group.

Students used in this study may also vary from the student population at large in terms of their academic achievements. Students applying to the school must complete an entrance exam. Student achievement on this exam is one of the criteria used for accepting students. Although the students that are accepted represent a range of academic abilities and achievement, few students can be classified as learning disabled. In addition, students must be proficient in English to attend the school. Although some students have English as their second language, all students can speak and read English sufficiently such that extra English assistance is not needed. In general, the school is composed of high-ability students.
Thus, the students that participated in the study do not represent a truly random sample with respect to socio-economic backgrounds, parental education, or academic achievements. Caution must, therefore, be taken when attempting to generalize the findings of this study.

A final concern of the study is that of researcher-subject familiarity. As a teacher in the school, I was known and respected by the students. It may be expected, then, that student responses might be biased, as students might attempt to give responses that would please the teacher-researcher. In an attempt to eliminate this bias, students were encouraged to respond honestly by assigning each student a random student number that was used as the only means of identification on student questionnaires. Upon reviewing student questionnaires, it appeared that responses were truthful as a wide variety of responses were evident. With each method of assessment, both positive and negative responses were received.

Summary

This study used a number of qualitative methodologies to develop an understanding of the attitudes of a select group of female high school students towards the use of alternative assessment in the science classroom. My observations and those of the teacher augmented the students' explanations by adding their perspective of how the students received the alternative assessment strategies. Viewing student attitudes through a number of lenses provided a richer understanding of student attitudes.

The possibility that alternative assessment strategies influence student attitudes towards science was also investigated through the collection of anecdotal remarks and supported by a statistical comparison.
Taking the Test

The bell rings for Science class to begin
And our not so geeky Science teacher comes in
My palms start to sweat and my heart skips a beat
As our teacher quickly hands out our test sheet
I look over the first section of the test
And then I stare blankly at the rest
What? Compare and contrast?
About Alkali and the Noble gas?
Science sure makes you think
And write so much that you run out of ink
Explaining the reason behind how things work
And why some creatures slither and lurk
Over my shoulder, I look around
Everyone is writing and not making a sound
I close and my eyes and suddenly...BLAM
Of everything I studied, I remember all I can
This isn’t difficult when you studied hard
Memorizing the periodic table with flash cards
Luckily I finish the test in time
To end this poem sadly with no rhyme

~ written by a Science 9 student
Introduction

When I first approached Jennifer about my study, she was enthusiastic about participating. However, she had some initial concerns over the amount of time it would take to develop, administer, and score the alternative assessment activities. We agreed that I would provide her with sample assessment activities that I had developed and refined during my pilot study. In addition, I agreed to provide her with assistance with the implementation of the activities and with developing criteria for assessing student understanding and assigning grades.

The sample activities that I gave to Jennifer prior to the study were designed to be used with the Science 9 curriculum. She was free to use these activities as they stood, modify the activities to suit her classroom, or abandon the activities and develop her own. After reviewing the activities, Jennifer felt confident in her abilities to incorporate them into her units. However, Jennifer did experience a few problems during the initial weeks of the study as she attempted to implement the alternative assessment strategies. The assessment-specific problems Jennifer encountered will be discussed later in this chapter.

The following sections will also summarize and discuss the students' attitudes towards each form of assessment used in the study. The students' reactions to each assessment strategy were investigated from three perspectives, namely that of the students, the teacher, and the researcher. The results are presented in the following sections according to the type of assessment used. Before describing the reactions to each assessment strategy in detail, I have begun by including a synopsis of student responses from the questionnaires so that comparisons can be made between the different strategies. Table 1 will be referred to during the discussion of each specific assessment strategies.
Table 1. Student Attitudinal Ratings of Alternative Assessment Strategies

<table>
<thead>
<tr>
<th>Percentage of students who felt assessment...</th>
<th>Portfolios</th>
<th>Drama</th>
<th>Practical Lab Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Was likeable</td>
<td>77%</td>
<td>94%</td>
<td>89%</td>
</tr>
<tr>
<td>Was suitable</td>
<td>75%</td>
<td>90%</td>
<td>95%</td>
</tr>
<tr>
<td>Conveyed understanding</td>
<td>69%</td>
<td>78%</td>
<td>88%</td>
</tr>
<tr>
<td>Improved understanding</td>
<td>52%</td>
<td>89%</td>
<td>76%</td>
</tr>
<tr>
<td>Made science more enjoyable</td>
<td>70%</td>
<td>96%</td>
<td>93%</td>
</tr>
</tbody>
</table>
Chapter 4: Findings

Portfolio Assessment

Classroom Observation

When portfolio assessment was first introduced, portfolios were to be used to document student learning in Science 9. The teacher discussed the concept of portfolios with the students at the beginning of the year, but only occasionally referred to them during class. The onus was placed on the students to add work to their portfolios as the unit progressed. Students were given complete freedom to submit whatever work they believed documented their learning in the course. Beyond the initial explanation, no further directions or guidance were given to students regarding their portfolios.

Occasionally, students were given time at the end of class to update their portfolios. These opportunities to develop their portfolios seemed to occur only when the teacher finished class a few minutes early and had no other work for students to complete. On these occasions, students seemed to react very negatively to the assessment. Many of the students audibly complained about the portfolios, referring to them as "useless" and "wastes of time". Most students begrudgingly took their portfolios to their desks and then proceeded to chat with their neighbours. Students seemed to have a very cavalier attitude towards portfolio assessment and put very little effort into them. By the end of several weeks, most of the portfolios remained empty.

It appeared that the biggest problem encountered in the classroom was neglecting to give students sufficient direction or class time to develop their portfolios. As a result, the students appeared confused about what to include and uncertain of the teacher's expectations.
Teacher Perspective

Initially, Jennifer felt very confident about her abilities to implement portfolios as an assessment measure. During her year of teacher education, there was an emphasis placed on using writing samples to assess student understanding and to enrich student learning. As a result, she decided that portfolios would be a safe place to start her journey into alternative assessment.

However, she found her initial attempts at portfolio assessment to be more challenging than she had anticipated. She was keenly aware that her students were putting very little effort into their portfolios and getting very little out of the process. She was disappointed with their final products and their negative attitudes towards this method of assessment.

Jennifer began to question the effectiveness of using portfolios as an assessment tool. She did not feel that the portfolios produced by her students gave her any insight into their understanding. And as

Student Perspective

Students responded very negatively to these initial attempts at portfolio assessment. They questioned the rationale behind portfolios and indicated that they did not believe portfolios should be used as an assessment tool. The overall feeling of the students towards portfolios can be captured by the reflections of one student who wrote, "I hate portfolios. They're a complete waste of time. It doesn't help me learn. And you never know what to put in it so you just you don't bother. It's not like they're ever collected so who cares?"

Some students even went as far as indicating that portfolios turned them off of science. One student wrote "It was boring so it caused me to not want to think about science". Another student wrote that portfolios made her "dislike science".
student submissions were previously marked assignments, Jennifer did not feel she could assign a mark to the portfolio. In her mind, this would be akin to counting good assignments twice. The only mark she felt comfortable assigning was a mark for completeness. Not surprisingly, it was not long before Jennifer also developed the attitude that portfolio assessment was a waste of time.

Classroom Observation

After a few unsuccessful weeks, Jennifer altered the way portfolios were used in her classroom. She and I had a few discussions and developed a new strategy for implementing portfolios into her classroom. Instead of documenting student learning over a unit, she decided to use portfolios as an informal means of communicating with her students. She did this by emphasizing the use of portfolios as learning logs. She made time for the students to write in their logs at the end of almost every lesson. In their logs, students were asked to write their understanding of the lesson in their own words and were free to ask the teacher questions. Logs were handed in almost every day. Jennifer would review the logs, make comments where necessary, and attempt to answer any questions asked. The only mark assigned to the logs was one for completeness.

When portfolios were used in this way, the attitudes of everyone in the class seemed to improve. Gone were the negative comments and persistent groans that had earlier plagued the classroom whenever the word "portfolio" was mentioned. Now, when class time was given to work on the portfolios, students would review their last log entry and any teacher comments and
then work diligently on their new entry. Students worked independently and remained completely
on task (an amazing feat for high school students!).

Teacher Perspective

Once Jennifer modified the role of the portfolio in the class so that they were regularly used as learning logs, her attitude towards this method of assessment became much more positive.

Jennifer expressed the belief that, as students were expressing their understanding in their own words, the learning logs gave her a richer understanding of each student's knowledge. The logs allowed her to comment on this knowledge as it was building and enabled her to address any problems as they arose. In addition, Jennifer commented that the logs enabled her to "hear" every student, not only the few students willing to express their thoughts out loud during class. Thus, Jennifer felt that the logs were valuable assessment tools. She felt in a traditional classroom setting she was unable to assess every student's understanding in this way, partly due to time constraints and partly due

Student Perspective

Once portfolios were used as learning logs, the attitude of students towards this method of assessment improved remarkably. Most students indicated that they felt portfolio assessment was an enjoyable, worthwhile form of assessment (see table 1).

The perception held by many students seemed to be that portfolio assessment was an easy form of assessment. However, students differed in how this perception affected their overall attitudes towards the assessment. Although many students indicated that they liked portfolio assessment because it was easy, other students stated that they disliked it for the same reason. The latter students found the portfolios unduly simple and perceived them as being "tedious" and "boring". One student wrote, "No offence, but I can't stand learning logs. It's so boring and dull". Because these students failed to
Chapter 4: Findings

to the students' inhibitions of speaking in front of the class. In her opinion, portfolios solved both of these problems, giving her timely insight into her students' understandings.

Jennifer also indicated that she felt the benefits of portfolios extended beyond their use as an assessment tool. Rather, she believed that portfolios also worked to increase student confidence, enhance student learning, and foster positive student-teacher interactions.

Jennifer noticed that when students first made log entries, they were likely to recap the day's lesson in scientific terms. However, over time students were more apt to express their knowledge in their own words. Jennifer believed that the students gained confidence in their ability to express their own understanding through the use of the logs, commenting that the students seemed to gain the ability to "speak their minds". She attributed this increased confidence to the informal nature of the log and to the fact that the log entries were focused on a small amount of information.

find the portfolios challenging, they failed to see their relevance.

When a comparison of assessment techniques was made, portfolio assessment was rated unsuitable with far greater frequency than any other method of assessment studied (see table 1). This may be explained, in part, by the perception of portfolios as unchallenging, as mentioned above. It may also be explained by the students' perception that although the portfolios foster learning, they do not allow the student to accurately display knowledge to the teacher. One student captured this sentiment when she wrote, "It does not assess how well we understand. It just helps us understand it." These students felt that the portfolios could be used in the classroom to enrich student learning, but did not think that they should be used to assess student understanding.

Although the reaction to portfolio assessment was less positive than to the other assessment techniques (see Table 2), most students still rated the assessment strategy favourably. The most positive
This increase in confidence not only strengthened the students' ability to verbalize their thoughts, but it also allowed the students to explore new areas of science and to tap into their personal experiences. The teacher noticed that students soon used the logs to express their interpretation of the concept, even if it differed from the interpretation given by the teacher. Further, she noticed that students began attempting to link the day's lesson with their own experience. These varied interpretations and past experiences gave rise to new insights and unique observations. Jennifer admitted that the students often brought up questions or topics that she normally would have omitted. She often raised these new issues as the starting point for the next day's lesson.

In this way, Jennifer believed the portfolios allowed the students to develop a deeper understanding of the curriculum. By using their own language and by exploring their outside-of-school knowledge, the students were able to internalize the information and make connections with the curriculum. She argued that this led to student comments about portfolio assessment seemed to concern the students' feelings rather than the students' academics. The majority of students claimed that the use of portfolios made science more enjoyable as it gave the students the opportunity to write out what they "feel". Most students welcomed the opportunity to express their thoughts and feelings informally.

