STUDENT IDEAS ABOUT SCIENTISTS AND THEIR WORK

by

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ABSTRACT

Students in a summer work experience in university science and engineering laboratories were interviewed before, and near the end, of their three week placement to find their ideas about scientists and their work.

The study indicates that the friendliness of the people was a significant feature of the scientist's setting for all the students. Although all but one of the seven boys mentioned elements of the task or working with equipment first when discussing significant features of the experience, they all commented on the friendliness of the people. However, for all five girls and one of the boys, the friendliness of the people was the most significant feature of the experience and little was said about the task or working with equipment.

Before the placement the students were unsure of the friendliness of the scientists, and anticipated that scientists had serious and grave dispositions. Many thought the atmosphere of the laboratory would be formal, while others held a variety of ideas about the laboratory's formality. Scientists' work was thought to be demanding, requiring dedicated, hardworking, single-minded, serious persons who worked abnormal hours.

Following the placement, the students were relieved to find that 'scientists were friendly'. In addition they found that the people in a scientist's setting were informal, that they were 'not serious' and were often 'joking around'. The students' initial idea that a scientist's work is demanding was confirmed. Following the placement the students thought that scientists needed to be dedicated and serious about their work, but like other professionals, scientists sometimes needed to work 'abnormal hours'. While scientists did

concentrate on the job, they were not 'thinking day and night only about their work'. However, the students thought that becoming a scientist took more effort than other similar careers.

There was no significant change in career choices as result of the experience.

Based on the results of this study it is recommended that in order to improve students' views of science, teachers and others should emphasize that scientists are friendly, informal, intelligent, normal people, and that there are a range of work roles in science requiring various levels of education, effort and commitment.

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CHAPTER 1: INTRODUCTION

> In the current global marketplace, maintaining a competitive position is increasingly linked to scientific and technological know-how. Canada's future economic prosperity is thus dependent on our scientific progress and our adaptability in the fields of science, technology and engineering. To keep up with its competitors, Canada requires an extensive supply of highly educated scientists and inventors. However, in recent years, graduate enrollments in the natural sciences and engineering have been leveling off, rather than increasing and only a very small percentage of these graduate students are women.
>
> (SSHRC Background paper, 1991 p. 1