A number of students also commented that they enjoyed being given the occasion to ask the teacher questions privately. One student wrote that she liked portfolios because "you get to ask questions so you won't be embarrassed asking them in class".

In contrast to these positive comments, a few students wrote that they felt hesitant about writing in their logs because it was "hard to think of things to write because I'm not sure if what I'm going to say is important". This displays the insecurity many students feel towards expressing their own thoughts either to the teacher or in front of the class.
improved understanding and greater retention of the information. To confirm this belief, Jennifer examined responses given by students on open-ended test questions. She asserted that the student responses on such questions improved after implementing the learning logs.

On a more personal level, Jennifer felt that the logs strengthened the relationship she had with her students. She was able to respond to each student individually and privately. The portfolios became open dialogues between teacher and student. She believed that it was important to make occasional comments in each student's log to show the student that she was "listening to what they had to say". Jennifer felt that her comments helped validate the students' thoughts.

The use of portfolios did not come without problems. Jennifer's problems lay primarily with developing a classroom routine that included portfolios. She expressed frustration with the amount of time and effort required developing a routine that made use of the learning logs on a

Overall, students seemed to be somewhat ambivalent to portfolio assessment. Although they rated portfolio assessment favourably on their questionnaires, their anecdotal comments were less than overwhelmingly positive. Most students seemed to see the merit in using portfolios to enhance students learning; however, few seemed to see the merit in using portfolios to assess student understanding.
regular basis. In addition, she expressed some concern over the time required to read the almost daily entries. She conceded, however, that the time it took was worthwhile. She believed that the improvement in student learning was so marked that it warranted the extra time needed. Jennifer indicated that she would definitely continue to use portfolios as learning logs in the future.

What does this all mean?

Looking at portfolio assessment from the three perspectives, the picture that develops remains hazy. The teacher felt the portfolios were invaluable, as they allowed her to assess every student's understanding as expressed in their own words. She did not see any other method of assessment as affording her this opportunity.

However, the students were less convinced of the usefulness of portfolios as an assessment strategy. A review of student questionnaires reveals that the students' biggest complaint was the monotony of the portfolios. Perhaps, by using portfolios in the classroom every day, the teacher went overboard in her attempts to implement a regular routine that included portfolios. Any assessment strategy may become tedious if used every day. And as one of the teacher's main concerns was the amount of time it took to read and respond to the entries, cutting back on the use of portfolios may also serve her needs.
Chapter 4: Findings

The tedium of portfolio could also be combated through the use of thought-provoking questions. These questions may challenge the students, altering their perception of portfolios as unchallenging and boring.

From teacher and student comments, it appears that the use of portfolios as learning logs can be an effective way to open the lines of communication between teacher and student. Both the students and the teacher seemed to relish the opportunity to communicate informally and relate one-on-one. The logs seemed to give the students a greater voice and give the teacher a greater insight into that voice.
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Drama-based Assessment

Classroom Observation

I observed a number of drama periods over the course of the study. Students performed a number of different types of drama-based assessment (hereafter referred to as “drama”) activities during these periods. Some of the activities included skits with full script, enactments with and without scripts, and even interpretative dances. All drama activities could be done individually or as a group and could be performed live or presented on video. Without exception, all live performances were done in small groups. The few students who chose to work independently presented their work as a video that was shown to the class.

During the initial observation periods, I noticed that students were given very little direction regarding assessment criteria. This lack of criteria may have led to less than satisfactory performances (i.e. performances that were entertaining but not overly useful in assessing student understanding). As Jennifer became more experienced with this assessment technique, the criteria given improved, and the students became more successful in demonstrating their understanding.

On the whole, the students and the teacher seemed to thoroughly enjoy this form of assessment. However, students did seem somewhat apprehensive at the beginning of each drama period and were reluctant to volunteer to present their skits. Often, the teacher had to call on a group to present the first skit. Once one or two skits were presented, students seemed to relax and were much more willing to volunteer to present. Once presenting, most students seemed to enjoy performing in front of the class. Their initial reluctance many indicate a lack of confidence in acting in front of their peers.
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Some students never seemed to get over their initial apprehension. It was obvious that these groups felt uncomfortable presenting to their peers from start to finish. It was only when they were finished that these students seemed able to relax. To alleviate their apprehension, these students often chose to present their information in the form of a video.

Regardless of their feelings while presenting themselves, all students seemed to enjoy watching the presentations of their peers. Students were extremely courteous of the other groups. The student audience laughed only when appropriate, did not talk during skits, and participated when prompted to do so by the students presenting. Student talk was limited to the times between skits when groups were setting up. In addition, students congratulated each other after each skit and made positive remarks to the students who had just presented. The overall mood of the class was one of complete acceptance. Peer evaluation of skits, however, indicated that despite the positive environment, all skits were not viewed positively. Students seemed able to congratulate their peers for their efforts, rather than for the quality of their presentation.
Chapter 4: Findings

Teacher Perspective

Jennifer's attitude towards drama was very positive. Although she initially found it difficult to give the students concrete evaluation criteria, she was quickly able to develop guidelines to help her students and herself evaluate the performances.

Once the problem of evaluation was solved, her primary concern was with giving feedback to the students. She found it difficult to respond to any misconceptions that may have become apparent during a skit. She felt compelled to let the skit continue and tried to respond to any misconceptions after the skits had all been completed. She was cognizant of the fact that it took courage for the students to perform in front of the class and was leery of pointing out any of the errors made during any of the skits. She tried to generally review the information presented, stressing areas that may not have been clear during the presentations. She also found it difficult to give each group meaningful feedback on their presentations. After trying a number of

Student Perspective

The students' reactions to drama were very positive. The vast majority of students stated that drama made science more enjoyable. Students explained that drama made science "fun and interesting" and, therefore, "helped (them) understand concepts and remember information".

Many students claimed that they enjoyed the use of drama. These students indicated that they relished the opportunity to express themselves and add their own personal style to their explanation of the scientific concepts. Along these lines, one student wrote that she enjoys drama because "you can express a concept in your OWN way, the way you see it".

Many students felt that drama allowed them to truly express their understanding of a concept. One student commented that drama "is a good way to assess because on a test they just write things down, but they may not understand what they are writing. With drama they have to explain so you can see if they really
different methods, she found that collecting a script from each group was the most effective techniques. She was able to respond to the information presented in the skit by making comments on the script itself.

Overall, the teacher felt that once the problems of establishing criteria and providing feedback were solved, drama became an effective, valid, and enjoyable form of assessment. She felt that drama improved her ability to assess student understanding and make the image of science less sterile. In addition, she felt that it improved the students’ confidence and enhanced the inter-personal relationships within the class. The teacher was very supportive of drama and thought that she would continue to use drama in the future.

Along the same lines, another student wrote that drama is “fun and it causes you to think about science and talk about it with your classmates. Sometimes you discover that people labeled as 'not good' at science know more about it than you.”

Many other students commented that they enjoyed being able to “interpret what you learn” through drama activities. Thus, drama seemed to be valued not only for its ability to express concepts, but also for its ability to express personal feelings and interpretations. By adding their own interpretations and feeling to their science, many students felt more connected to the scientific concepts. One student explained that drama made the students “a part of science”.

Of the students who did not enjoy drama, most explained that they felt nervous and uncomfortable acting in front of the class. One student commented "I hate acting and I can’t act. I would concentrate too much on how to make it funny." This sentiment was echoed by a number of
students who commented that they were more concerned with entertaining than with explaining the concept.

A small number of students also indicated that they felt that drama was an unsuitable form of assessment. Many of these students felt that students lost sight of the scientific concept as they focused on entertaining the class. Other students who rated drama as "unsuitable" explained that drama was "not really science". These students felt that science assessment had to be "more serious" and "more scientific".

These negative comments, however, were not widespread as most students rated drama as a suitable form of assessment that enabled them to express their understanding while enriching their comprehension of the material.
Chapter 4: Findings

What does this all mean?

By examining the three perspectives, drama assessment emerges as a very enjoyable, suitable form of assessment. Both the teacher and students seemed to value the role that drama played in science assessment. Overall, it was rated as the most preferred method of assessment used in the study.

The biggest problem associated with this technique seemed to stem from the lack of established criteria. The students seemed to be unaware of teacher expectations and confused about what to include in their presentations. This was reflected in a number of student comments as they wrote about "missing the point" of the skits and getting carried away with entertaining rather than explaining. Marking criteria was equally hazy. The teacher struggled to develop a system whereby students could be assessed for understanding and then given feedback regarding this assessment. Once the teacher was able to develop such a system, drama assessment seemed to become more useful for both the students and the teachers. A description of the drama-based activities used in this study can be seen in Appendix B.
Chapter 4: Findings

Performance Assessment: Practical Lab Test

Classroom Observation

At the end of the chemistry unit, the students were given a practical lab test to assess their scientific skills. A sample of the practical lab test items can be seen in Appendix B. On the day of the test, the teacher and the students seemed very apprehensive as they waited for the test to begin. Neither the teacher nor the students had ever been exposed to this form of testing prior to this study. As students milled around before class started, they talked to each other about what kinds of questions they were expecting, how hard the test might be, and whether or not they thought they would do well on the test. Most students expected the test to be very difficult. Many students also indicated that they believed they would fail. The teacher seemed equally nervous in the final minutes before commencement of the test. She asked a number of logistical questions and seemed concerned about the order of things. This trepidation was somewhat surprising to me since I had given her a great deal of support in the design, administration, and scoring of the practical lab test.

As students began the test, most remained nervous. During the course of the test, however, students visibly relaxed. And by the conclusion of the test, students seemed happy and excited. After the test was finished, many students made comments to each other indicating that they were surprised to find the test fun and easy. In general, students seemed to thoroughly enjoy this form of assessment. The teacher also seemed to warm up to this form of assessment as she watched the ease with which the practical lab test was conducted.

<table>
<thead>
<tr>
<th>Teacher Perspective</th>
<th>Student Perspective</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jennifer initially approached the practical lab test with a great deal of</td>
<td>Immediately after completing the practical lab test, student opinions were</td>
</tr>
</tbody>
</table>
apprehension. As she had no prior experience with this form of performance assessment, she felt somewhat overwhelmed by the logistics of administering such a test. Among her concerns were concerns over (1) the time required to set up the stations, (2) the difficulty of making up appropriate questions, (3) the logistics of having 31 students rotating around the classroom during the test, (4) the quantity of equipment required to conduct such a test, and (5) the difficulty with supervising all 31 students during the test. As a result of these concerns, I assisted her greatly with the development, administration, and scoring of the practical lab test.

After the lab test was complete, Jennifer had mixed emotions about this form of performance assessment. She believed the test to be very relevant as it allowed her to assess each student's scientific skills in practice rather than in theory. She further believed that the test gave students the opportunity to develop confidence in and proficiency at laboratory skills. However, Jennifer did not believe that she would use

surveyed with a student questionnaire. Overall, students indicated that they enjoyed the practical lab test and felt that it was a meaningful form of assessment (refer to table 1).

The vast majority of students liked the practical lab test and felt that this form of assessment had made science more enjoyable. The comments of many of the students are reflected in this quote from one student's questionnaire which said that the practical lab test was "fun and interesting because it allowed me to do science".

When asked to explain why they liked the practical lab test, students gave the "hands-on" approach of the test as the primary reason.

Many students also indicated that they enjoyed the opportunity to work with the materials and apparatus on their own. As most labs done throughout the year were conducted within lab groups, the practical test was a rare opportunity for some of the students to manipulate the apparatus and practice laboratory skills. One student wrote, "I like how we get to do things on your
Chapter 4: Findings

this form of assessment in the future. She felt that the practical lab test was too large of a logistical challenge. She did not have confidence in her ability to effectively use this form of assessment without support.

own. Because we always do labs in a group, we never usually get to do everything.” Along the same lines, another student commented that the practical lab exam was good because “some people just let all their lab partners figure things out but when we do this they have to think for themselves”. Many other students expressed similar sentiments to these comments. Students seemed to perceive the practical lab test as a fair and suitable form of assessment because it makes them rely on their own skills and knowledge and “forces (them) to pay attention during labs”.

Students also indicated that they preferred the practical lab test to more traditional written tests. Many students felt that unlike written tests, which assess a student’s ability to memorize, the practical lab test evaluated each student’s understanding. They, therefore, viewed this strategy as a valid means of assessment. Many students indicated that the practical lab test also enriched their learning. They believed that because the lab test relied on understanding and not memorization, it
improved their retention of information. Many students commented that information that is memorized and not used is soon forgotten. One student wrote, “I enjoyed this lab exam because it was more hands-on and it tested our knowledge that we had without having to study much. Usually, when I study for an exam, I remember everything that I have studied [only] until the test is over.”

Despite the overwhelming positive responses of the students towards the practical lab test, a small percentage of the students indicated that they did not like this form of assessment. Most of these students indicated that they found the practical lab test too stressful because they were unable to get help from their lab partners. One student indicated that she felt that the lab test was difficult because “now you have to know what you’re doing during lab activities”. These students indicated that they preferred to work in groups. While working along, these students were scared that they would make mistakes that they could not fix and were apprehensive about damaging the equipment. One student
expressed this concern as she wrote, “Labs make me nervous because I’m scared to break something of big value or screw it up”. Another student emphatically exclaimed, “Ack! I feel so pressured working on my own”. It appears as though working alone is an asset for most students, but it is also a point of concern for other students.

Overall, the introduction of a practical lab test was well received by the vast majority of the students. These students indicated that they enjoyed the lab test and saw its merit as an assessment tool.

What does this all mean?

By looking at the practical lab test from three perspectives, an overall positive picture of this form of performance assessment emerges. Both the teacher and students seemed to see the value of this form of assessment. They believed that the practical lab test allowed the teacher to assess scientific skills in ways that traditional tests could not. As the development of scientific skills is a cornerstone of the provincially mandated curriculum, practical lab tests should be regarded as an important component of a teacher’s assessment plan.

In the classroom, the only real obstacle standing in the way of implementing practical lab tests, is the logistics of designing, administering, and scoring the test. However, a few
modifications to the implementation of this form of assessment may encourage the teacher to use this technique in the future. For instance, a practical lab test could be conducted informally over a number of laboratory sessions to reduce the number of students being tested at any one time. Alternatively, students could rotate through one or two practical lab questions that are set up as stations during traditional tests.
Chapter 4: Findings

Student Directed Assessment

The final alternative assessment approach used with the students during this study was done at the end of the year as students were preparing for their final exams. This student-directed assessment challenged students to display their knowledge of any topic that had been covered during the term. To accomplish this objective, students could select and use any assessment method they wanted to express their knowledge. In addition, students were given the choice of working alone or in groups.

The student-directed assessments completed by the students covered a wide variety of topics, including topics in biology, astronomy, and physics. The methods chosen by the students to display their knowledge included drama, research papers, and writing samples (similar to writing samples that were used in the portfolios).

<table>
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<tr>
<th>Teacher Perspective</th>
<th>Student Perspective</th>
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| Jennifer indicated that she enjoyed the freedom that this assignment offered the students. She felt that many of the groups expressed their knowledge in a way that she could never have imagined. Students were not limited by her guidelines or by set criteria. Unlike other assignments that had criteria that were well established by the teacher, in this assignment the criteria were established by the students themselves. | Student reactions to this assignment were all very positive; there was not a single negative response made by any student. Students appeared to relish the opportunity to choose the topic and the mode of assessment. They felt that this choice allowed them to pick an assessment technique that was suited to their talents and to the topic of interest. Many students indicated that they "learned more and tried
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However, Jennifer admitted that a lack of consistent criteria (i.e. the consistent criteria that could be imposed by teacher-directed assessment) posed a problem when it came to evaluating the assignments. Evaluation became holistic as each group chose a different topic and presented it in a different way. Jennifer felt that this lack of consistent criteria was a problem that could be overlooked, as she believed that the grade assigned to this assessment was not pertinent. Instead of viewing the assessment as a means of obtaining a grade, she viewed the assessment as a way of gaining insight into student understanding prior to the exam. In addition, Jennifer felt that this form of assessment gave the students the freedom to explore topics, enhancing their understanding and interest.

Jennifer also discussed her belief that the choice given to the students using this assessment approach could benefit the students in ways beyond improving their understanding of scientific concepts. By giving students choices, Jennifer believed she was giving them a platform to use their strengths and be successful. In addition,
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she believed that choice allowed the students to have greater ownership over their learning. She believed that increased success and greater ownership would lead to greater self-esteem and confidence in the classroom.

Jennifer, therefore, believed that this assessment strategy had benefits both inside and outside of the curriculum. She believed that it was successful in fostering positive attitudes towards science as well as improving student and teacher understanding. She claimed that she would definitely make use of this assessment technique in the future.

However, due to the problems with assigning grades to the students, she felt that the technique would have limited use in the classroom. It would become part of her assessment plan, but not used to the exclusion of the other techniques.
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Jennifer also commented on the types of assignments handed in by the students. She expressed surprise over the large number of students who chose physical science and astronomy topics. Interestingly, she had anticipated that the female students would focus primarily on medical and biological topics.
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Traditional Assessment: Written Tests

Although Jennifer focused on using alternative assessment techniques to evaluate student understanding, she continued to use traditional testing throughout the study. Tests were given at the end of each chapter and at the end of each unit; a comprehensive exam was given at the end of each term (twice per year). The tests included a variety of question formats (multiple choice, open-ended short answer, fill-in-the-blank, etc.) and attempted to evaluate knowledge, understanding, and application of concepts.

Classroom observations were not made during in-class tests. Jennifer and I discussed at length whether students should be observed as they wrote their hour-long tests, and we decided that it was not necessary. We believed that this procedure would be unduly stressful on students and provide me with very little information. However, at the end of the study, I interviewed Jennifer and surveyed students through questionnaires to determine their attitudes regarding written tests.

<table>
<thead>
<tr>
<th>Teacher Perspective</th>
<th>Student Perspective</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jennifer felt that testing was necessary. She felt that part of her job was to prepare her students for government exams and for university. She, therefore, felt that the students must be practiced in the art of test writing. She felt frequent tests and comprehensive exams would help the students master their test writing skills.</td>
<td>Students' attitudes towards tests were surveyed at the beginning and end of the study. Over the course of the study, students' attitudes remained fairly static. Similar to the belief of their teacher, students felt that tests were necessary. They believed that teachers were mandated to give tests in order to fulfill curriculum requirements. Although they rated tests as the least preferred method of assessment (see Table 2), they saw tests as the only true way of assessing student...</td>
</tr>
</tbody>
</table>
order to accommodate these students, it is necessary to give tests. A balanced classroom, in her opinion, should include as many assessment techniques as possible, including tests. She was positive that she would continue to test in this manner in the future.

Students also felt that tests were necessary because they motivate the students to study. A number of students commented that tests "force students to study" and are the only way to motivate students to learn the material.

Although the students believed that tests were a necessary part of school life, they saw tests as being long and difficult. The students primary concern lay with the vast amount of information they felt they had to memorize. Many students felt that this information would be remembered for the test and then forgotten the very next day; they felt that tests evaluated memorization skills and not understanding.

Students also found tests very stressful. Many students stated that the stress hindered their performance on tests. These students felt that the high levels of stress during the tests caused them to forget understanding. From their comments, it appears as though the students thought tests were more valid than other forms of assessments.
information that they actually knew. Both before and after the study, many students stated that tests were the thing they liked least about science and the thing they found most difficult about science.
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Comparisons between Assessment Strategies

At the end of the study, students were given a final questionnaire that asked them to rank each method of assessment they had been exposed to during the study. These methods included the three alternative assessment approaches (i.e. portfolios, drama activities, and practical lab tests) as well as the traditional method of written tests. The results of these rankings are displayed in Table 2 below.

Table 2. Student Rankings of Assessment Technique

<table>
<thead>
<tr>
<th></th>
<th>First (1 pt)</th>
<th>Second (2 pts)</th>
<th>Third (3 pts)</th>
<th>Fourth (4 pts)</th>
<th>Average Ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drama</td>
<td>49</td>
<td>11</td>
<td>10</td>
<td>13</td>
<td>1.8</td>
</tr>
<tr>
<td>Performance</td>
<td>11</td>
<td>32</td>
<td>29</td>
<td>11</td>
<td>2.4</td>
</tr>
<tr>
<td>Portfolios</td>
<td>14</td>
<td>23</td>
<td>26</td>
<td>20</td>
<td>2.6</td>
</tr>
<tr>
<td>Testing</td>
<td>16</td>
<td>20</td>
<td>15</td>
<td>32</td>
<td>2.8</td>
</tr>
</tbody>
</table>

Overall, drama was rated as the students' most preferred method of assessment. This rating was not surprising given the anecdotal comments made by students about drama. It was obvious from student comments and classroom observations that students really enjoyed drama as a means of assessing student understanding. It should be noted, however, that students might have used "enjoyment" as the only criteria when ranking each assessment method. They might not have considered which method was the best method for conveying their understanding of science.

Student Attitudes towards Science

In addition to asking students about their preferred method of assessment, the final questionnaire (questionnaire #4) also asked students a number of closed-response (i.e. "yes" or "no") questions about their attitudes toward science. The identical attitudinal questions were asked at the start of the study (questionnaire #2) so that a comparison could be made between student attitudes before and after exposure to alternative methods of assessment. Table 3
Chapter 4: Findings

summarizes the closed-response attitudinal questions asked on the questionnaires and the student responses to those questions.

Table 3. Differences in Student Attitudes toward Science

<table>
<thead>
<tr>
<th></th>
<th>% of “Yes” Responses Questionnaire #1</th>
<th>% of “Yes” Responses Questionnaire #4</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Do you enjoy science?</td>
<td>90%</td>
<td>97%</td>
<td>+7%</td>
</tr>
<tr>
<td>Is science one of your best subjects?</td>
<td>35%</td>
<td>51%</td>
<td>+16%*</td>
</tr>
<tr>
<td>Is science difficult?</td>
<td>64%</td>
<td>37%</td>
<td>-27%*</td>
</tr>
<tr>
<td>Do you plan on taking science in senior high school?</td>
<td>85%</td>
<td>88%</td>
<td>+3%</td>
</tr>
<tr>
<td>Do you plan on taking science in university or college?</td>
<td>67%</td>
<td>72%</td>
<td>+5%</td>
</tr>
<tr>
<td>Do you plan on pursuing a science-related career?</td>
<td>53%</td>
<td>68%</td>
<td>+15%</td>
</tr>
</tbody>
</table>

* Denotes the difference is statistically significant (Chi-square test; \( \alpha = 0.05 \))

Questionnaire #4 also contained a few open-response questions that asked students to provide anecdotal responses. In addition to these solicited anecdotal responses, a number of students offered further anecdotal comments to supplement their answers to the closed-response questions. These anecdotal comments and the students' responses to closed-response questions will be discussed in the following sections.

As can be seen in Table 3, some noticeable changes in student attitudes were observed during the course of the study. At the end of the study, student responses tended to be more favourable towards science and more students seemed interested in pursuing science-related education and careers.

A Chi-square analysis of pre- and post-test data was done to determine if the shift in student attitudes were statistically significant (see Appendix C). This analysis indicated that there were statistically significant differences in the students' self-perceptions and general perceptions of science.
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In particular, students' confidence in their scientific abilities improved significantly. This improvement was reflected in the increased number of students who rated science as one of their best subjects. In addition, this increase in self confidence was reflected in the anecdotal comments students made in their questionnaires. In general, students seemed more confident in their abilities to "do science" and more expectant of experiencing success.

Students' general perceptions of science were similarly affected. The pre- and post-test data indicated a large decrease in the number of students who viewed science as difficult. Anecdotal comments of students supported this change in students' perceptions of science. At the onset of the study, many students expressed the opinion that science was difficult because it requires the use of "precise, technical vocabulary". Students felt that this vocabulary impeded their understanding of the concepts and their ability to verbalize their knowledge. After the study, however, very few students stated that they had problems with the language of science. Students felt more proficient in understanding topics and conveying that understanding to the instructor. The comments demonstrate a shift in the way these female students viewed science.

A variety of other attitudinal factors were also found to change during the course of the study (see Table 3). The number of students who stated that they enjoyed science increased, as did the number of students who planned on pursuing science-related education and careers. However, while these changes may show a trend in the attitudinal shift of students, they were not statistically significant. This lack of significance could indicate that the student attitudes towards science were not significantly influenced by exposure to alternative assessment. The lack of significance could also be due to the overwhelmingly positive attitudes of these students at the onset of the study. For example, an overwhelming 90% of students claimed to enjoy science at the study's onset. Given this high percentage, it may be difficult to observe any statistically significant positive change.
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Some attitudes, however, remained very static throughout the course of the study. While the numbers of students aspiring towards science-related careers increased, the fields of interest did not vary. Of the students planning to pursue a science-related career, most indicated that they planned on entering the field of medicine. This finding was true both before and after the study. Further, students remained held fast in their belief that a successful scientist must be "logical, smart, and good at math". Both before and after the study, "creativity" and "poor math skills" were cited as personality traits that would promote greater success in fields outside of science. The increased use of alternative assessment techniques that gave students the freedom to be creative apparently did little to change the stereotypical image of scientists in the minds of these students.

Discussion

Overall, the reactions to the alternative assessment strategies used in this study (practical lab tests, portfolios, and drama) were positive. Both the students and the teachers were excited about these strategies. These positive reactions to alternative assessment were accompanied by a positive shift in student attitudes towards science and their abilities to be successful in science. Although it is impossible to give causal explanations for this positive shift in student attitudes, the following section will discuss implications based on the information obtained in student questionnaires.

Changes in Students' Views of Science

Comments made by students suggest that their view of science may have changed over the course of the study. At the end of the study, students viewed science as more interesting and less difficult. However, their view of scientists did not change.

The increased frequency of students perceiving science as an interesting subject was accompanied by the student perception that alternative assessment strategies are fun and
interesting. It may be suggested, therefore, that the increased frequency is due, in part, to the exposure to new and interesting modes of assessment. The alternative assessment strategies afforded the students the opportunity to explore new ideas and investigate personal interpretations. Research (e.g. Roychoudhury, Tippins, & Nichols, 1995) has shown that, in order to make science meaningful, female students need to experience this personal connection. Thus, these strategies may have helped change the students' view of science from that of a sterile, abstract discipline to that of an interesting, meaningful field.

It is my assertion, therefore, that the exposure to alternative methods of assessment contributed to this increased level of interest in science among students. However, it would be erroneous to make such an assertion without considering alternative influences. One alternative explanation that springs to mind is that exposure to the Science 9 curriculum itself caused the increased level of interest among students. However, if the fields of interest are examined, it is seen that the focus of interest overwhelmingly lies in the field of medicine, a topic which is not part of the Science 9 curriculum. This focus is apparent at both the onset and the conclusion of the study. It seems, therefore, that the curriculum did little to interest the students in new, exciting areas of science. This is not to suggest that the curriculum had no impact on the increased level of interest among the students; it is merely suggesting that the curriculum may not have been the only factor at play.

The perceived difficulty level of science also decreased over the course of the study. This may be largely due to the increased success that students felt when using alternative assessment strategies to express their knowledge. Because alternative assessment strategies enriched the students' understanding of the material and allowed students to use their strengths to express this understanding, the students experienced a heightened feeling of success. The feelings of success experienced by the female students in this study are in stark contrast to the low levels of success experienced by female students in general. Females, in general, receive
less praise for the content of their work (Spear, 1987a) and have less confidence in their abilities (AAUW, 1992). Alternative assessment strategies, however, may help overcome some of the feelings of incompetence experienced by female students.

However, not all perceptions of science were altered during the study. Based on the anecdotal comments of students in questionnaire #2 and questionnaire #4, both the students' images of a successful scientist and the students' indications of possible future science-related careers remained static. The traditional stereotypes for scientists persisted in the minds of the students. This may be due to the age of the students in the study. Research shows that students come to school with well-developed ideas about appropriate male and female roles (Kahle & Meece, 1994).

Changes in Self-Perceptions: Finding a Voice

The alternative assessment strategies may have also altered the students' attitudes toward themselves as students and, more importantly, as thinkers. Based on comments made by the students and the teacher, it appears that the assessment techniques may have allowed students to develop greater self-confidence and strengthen their voice in the classroom.

As outlined previously, the increase in the self-confidence of the students in the study may be due partly to the increased success they experienced using the alternative assessment strategies. The students' self-confidence may have been further increased by the validation of their personal insights and thoughts through the use of alternative assessment. Roychoudhury et al. (1995) found that this validation is particularly important and beneficial to female students. It was obvious at the onset of the study that students were apprehensive about using their own words or feelings to express their understanding of a scientific concept. This apprehension is apparent in the comment made by one student who wrote "...I'm not sure if what I'm going to say is important". Many studies have shown that female students try to please and conform. Female
students are less likely to take risks and more likely to be concerned about doing things right (Kelly, 1985). As a result, females are more apprehensive about expressing their thoughts in their own words. The alternative assessment strategies, however, allow students to take these risks in an unthreatening environment.

When students are encouraged to take risks and express themselves in their own way, the increase in the students' self-confidence becomes apparent. It became obvious that students soon gained the confidence to speak in their own voice and rely on their own skills. Students started to use their own language instead of the language of the teachers and were more likely to ask questions and explore their own ideas. All students were given the opportunity to find their voice, express that voice publicly, and have that voice respected. In all cases observed, their teacher and their peers positively received this personal expression. This acceptance by their teacher and their peers may give students a boost of confidence at a time in their lives when their self-image may be fragile.

A Connected Curriculum

The teacher and the students appreciated the freedom that the alternative assessment strategies afforded the students. Students felt free to explore new ideas, delve deeper into areas that interested them, and ask questions. As a result, students were able to investigate areas of science that mattered to them and were, therefore, able to develop a personal connection to the scientific content. As stated by one of the students in the study, the alternative assessment techniques made her feel more "a part of science".

In addition, the assessment activities allowed students to relate the scientific concepts to their past experiences. This augmented their feeling of connectedness to the curriculum as it allowed them to see the relevance of science in their own lives. Science is often perceived as
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being abstract and irrelevant to the lives of people. Research has shown that many females are concerned with real-life experiences (Belenky et al., 1997). The abstract nature of science often does not fit in with females’ desire to help others. Through the use of alternative assessment, however, female students are able to see the more personal side of science. It must be noted, however, that alternative assessment alone cannot display the humanistic side of science. Other intervention measures must be taken to show the relevance of science in the lives of all humans.

Feminine Language

Both the teacher and the students enjoyed the opportunity that students had to explain their understandings of science in their own language. The teacher believed she gained a richer picture of student understanding as they strove to internalize and verbalize scientific concepts. Similarly, the students enjoyed being able to express themselves through their own language. They believed that this gave a truer representation of their understanding while helping them remember the scientific concepts. By giving students the freedom use their own words to explain concepts and the opportunity to do so through narration and description, alternative assessment appeals to the feminine style of communication and language.

Roles of Alternative Assessment

As outlined above, alternative assessment may alter female students' perceptions of science while increasing their confidence in their own abilities. By allowing female students to connect with the curriculum and communicate their knowledge in their own way, alternative assessment embraces the feminine perspective and feminine language missing in our curriculum. Alternative assessment may, therefore, decrease the alienation that females feel in the science classroom and encourage the development of positive attitudes toward science.

Although these findings may show alternative assessment strategies as having a positive impact in the classroom, the implementation of these strategies does not come without problems.
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All forms of alternative assessment had some initial "growing pains" that cannot be ignored. Both the teacher and the students needed time to become comfortable with the alternative assessment strategies.

In spite of the fact that Jennifer was confident in her abilities to use alternative assessment strategies, she encountered a number of problems during the first few weeks of the study. Perhaps due to her lack of experience with alternative assessment, Jennifer’s initial attempts at using these assessment strategies became somewhat problematic. In general, the greatest problems seemed to stem from the lack of specificity in the directions and evaluation criteria established by Jennifer. To assist Jennifer in her endeavours, I observed a number of classes during the first few weeks. My observations of the classes gave me the opportunity to observe the students during the activities as well as the opportunity to discuss Jennifer’s instructions and evaluation criteria. I felt that most of the problems encountered by Jennifer were easily overcome with slight modifications to the assessment activities. However, Jennifer felt our communication was not only necessary but invaluable to her as she strove to overcome these initial problems. Based on Jennifer’s experiences, it would seem evident that professional development would be beneficial to teachers attempting to adopt alternative assessment strategies.

Not only was it necessary for the teacher to become skilled at, and comfortable with, alternative assessment, but the students also had to adapt to these activities. In particular, students had to become comfortable with expressing more of themselves during the alternative assessment activities. Students quickly gained confidence and became comfortable with their participation in alternative assessment activities. I believe that the benefits of alternative assessment (i.e. the positive impact on the attitudes of female students) outweigh the initial problems.
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Summary

It has been seen that the students and the teacher positively received the alternative assessment strategies used in this study. Shifts in student attitudes towards science were apparent during the course of the study. Although, pure causal conclusions to explain this shift cannot be drawn, comments made by students do suggest that the alternative assessment strategies may have played a part in the shift. The students' attitudes towards science and towards themselves appeared to change during the study. The net result was an increase in the number of students who planned to take advanced science courses and to pursue science-related careers. I have argued that this shift in perception may be due, in part, to the use of alternative assessment which gave students the opportunity to express their feelings and understandings of science in their own terms and by using a number of different skills.
Science

Science is like the first dive into
a freezing cold lake
You feel the water and the

Words flowing, flashing, flying
Facts that fit only if you
Shift
your mind and thoughts and perceptions
and look at it a different way

Science is a game and a puzzle
and the prize
that is won by the flash
of comprehension
from the eager, stubborn mind

That refuses to give up on a problem
or listen to those
who say it is too hard, too logical,
for a dreamer, a girl, like you
to wrestle with, to grasp

So you fight them and the fact that
won't fit
dragging them in, kicking and screaming
until
finally
you understand

~ written by a Science 9 student
Traditionally, science instruction and assessment has embraced a masculine perspective and style of communication. Research has shown that a masculine perspective is object-oriented. As such, males tend to be concerned with defining their world through abstract rules and theories. Males, in turn, communicate their understanding of the world through technical verbal representations of these rules. This masculine perspective and mode of communication is in stark contrast to perspective and mode of communication preferred by females. Research suggests a feminine perspective is person-oriented and grounded in real-life applications and context. Females, in turn, explain their understanding of the world in context. Out of necessity, then, feminine communication tends to be descriptive and narrative.

Traditionally, science has embraced the masculine perspective and style of communication. Science has been taught as a series of theories, laws, and formulas. Consequently, science assessment has been focused on the ability of students to relate and apply these abstractions. The very nature of science instruction and assessment, then, is foreign to females' natural constructions and communications about the world in which they live. The nature of high school science may, therefore, alienate females from science education and careers. This alienation may be augmented by the fact that females continue to be under-represented in advanced science courses (Statistics Canada, 1997) and careers (Jones, 1991).

Although the development of gender-inclusive science instruction has received a good deal of attention in educational research and literature, gender differences still exist. Current research in gender issues in science indicate that gender differences exist in high school science students' achievement (AAUW, 1992), enrollment (Statistics Canada, 1997), participation in extra-curricular activities, (Catsambis, 1995) and career-aspirations (Statistics Canada, 1997). In essence, the persistent view of science is that it is more male-appropriate, and science continues
to be seen as a male domain. It is my assertion that much of this gender disparity arises from the attitudes of males and females towards science.

Female adolescents lack the confidence of male adolescents (AAUW, 1992). This lack of confidence, coupled with the stereotypical view of science, may discourage females from pursuing science-related education and careers. Head (1987) found that girls who pursue science have even lower levels of self-esteem than their female classmates in terms of being socially and sexually attractive.

Alternative assessment techniques that were used in this study appear to promote positive attitudes toward science. The female participants were exposed to traditional and alternative methods of assessment and queried about their attitudes towards these assessment techniques, in particular, and science, in general. The goals of the study were (1) to determine the attitudes of female students towards the use of alternative assessment in the science classroom, and (2) to determine if the use of alternative assessment affects female students' attitudes toward science.

The findings of my research show that all three methods of alternative assessment were positively received and preferred over traditional assessment as a means of conveying student understanding. The female students appreciated the opportunities that alternative assessment afforded them. In particular, students enjoyed the opportunity to explore their interpretations of a scientific topic, to develop a greater connection with the topics, and to communicate freely about the topics. Each of these issues will be discussed in the following sections.

Exploring Student Interpretation

Research has found that female students, in particular, benefit from being able to express their thoughts and have those thoughts validated by teachers through positive communication and praise (Roychoudhury et al., 1995; Hewitt and Seymour, as cited in AAUW, 1992).
Alternative assessment gives females the opportunity to explore their insights, explain their thoughts, and share those thoughts in a low-risk environment. Students' responses to portfolios in the present study illustrate this point. Portfolios were found to be an excellent outlet for incorporating student insights into the classroom. In addition, portfolios allowed students to explain their thoughts and gave the teacher the opportunity to comment on those thoughts. More than the students, the teacher welcomed the opportunity to informally communicate with students. She felt that this gave her a richer picture of student understanding and allowed her to address student insights in class.

Deepening Student Connection

Gilligan (1982) claims that feminine knowledge is infused with real-life connections and context. As such, females do not readily abstract events from their context. For science to be meaningful, therefore, it must associate scientific principles with real-life experiences. Alternative assessment activities also lend themselves to a contextual exploration of science. For example, drama activities allow students to explore the personal nature of science and explain their scientific understanding as it relates to people. In this way, alternative assessment activities may embrace the person-oriented feminine perspective. Many students echoed the importance of this attribute as they commented that alternative assessment allowed them to be a "part of science".

Encouraging Feminine Language

Gorman (as cited in Murphy, 1996) argues that females prefer to communicate through extended reflections while males prefer to communicate through episodic factual comments. The foundation of science has been historically grounded in the masculine mode of communicating abstract facts. Even if females understand scientific concepts, they may have trouble communicating that understanding, as scientific discourse is foreign to them. Alternative assessment strategies give females a platform on which to engage in female-friendly scientific discourse. In this study the use of both portfolios and drama allowed the students to explain their
understandings of science in their own language. Many students commented that they enjoyed being able to express their understanding in their own way. These students further believed that these alternative assessment activities got to the root of their understanding. They recognized the fact that the regurgitation of notes does not indicate understanding. If students have to explain concepts in their own words, they are forced to understand the topic thoroughly. Below is a sample of writing submitted by a grade 9 science student that illustrates the importance of allowing alternative voices to be heard in the science classroom.

Science

On Saturday, I was watching Much Music. It was a phone-in show where people got to ask Geri Halliwell, the artist formerly known as Ginger Spice, questions. I was watching it for laughs, I am not one of those girls who think women dressed in sequins and spandex exhibit "Girl Power".

One of the callers said that Geri was the inspiration for her first place science fair project. The girl didn't think a female could win the award, but Geri made her believe in herself.

I found this quite disturbing. The encouragement to do well should have come from her teachers. I have had female science teachers my entire life as a high school student. Although their teaching styles were very different, both of them helped.

Ever since grade 2, people have been trying to point me in the direction of the arts. I was going to follow that direction until my science classes changed. In grade 9, we did this "alternative assessment" thing. Interpretive dances, poetry, story writing and songs replaced the usual note-taking routine.

I finally realized that everyone was wrong, that I could do just as well in science as I could in the arts. This was because alternative assessment let me use something I understood, the arts, to learn and express ideas I couldn't understand. Science became fun for once.

Even though we use lots of alternative assessment in class, this doesn't mean that I can only do well in "alternative" aspects of science. Texts and exams have become less of a challenge as well. This isn't because I wasn't smart enough for real, traditional science. It's because alternative assessment helped me realize that science didn't have to be "boring and emotionless" as I previously thought. It could be interesting. After all, it's the only way we can understand how our world works – that's pretty deep.
Changing Students' Self-Perceptions

Adolescent females lack the self-confidence of their male classmates (AAUW, 1992) as can be seen by their passive participation in the classroom (Kahle & Meece, 1994), their hesitation to guess when they do not know answers (Bolger & Kellaghan, 1990), and their reluctance to engage in scientific discourse (Kelly, 1985). The use of alternative methods of assessment may give students the confidence they need to participate actively in the science classroom. For example, the use of portfolios allowed the students in this study to engage in scientific discourse with the teacher in a low-risk environment. Although initially hesitant to offer ideas and use their own voices in portfolio entries, students soon gained the confidence to make assertions, state their understandings, and ask questions.

Student Attitudes

The alternative assessment strategies used in this study allowed females to engage in scientific exploration that included their own experiences and insights and allowed for feminine discourse. Consequently, the students' attitudes towards alternative assessment were very positive. This positive reaction may then have had a positive impact on their attitudes toward science. The change in student attitudes towards alternative assessment and science will be summarized in the next sections.

Attitudes of Students towards Alternative Assessment

As discussed above, anecdotal student comments indicate that students had very positive attitudes towards alternative assessment. In particular, students seemed to enjoy drama-based activities. These activities may be the most suitable method of assessment for embracing feminine knowledge and communication. Drama-based assessment activities allow students to use their own language while exploring their personal understandings of scientific concepts. However, all three methods of alternative assessment received very positive student responses.
Attitudes of Students Towards Science

Although this study clearly indicated that students showed positive attitudes towards alternative assessment, it was less clear whether these positive attitudes had any effect on students' attitudes toward science. Although there were slight increases in the number of students who claimed to enjoy science, and even larger increases in the number of students planning on pursuing a science-related career, these changes were not statistically significant.

However, as argued earlier, the lack of statistical significance could be due to a number of reasons. The most likely explanation for the lack of statistical significance is the inability of alternative assessment to have a large impact on the attitudes of adolescent females. However, the lack of significance could also be due to the overwhelmingly positive attitudes of these students at the onset of the study and the difficulty in observing any statistically significant positive change.

Interestingly, some views about science did not change at all throughout the study. One of these views was the students' perception of a successful "scientist". This perception mirrored the popular stereotypical view of scientists (i.e. logical, good at math, etc.). Student attitudes towards possible professions also remained unchanged throughout the study. Although the number of students interested in pursuing a science-related career increased, their fields of interest remained focused on health science careers (e.g. nurse, doctor, and psychologist). Again, these fields of interest mirror the stereotypical images of female scientists. Thus, the adolescent females that participated in this study seemed to have well defined ideas about scientific careers that remained rigid throughout the study.

In summary, student attitudes towards science improved while student views regarding science related careers remained static throughout the course of the study. Anecdotal student comments seemed to support my assertion that this improvement in students' attitudes towards
science may be directly related to the incorporation of alternative assessment strategies into the Science 9 curriculum. Perhaps, if a similar study were conducted with younger students, changes in student attitudes towards science-related careers would be more significant.

What I Learned about Alternative Assessment

While both the students and the teacher reacted very positively towards the use of alternative assessment, the implementation of these practices did pose some challenges. Based on my observations of the classroom, and through discussions with the students and the teacher, I have developed a list of suggestions that might reduce the challenges associated with introducing alternative assessment strategies:

1. Start off small (e.g. when conducting practical lab tests, start with small groups of students before attempting to do any large-scale assessment).
2. Establish criteria for evaluation and share it with the students before assigning activities.
3. Develop a routine that effectively incorporates alternative assessment into the classroom (e.g. log writing once a week).
4. Do not neglect feedback (e.g. when using drama, have students hand in a script on which comments can be made).
5. Do not use alternative assessment strategies at the exclusion of other techniques – don’t lose sight of the fact that students will still be expected to perform well on written tests.
6. Challenge students with alternative assessment activities – they should be fun but challenging.

Although implementing the use of alternative assessment in the classroom is challenging, its rewards are obvious. In a nutshell, students enjoy the alternative activities, and their attitudes towards science may improve as a result of these activities. Alternative assessment embraces
feminine knowledge and language, and welcomes unique approaches and insights. Students can exploit their differences and talents as they strive to understand the world of science.

Further Study

As argued earlier, this sample of students may not be representative of the population of high school science students in British Columbia. Consequently, this study could be replicated in other schools or settings to see if these findings are generalizable. It would be particularly interesting to further this study to assess the attitudes of male and female students in co-educational schools towards alternative assessment.

Further research could also be done to investigate the effectiveness of alternative methods of assessment in evaluating student understanding. During the present study the teacher felt that alternative assessment activities were effective (and in some cases more effective) in assessing students’ understanding of scientific concepts. Further research could investigate this claim.
Science makes me feel...

Creative and confident

Intelligent and independent

Energized and enthusiastic

Nice and neat

Curious and convincing

Entertained and encouraged

~ written by a Science 9 student
References


**Marie's Story**

There once was a girl named Marie
When she was three, she wanted to see
Why blocks fall to the floor
She wanted to know more

As she grew
the more she knew
Like how things burn,
But she still wanted to learn

Marie started to go to school
Which was a very useful tool.
There she learned more science
Like how a circuit connects to an appliance.

They asked her what she wanted to be
And she replied so joyfully
“A scientist, like my daddy”
They said “no no Marie!”

Marie would prove them all wrong
She started to work hard and long.
She worked day and night and in the end
She beat all those egotistical men.

Marie later on became
A world renown scientist, by name
It’s not gender that earns the occupation
It depends on hard work and dedication.

~ written by a Science 9 student
Appendix A

Pilot Study: Alternative Methods of Assessment: Student and Teacher Reflection

1. Introduction

Much attention has been given to students' ways of learning. Teachers have been encouraged to vary their teaching strategies to allow all students to have success in the classroom. However, a disproportionately small emphasis has been placed on alternative methods of assessment. We encourage students to learn in the way best suited to them, but we do not allow them to demonstrate their knowledge in a way that makes use of their individual strengths. This paper attempts to look at various methods of assessment, as they have been used in a science 9 classroom, and to critique these methods based in part upon an analysis of student feedback and my own reflections on these methods.

After completing a unit on biology, students were asked to write anecdotal remarks about their feelings on eight different methods of assessment and to rank them from one to eight (one being the best and eight being the worst). These methods include (1) drama, (2) products, (3) portfolios, (4) multiple choice test questions, (5) projects, (6) creative writing tasks, (7) open ended test questions, and (8) concept maps. A detailed description of the assessment activities is provided at the end of the paper. This paper looks at these methods of assessment as well as two additional methods, namely self-assessment and practical lab exams, that were not ranked by the students. The reason that these two assessment methods were not included in the student questionnaire is that these methods were not used during the study period due to time constraints. Prior to this study, however, extensive questions on these two methods of assessment had been completed by the students. Their anecdotal remarks have been included in this paper. These two additional methods, however, have not been ranked in relation to the other 8 methods. It should be noted that all students used in this study were female science 9
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students, aged 14 and 15. The following discussion includes a brief description of each method of assessment as well as a synopsis of student and teacher reflection on each method.

2. Drama

2.1 Use of Drama in the Science 9 Biology Class

In this study, students were asked to create a skit to portray the importance of a particular nutrient. This task was to be completed after the class had investigated the use of each nutrient in the body. However, many groups decided to do additional research on their nutrient to supplement the material covered in class. Groups of approximately 4 students were formed, and each group was able to choose the nutrient that they would like to present.

2.2 Students' Reactions and Critique

Drama was by far the most preferred method of assessment. An astonishing 47% of the students rated drama as their favourite method of assessment. The reasons given for this preference were many. Almost all students felt drama was fun, but most also pointed out the positive effect that drama had on their learning. One student commented: "It is fun to make your information into a skit so that it is easier for everyone to understand." Many students made similar comments, pointing out the fact that it was easier to remember concepts that had been presented in class in the form of a skit.

Drama was also rated as the most preferred method of assessment because it afforded students the opportunity to express their knowledge in a unique way. Many students who have difficulty expressing their understanding through written work have the opportunity, using drama, to use their strengths in verbal or physical expression to express their understanding of a concept. One student commented that drama "gives individuals a chance to physically express their feelings and interpretations on the
subject”. Often students who appear to have a very weak understanding of a scientific concept on written assignments can use drama to demonstrate a level of understanding that surpasses expectations for even the most gifted students. Not only does drama indicate student understanding that might otherwise have gone unnoticed, but it also enables the student to experience success in the classroom.

Drama, therefore, gives students the freedom to express their knowledge in a fun, creative, meaningful way. Thus, drama can motivate students and can break down many barriers in the classroom. It allows students to express themselves in a way that is rare in a secondary classroom. It gives students the voice that they are so often lacking. Thus, it builds self esteem and confidence.

However, not all comments regarding drama were positive. One student agreed with the consensus that drama was a good way to remember concepts, but she felt that drama was too much fun and, therefore, should not be used. She commented that drama "was not very scientific because it provides too much amusement". This is a dire comment on the view of science in society. Alternative methods of assessment, such as drama, could do much to change this view of science in our youth.

Although not commented on by students, drama can also be a valuable assessment tool. Because students are attempting to give meaning to the concept in their own words, incomplete understanding of a concept becomes readily apparent. Similarly, complete understanding of a concept not only becomes apparent, but it can also be used as a meaningful way of presenting information to other members in the class.

Like all forms of assessment, drama does not come without some difficulties. One difficulty with drama lies in establishing objective criteria. However, establishing criteria for drama is no more difficult than establishing criteria for any other method of
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assessment. Like all forms of assessment, it is imperative that the students are involved in the establishment of the criteria and that they thoroughly understand the objectives that must be met.

The obvious drawback to using drama in the classroom is that it forces students to stand up in front of the class. This is something that many students feel uncomfortable with. One student pointed out that she felt uncomfortable doing drama because she was shy. She further pointed out that shy students usually end up in groups together, and as a result, these groups have difficulty completing the task. This difficulty is further magnified by students that are learning English as a second language. However, drama does not have to involve complex English, nor does it have to involve speaking. A group that has difficulty expressing their knowledge verbally, can express it through physical means. One ESL student commented that drama is good because it "helps to visually show understanding of what is being learned". In addition, video tapes can be made and presented in class in lieu of a live performance. This can greatly decrease the anxiety felt by the students.

3. Educational Products

3.1 The Use of Educational Products in a Science 9 Biology Class

In this study, students made products after conducting independent research on eating disorders. Although the topic of eating disorders was talked about in class, most of the information that the students needed was obtained from library and internet searches. Students were asked to produce an educational brochure that could be used to educate teenagers about eating disorders and to inform them of places in the community they could go for help. In addition to this type of assignment, products such as brochures, pamphlets, and models can be made at the end of a unit to summarize learning.

3.2 Student's Reactions and Critique
Overall products were rated as the second most preferred method of assessment. Students pointed to a number of benefits including having the choice of working independently or as part of a group, being interested in what they are doing, and being able to be creative. Many students also commented on the fact that creating a product allowed them to use their hands and/or their computers to present the information they knew. In this way, products afford students the opportunity to express their knowledge in a way that allows them to make the best use of their strengths (e.g., desktop publishing, art, photography, etc.). Again, this acts to motivate students and increases their chances of achieving success.

Students also remarked that products were useful learning tools in addition to being useful assessment tools. One student commented that she "learns a lot (by creating a product) and is able to produce something that (she) is proud of". This statement not only makes reference to the fact that products are useful learning tools, but it also alludes to the importance of developing a sense of pride in students. A sense of pride not only develops self esteem, but it is also essential in developing intrinsically motivated students. This sense of pride gives students the incentive to do their best work. This is particularly true if the product is to be shared with the rest of the class during a presentation.

In addition, each student or group of students can be assigned a slightly different topic, and students can, therefore, be made to feel as experts on their topics when they present this information to the class. This further develops self esteem and pride.
4. Portfolios

4.1 The Use of Portfolios in a Science 9 Biology Class

Portfolio assessment is a collection of student work. The work selected for the portfolio can be chosen by the teacher or the student. The portfolio will essentially document the student's progress over a specified period of time. It should include the student's reflections of his/her learning, items produced by the student to represent his/her learning of a concept, and items that the student is particularly proud of. In this study the portfolio folders were decorated with pictures from magazines, and student work was placed inside the portfolio throughout the course of the unit.

4.2 Students' Reactions and Critique

Most students ranked portfolio assessment as a preferred method of assessment (ranked third overall). Positive student remarks pointed out that portfolios were "good because you get to show your parents your good accomplishments". Many students remarked that they worked harder on assignments that they knew would be placed in their portfolios because they felt proud of their portfolios and only wanted their best work to be seen. This seems to be primarily due to the fact that portfolios were shared with parents. The thought of their parents having the opportunity to view their work, inspired and motivated students to do their best.

Some students pointed out that portfolios also made them feel proud of themselves. They enjoyed looking back on their work and took pride in their accomplishments. Pride in their own work became an intrinsic motivator for these students. One student commented that portfolios "are fun because you see your good work and you have a good feeling about yourself". This not only motivated the students to do their best work, but also worked to build self-esteem.
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Self-esteem was also developed through the use of portfolios by allowing students
to be creative. One student wrote: "Portfolios show our creative side. It shows we are
individuals." This is an important aspect of portfolio assessment. Each student's
individuality should be represented by the portfolio. The portfolio should be a mirror into
the student's learning and thinking.

Although students enjoyed creating and maintaining their portfolios, most
questioned their value as an assessment tool. They saw portfolios as a way to document
learning, but they did not agree that portfolios should be marked. Although students
agreed with assessing a mark to some of the assignments placed in the portfolio, they did
not agree that a holistic mark should be assessed to the portfolio in its entirety. This is
unusual as marks have become the focal point in students' lives. Students seem to
assess the amount of effort that something deserves by how many marks it is worth.
Learning appears to be seen as a by-product of achieving marks. Through alternative
methods of assessment, such as portfolios, this philosophy may be changing. Rather
than viewing the final mark as the most important aspect of portfolios, students viewed the
production of the portfolio as the critical aspect of this method of assessment. Thus,
alternative forms of assessment may be encouraging students to view learning, not marks,
as the goal of education.

The portfolio not only documents student progress, but it is also a useful tool for
teacher, parent, and student reflection. It can help teachers explain a student's strengths
and weaknesses to other teachers, teacher aides, administrators, or parents. Portfolios
afford the opportunity for the comparison of student work over a period of time. This
enables teachers, parents, and students to see changes in student work and encourages
reflection on student learning over that time period.
However, portfolios are useful only when the purpose of the learning is defined in advance and criteria for assessing learning are identified (Reichel, 1994). Portfolios should not just be modified notebooks that house student work. Goals need to be set, and periodic reflection back on those goals is necessary. Like other methods of assessment, portfolio assessment is most successful when the students are an integral part of this goal and criteria setting.

5 Multiple Choice Test Questions

5.1 The Use of Multiple Choice Test Questions in a Science 9 Biology Class

In this study, multiple choice test questions were used at the end of each unit. Questions, designed to test knowledge and understanding, included multiple response questions, true/false questions, and labeling questions.

5.2 Students' Reactions and Critique

Students ranked multiple choice test questions as fourth overall. Although most students ranked multiple choice questions relatively favourably, their feelings towards these questions varied greatly. Many students felt that multiple choice tests were easy because of the ability to guess answers. However, many others felt that multiple choice test questions were extremely difficult, commenting that they felt that multiple choice questions were "trick questions". These two contradictory sentiments emphasize the need for multiple methods of assessment in the classroom. What works for one student, is not going to work for another.

Other students made general comments about testing. They felt that test questions (whether open ended or multiple choice) did not test student understanding. Rather, they felt that test questions served only to test the ability of the student to work under pressure. Many students commented on the high stress levels associated with
writing tests, and they commented that they were not able to do their best because of the stress. Again, this points to the need for multiple methods of assessment.

6. Projects

6.1 Use of Projects in the Science 9 Biology Class

In this study, students conducted independent research on a current issue in biology. The students were asked to keep a journal in which they placed articles dealing with current events in science (e.g., medical advances, the environment, etc.). Each student was then asked to investigate one article in detail and write a paper on it.

6.2 Students' Reactions and Critique

Most students rated projects favourably, ranking it as the fifth most preferred method of assessment. The most common statement made by students was that they enjoyed being able to choose what they learn. One student pointed out that projects were a "good way to find out things you've always wanted to know". These students were referring, primarily, to open-ended research projects in which the topic was chosen by the student and approved by the teacher. Many students pointed out that they enjoyed these self-directed projects provided "strict criteria" was given. Again, the need for strict criteria is essential as it is difficult for students to feel confident and achieve success if they do not thoroughly understand the task given to them.

Many students also felt that research projects were helpful in the development of life and study skills. They felt long-term research projects helped them learn how to set goals and work to deadlines. Although this point was not emphasized with these students in class, most students realized that this was at least as important as learning about the topic they had chosen.
In addition, many students also pointed out that projects allowed for creativity. One student stated that the "fun" of projects came from the ability to "think up something really original that no else will ever have thought of in a billion years". Although not all students were this ambitious, many students did comment that they enjoyed projects because they could do them in their own "style". Projects allow students to show their understanding in a way that they feel is most suited to them.

Finally, many students commented that projects allowed the students to do well provided they worked hard. One student stated that she liked projects "because you do not necessarily have to be the smartest person, but if you work hard, you will get a good mark". This belief encourages students to work hard because they feel success is guaranteed. However, students also find projects stressful because they feel compelled to put in a concerted effort as they can no longer blame poor marks on anything other than a lack of effort.

7. Creative Writing Tasks

7.1 Use of Creative Writing Tasks in the Science 9 Biology Class

In this study, creative writing tasks included writing journal entries, short stories, and poems. In each task, students were asked to explain concepts in their own words.

7.2 Students' Reactions and Critique

Overall students ranked the use of creative writing tasks surprisingly low. Overall, it was rated as the sixth most preferred assessment tool. In their anecdotal remarks, students who felt that they had above average writing skills related that they enjoyed doing creative writing tasks and felt that the tasks helped them express their understanding. However, students who felt that their writing skills were below average expressed that they disliked creative writing tasks because they were not good at them.
Whether or not students thought that creative writing tasks were a suitable form of assessment for them, they agreed on one thing. They felt that creative writing tasks helped them remember the concepts that they were writing about. They felt the biggest advantage of creative writing tasks came when they were writing tests. Students commented that it was much easier to remember information in their own words than in the words of the teacher. One would think that if the students were able to see this benefit of creative writing tasks, they would have ranked it higher. Perhaps the low overall ranking of creative writing tasks was due to the fact that students saw the value of the tasks as a learning tool but not as an assessment tool.

The completion of a creative writing task can be a fun, creative way to assess student understanding. It allows students who are strong in languages or fine arts (who may or may not be strong in science) an opportunity to use their strengths. In addition, creative writing tasks help assess student understanding since students have tried to use their own vocabulary to explain a topic, rather than regurgitating the vocabulary of the teacher. The use of creative writing tasks can also have a benefit for students who are learning English. These tasks afford the students the opportunity to form unique sentences, different from the sentences in their texts or notebooks.

8. Open Ended Test Questions

8.1 Use of Open Ended Test Questions in the Science 9 Biology Class

Similar to multiple choice test questions, open ended test questions were used at the end of each unit. These questions were designed to test knowledge, understanding, and the ability to apply knowledge to unique situations.

8.2 Students' Reactions and Critique

Most students rated the use of open ended test questions unfavourably. It was ranked as the second lowest method of assessment in terms of student preference. The
students displayed amazing similarities in their anecdotal comments on open ended test questions. Almost all students commented that they disliked open ended test questions because such questions relied heavily on English skills that they did not feel they possessed. One student commented that she "can never write down what (she) wants to say. It never comes out right." This sentiment was repeated by almost all students.

Many students also felt that open ended test questions did not test their understanding. They felt that these questions tested their memorization skills only. One student commented: "All you do is memorize everything and you still might not understand it." This highlights the major obstacle that teachers face when making up open ended test questions. The difficulty lies with creating questions that truly test student understanding, forcing students to think and to apply their knowledge. Not only are these types of questions difficult to create, but they are also more difficult to mark. As a result, many teachers rely on more simplistic questions that ask students only to reiterate facts.

Not all comments on open ended test questions were negative ones, however. Some students said that they preferred these questions over multiple choice or true/false test questions because they offered the opportunity to receive part marks. Such positive comments, however, were rare.

9. Concept Maps
9.1 Use of Concept maps in the Science 9 Biology Class

In this study, concept maps were used to summarize the units on human physiology. Given a list of words, students were asked to connect the concepts with arrows and to explain the connections.
9.2 Students' Reactions and Critique

Students rated concept maps as their least favourite method of assessment. Approximately 72% of students rated concept mapping unfavourably. The reasons for such an unfavourable response were many! Many students felt that this method of assessment was immature. Comments ranged from "I don't really like it because you do it in elementary school" to "a little grade 2".

Students also found concept maps "tedious" and "never-ending" because you could continue to make connections for ever. One student commented that concept maps were "kind of hard because they never seems to end and you don't know how the teacher wants them". Students at this level seem to be very focused on what is right and wrong and on the marks assigned to right and wrong answers. They feel that concept mapping is ambiguous, and they feel insecure in completing them.

However, some students commented that they enjoyed making concept maps. One student commented: "This is great! You can actually see connections which gives a general outline of what you've learned." Another student commented: "I don't like doing them on my own, but if we do them together then I like them because it helps me see connections." Both of these comments, and those of other students, mention the benefit that concept mapping has on learning. None of the students, however, felt that concept mapping was a good assessment tool.

Although most students related that they disliked concept mapping, there are some positive attributes of using concept mapping as a means of assessing student understanding. They allow the instructor to identify gaps in knowledge. A study done by Willson and Williams showed that concept mapping was a powerful diagnostic tool that can assess both gaps in knowledge and the effectiveness of instructional techniques used to overcome these gaps in knowledge (Willson & Williams, 1996).
10. Self-Assessment

10.1 Use of Self-Assessment in the Science 9 Biology Class

In this study, students were not asked to complete a self-assessment of any of their tasks. Earlier in the year, however, students had used this method of assessment. Anecdotal remarks made by students were recorded at that time. Their feelings on this method of assessment follow.

10.2 Students' Reactions and Critiques

Most students commented that they did not feel that this was a valid method of assessment. The students were able to see a few benefits of self-assessment, including the opportunity to reflect back on their own work and the opportunity to indicate how much effort they put into the assignment. However, most students did not feel that self-assessment was a fair method of assessment, commenting that it should not count for marks. They identified the discrepancy between students as the biggest problem with this mode of assessment. Two students who did identical work might give themselves very different assessments.

This discrepancy is a very real problem associated with self-assessment. In the science 9 classroom, student self-assessment was not used to generate marks. Self assessment went beyond having the students assess their understanding of one concept or their achievement on one assignment. Rather, it was used in order to encourage students to reflect on their work and on their study habits on an ongoing basis. This reflection can be very beneficial. It allows students to evaluate their past performances and encourages them to set goals and guidelines for the future. Most importantly, self-assessment empowers the student to take ownership of their learning. By reflecting on past performances and setting goals for future performances, students are able to take ownership of their learning. They can see that learning is directly related to the amount
and the type of effort they put in. Learning becomes student-based rather than teacher-based.

For self-assessment to be successful, students need to be given the skills to reflect on their past learning and to set goals and guidelines for their future learning. The teacher can facilitate the acquisition of these goals in a number of ways. Firstly, teachers can ask students to reflect on a number of specific questions relating to their past or present learning. Secondly the teacher can explain the need to set tangible goals that can be achieved. Not only must the goals be realistic, but they must also be specific. For example, the goal to hand in assignments complete and on time is attainable and specific. The student will then be able to outline the steps necessary to obtain this goal. The goal to improve your mark is vague. It is hard for the student to know where to start this "improvement". Goal setting can also be done on an assignment-to-assignment basis. In order to set these goals, students need to understand the exact nature of the assignment and the assessment criteria.

11. Practical Lab Assessment

11.1 Use of Practical Lab Exams in the Science 9 Biology Class

This study did not include any practical lab assessments as no practical laboratory skills were developed during the course of the study. However, practical lab assessments have been used during the course of the year, particularly during the physics and chemistry units. Students' anecdotal remarks on practical lab assessments were done at that time, and their remarks have been included in the following section.

11.2 Students' Reactions and Critique

On the whole, students reacted very favourably to practical lab exams. Students commented that practical lab exams were "better than (written tests) because they weren't as boring as filling in a bunch of bubbles". A number of students also commented that
they felt confident performing the practical tasks. These students related that they were able to assess their performance during practical lab exams better than during written exams. As a result, most students experienced less stress during the practical lab exams.

Not only are practical lab exams an enjoyable means of assessment in the minds of the students, but they are also extremely valuable pedagogical tools. Science teachers claim that the development of scientific skills is a valued aspect of the curriculum, yet many teachers do not assess students' ability to perform such skills. As most school labs do not have adequate supplies to give each student the necessary equipment to complete a lab, lab groups are formed. Because of this, dominant students tend to take over the activity, while the more reserved students passively watch. It is, therefore, possible for a student to graduate from high school without developing any of these important practical scientific skills.

Thus, it is essential to assess students' ability to perform practical laboratory skills on an ongoing basis. This can be done informally during a lab, or more formally during a practical lab exam. The fear of practical lab exams is often due to the perception that they are logistical nightmares or that they consume copious amounts of time. With careful planning, the practical lab exam is neither.

Not only is a practical assessment necessary to ensure the proper development of lab skills, it is also a very suitable assessment tool for kinesthetic learners. Such learners may have trouble expressing their knowledge verbally, and may only find success by performing their knowledge. Too often these learners are left out in the cold.

12. Conclusion

After analyzing student reactions to ten methods of assessment, it is clear that there is not one method of assessment that is preferred by all. Students' feelings towards
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each method of assessment differed. This emphasizes the well known fact that each student is an individual with individual needs. Students had different reactions to each method of assessment because they had each experienced different levels of success with each method.

Because they have different strengths and weaknesses, students have different assessment needs. As teachers, we should be responsible for ensuring that all students have the opportunity to express their knowledge in a way that is most suitable for them. Students who have a flawless understanding of a concept should not be penalized for the inability to explain it on a multiple choice test. Rather, student understanding should be recognized, regardless of whether it is in the form of a paragraph, diagram, or skit. It is obvious that secondary students need to develop test-taking skills as this is the most universal method of assessment in colleges and universities. However, such skills should not be the only skills emphasized in the classroom. Alternative methods of assessment encourage students to develop a voice that enables them to express their thoughts to others. It does so by developing self-esteem and confidence, developing communication skills, and encouraging students to display their individuality.

By allowing students to express their knowledge in a way that is best suited to them, teachers are able to recognize student understanding that might otherwise have gone unnoticed. It is possible that students who do not seem to understand a concept actually do not understand the scientific vocabulary. They may not be able to express their understanding because they are struggling with terms. If given the opportunity to express their understanding in their own words, they may be able to explain the concept flawlessly. This recognition of student understanding, fosters the development of positive self-esteem. The students feel good about themselves and about their learning. Many students who have never experienced success in the classroom, because of their inability to relate their understanding in a traditional way, can experience success with one or more
of the assessment methods outlined in this study. By experiencing success, students are encouraged to take risks in their learning. They no longer will quit before they have even begun simply because they expect to fail. Most students in this study did not comment on the educational value of each method of assessment. Rather, they commented on how the method of assessment made them feel. By developing positive feelings in the classroom, a learning atmosphere can be created.

Because alternative methods of assessment require students to use their own vocabulary to explain concepts, communication skills are practiced. Students are not asked to communicate through formal writing alone. Rather, they are expected to communicate in a number of different ways, including informal writing, diagrams and models, physical cues, and verbal cues. Thus, the students become well-rounded, able to draw on a number of different skills in order to best communicate their thoughts.

Alternative methods of assessment also encourage students to draw upon their creativity to express their thoughts. Students are given the opportunity to use more than pen and paper to communicate their understanding. Students are encouraged to draw upon their individual strengths and to use the media that best suits them. Many students throughout this study commented on the positive feelings they had towards alternative methods of assessment because of the ability to be creative. This creativity develops a sense of individuality in the students and heightens the confidence they have in themselves as unique individuals. This should allow students to take greater risks in the classroom. In doing so, alternative methods of assessment enable students to accept and appreciate the differences between the diverse members of the class.

Students can also be encouraged to view the process of learning as important through the use of alternative methods of assessment. Many students made comments that the methods of assessment used in this study had benefits beyond the final mark.
assigned. They recognized the fact that many of these assessment strategies were also important learning tools. These strategies helped the students retain the information presented and afforded the students the opportunity to reflect on their learning. Thus, students can become more educated on the learning process through the use of alternative methods of assessment. Many students went as far as commenting that marks should not be assigned to some tasks. They viewed the process of the task as being more valid than the final mark obtained.

Using these strategies to gain insight into student learning is one of the biggest advantages of alternative methods of assessment. In this way, many of the methods presented in this paper can best be used as means of formative assessment. Formative assessment aims to further learning by encouraging pupils to (i) reflect on their learning in a structured and systematic fashion, (ii) engage in discourse with their teachers regarding their progress and what they need to do to improve, and (iii) develop greater awareness of, and competence in, the process of learning (Daws and Singh, 1996). In contrast, summative assessment aims to describe and compare pupils in a norm-referenced way - e.g. to rank order their performance on a set of end of topic tests - for selection, setting or reporting purposes (Daws and Singh, 1996). The alternative methods outlined in this paper can help the teacher and student achieve all of the goals of formative assessment outlined above. The biggest advantage of formative assessment lies in the fact that it enables students to learn about their learning. This is profusely more useful to the students than norm-referenced data obtained from summative assessment.

If there was one common complaint of students regarding alternate methods of assessment, it was the lack of strict criteria. From experience, most students know what to expect from tests, but many have no idea of what to expect from other methods of assessment. As a result, it is important for instructors to outline the criteria carefully. Students cannot succeed in meeting the expectations of the teacher if these expectations
are unknown. Students should also be a part of the setting of the criteria. In doing so, they will have a deeper understanding of the nature of the tasks. In addition, they will be empowered to take ownership for their learning because they feel responsible for the direction of their learning. The development of self-esteem and feelings of empowerment in our students goes a long way towards developing intrinsically motivated students. Students who have pride in and ownership over their work will be motivated to do their best.

This paper is not suggesting that there is no place for traditional assessment techniques (i.e. formal testing) in the science classroom. Rather, it is suggesting that there is a need for multiple assessment techniques. The use of multiple assessment strategies allows all students to feel success in the classroom, enabling the students to develop the confidence necessary to take risks in the classroom. In addition, these methods allow students to develop a sense of identity as they are encouraged to think in their own words and demonstrate their knowledge in their own style.
Detailed Description of Tasks

Drama

Students were asked to research a particular nutrient of their choice. Prior to this, students had received information on each nutrient, but many groups did extra research to supplement the information given in class.

Students were then asked to make a skit to portray the importance of that nutrient. Suggestions were given to the students including making a commercial, news report, infomercial, or talk show. Each skit was to be presented in class (live or on video) and should be no more than 5 minutes long.

The skit had to contain some information about the role of the nutrient in a healthy lifestyle (i.e. why do we need that nutrient).

Students had two classes to do research and prepare/video tape their skits.

Marks were assigned for content and creativity.

Products

After receiving brief instruction on nutritional deficiencies and eating disorders in class, groups of 3 or 4 students were formed. Groups were assigned a nutritional deficiency or eating disorder to research (pulled out of a hat by a member of the group).

Each group had a different topic.

Students used the library and the internet to obtain information of their topic.

Students were asked to produce an educational brochure about their topic. This brochure should include the causes, effects, symptoms, treatments, and cures (if any) of their deficiency/disorder. In addition, the brochure should include information about where the reader can go to get help or more information on the topic (needs to be local resources).

The brochure should target teenagers with the goal of making them aware of the deficiency/disorder and the dangers associated with it.
Appendix A: Pilot Study

Portfolios

1. Students were asked to decorate a file folder at the start of the first lesson in the biology unit. The front of the folder was to be decorated with pictures from magazines of the "ideal" body (i.e. models, etc.). At the end of the unit on health and nutrition, students were asked to decorate the back of the file folder with pictures from magazines of healthy bodies. Throughout the biology unit, students were asked to place particular assignments in their portfolios. These included students' preinstructional ideas of topics (eg. ideas about digestion before being taught it), products and assignments completed throughout the unit, and summary activities done at the end of each topic (eg. a concept map linking nutrition and digestion).

2. Students are asked to research a respiratory or circulatory disease (eg. emphysema, arteriosclerosis, etc.). Students are asked to make a poster outlining the dangers of the disease.

3. At the end of the physiology unit, students are given 3 periods to design and build a board game that deals with physiology. The players of the game should be expected to answer some physiology questions, but the game should not just be a physiology version of trivial pursuit. Marks are awarded for content, creativity, instructions, and for the actual board itself (eg. is it sturdy?)

Projects

Students were assigned a current events project at the beginning of the year. Students were to find current articles from magazines, newspapers, or the internet relating to science (eg. biomedical technology, environmental issues, astronomy, etc.). They were to cut out and summarize one article every two weeks. These articles and summaries were to be referenced and placed in a journal.
Appendix A: Pilot Study

During the biology unit, they were to pick one article that had to do with biology to research in more detail. Students were asked to write a short paper on their topic. Students were given computer time to do internet searches of their topic as the school library was often lacking information on these current topics.

Creative writing Tasks

1. Write a story of "a day in the life of...". This story should highlight a day in the life of a particular type of food. The story should outline what happens to the food as it passes through the digestive system (focusing on one nutrient found in the food).

2. After completing a circulation/respiration activity in which students move coloured bean bags around the classroom to simulate oxygenated and deoxygenated blood, students are asked to explain gas exchanged through the body in their own words. (this is done before students are given notes on gas exchange).

Concept Maps

Concept maps are done at the end of the physiology section to encourage students to put the "big picture" together by finding connections between the various systems of the body. Students are given a list of words that they must connect. In addition, students must explain the connection.

Smaller concept maps are also done periodically to ensure proper understanding of each system (eg. at the end of the digestion unit).

Open Ended and Multiple Choice Test Questions

These are primarily used at the end of each mini-unit (eg. digestion, respiration, etc.) and then again at the end of the entire physiology unit.
Appendix A: Pilot Study

References

Daws, N. and B. Singh (1996). Formative Assessment; To What Extent is its Potential to Enhance Pupils' Science Being Realized?. School Science Review, 77(281), 93-100


Women In Science

We preach about equality,
men and women all the same!
But there is still discrimination,
and we are all the ones to blame.

From the early years of my life
I was given dolls and other girly toys
but all I ever really wanted,
was a chemistry set like the boys!

Why did they get to have all the fun?
While I sat around and moped.
I was made to play with barbies,
when I wanted a microscope!

Ponds, algae, acids and bases,
rocks, gems, elements and trees.
Biology, chemistry and physics,
that's all I'm asking for PLEASE!

I feel most comfortable in a labcoat,
sitting beside a beaker with goggles on my face.
I don't care who stares at me,
I know I'M in the right place.

They say behind every great man there's a woman,
well women, don't stand behind the men anymore!
Don't be afraid to ask for a chemistry set,
because there is an amazing world of science to explore.

~ written by a Science 9 student
Appendix B: Assessment Activities and Criteria

Portfolio Assessment Activities and Criteria

In this classroom, the portfolios were used most effectively as learning logs. In these logs, students were primarily asked to explain their understanding of a topic through the posing of a question or questions. For example, after a lesson on circulation, students may be asked to answer the question "What role does diffusion play in gas exchange?" The strength of the portfolios came from their open-endedness which enabled students to answer the questions through words, pictures, diagrams, or any other meaningful means of communication. Students were encouraged to answer questions in their own words and to avoid reiterating the words of the teacher.

Students were also asked to relate scientific concepts to their real-life experiences and insights. Students were encouraged to share their insights and ask questions in their portfolio entries. On occasion, student entries were limited only to questions which the teacher then tried to answer or make comments on.

Because students were encouraged to relate their own understandings, insights, and questions in the portfolio, these entries were not assessed a mark. Student portfolios were marked only for completion.

Drama-based Assessment Activities and Criteria

During this study, drama-based assessment activities were used extensively to assess student understanding. The following is a sample activity used during this study.
Appendix B: Assessment Activities and Criteria

Purpose: Enactment to explain gas exchange in the human body.

Group size: Maximum of 5 students per group.

Presentation date: April 5

Presentation length: Aim for under 3 minutes (although I won’t be timing).

Criteria:

Does your presentation show the exchange of oxygen and carbon dioxide at the lungs and the tissues?

Does your presentation show how oxygen is transported through the body? (role of blood, blood vessels, and heart)

Does your presentation show the relative concentration of gas in the lungs, tissues, and blood vessels?

Does your presentation explain the process of diffusion?

Are all people in the group involved in the presentation?

Is it clear who all of the "actors" represent?

Is the information presented in a clear manner?

Is the information presented in a creative way?

Students were given the pre-established criteria when the drama-based assessment was assigned. Sheets like the one above were then used during the marking of the presentations and could be used to provide students with feedback. If student presentations involved the production of a script, written scripts were collected before each presentation and commented on by the teacher to give students feedback on the scientific content of the presentation.

Practical Lab Test

During this study, a practical lab test was given at the completion of the chemistry unit. Students were required to visit a number of stations at which they were to perform laboratory skills. Some of these stations included:
Appendix B: Assessment Activities and Criteria

Station 1
Without changing the temperature setting of the hot plate, heat the liquid in the beaker. Measure the temperature of the liquid every 20 seconds for a total of 5 minutes. Using the graph paper provided, make a temperature vs time graph of your data. On your graph, label all significant phases during the heating process.

Station 2
Measure the volume of substance A and the mass of substance B. Using any of the available materials, design and perform a controlled experiment that would test for the production of a gas during a reaction between substances A and B. Make a sample lab report showing your procedures, results, and conclusion.

Station 3
Using bromothymol blue as an indicator, determine if each substance (A – E) is acidic or basic.
Using the available equipment, design and perform an experiment to find out how many drops of solution A is needed to neutralize solution B. Make a sample lab report showing your procedures, results, and conclusion.

Students were observed during these activities but were not assessed. The assessment of students came from their written components which were contingent upon the completion of scientific skills.
Crime in a Lab

Crime in a lab
and I know I'm meant to pay
oppression weighs me down
in this room, cold and grey

They fill my mind with knowledge
and tell me I'm free to learn
but I can't escape the feeling
let the system crash and burn

Cause every time I enter science class
I know I'm bleeding empty
can't grasp it because of my gender?
that lie is told a plenty

So I sit back once again
and feel the chemicals fry my brain
crime in a lab
I'm going insane

~ written by a Science 9 student
For all Chi-square tests, the following conditions were used:

\[ \alpha = 0.05 \]

\[ H_0: \mu_1 = \mu_2 \]

**Question: Do you enjoy science?**

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<tr>
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\[ \chi^2 = 0.116812 + 1.817077 + 0.103504 + 1.610068 = 3.647461 \]

At \( \alpha = 0.05 \), we fail to reject the null hypothesis and cannot conclude that there is a significant difference between questionnaire #1 and questionnaire #4.

**Question: Is science one of your best subjects?**

<table>
<thead>
<tr>
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<th>questionnaire #4 observed</th>
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<td>88</td>
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<td>166</td>
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</table>

\[ \chi^2 = 2.141728 + 1.808571 + 2.416309 + 2.040439 = 8.407047 \]

At \( \alpha = 0.05 \), we reject the null hypothesis and conclude that there is a significant difference between questionnaire #1 and questionnaire #4.

**Question: Is science difficult?**

<table>
<thead>
<tr>
<th></th>
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<th>questionnaire #4 observed</th>
<th>questionnaire #4 expected</th>
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\[ \chi^2 = 2.538599 + 2.575931 + 2.429802 + 2.465534 = 10.00987 \]

At \( \alpha = 0.05 \), we reject the null hypothesis and conclude that there is a significant difference between questionnaire #1 and questionnaire #4.
Appendix C: Statistical Analysis

**Question: Do you plan on taking science in senior high school?**

<table>
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</table>

\[ \chi^2 = 0.013784 + 0.087497 + 0.014975 + 0.095059 = 0.211315 \]

At \( \alpha = 0.05 \), we fail to reject the null hypothesis and cannot conclude that there is a significant difference between questionnaire #1 and questionnaire #4.

**Question: Do you plan on taking science in university or college?**

<table>
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<th>questionnaire #4 expected</th>
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<td></td>
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</table>

\[ \chi^2 = 0.073926 + 0.168146 + 0.082348 + 0.187302 = 0.511723 \]

At \( \alpha = 0.05 \), we fail to reject the null hypothesis and cannot conclude that there is a significant difference between questionnaire #1 and questionnaire #4.

**Question: Do you plan on pursuing a science-related career?**

<table>
<thead>
<tr>
<th></th>
<th>questionnaire #1 observed</th>
<th>questionnaire #1 expected</th>
<th>questionnaire #4 observed</th>
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<tr>
<td>total</td>
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</tbody>
</table>

\[ \chi^2 = 0.637121 + 0.955682 + 10.728139 + 1.092208 = 3.413149 \]

At \( \alpha = 0.05 \), we fail to reject the null hypothesis and cannot conclude that there is a significant difference between questionnaire #1 and questionnaire #4.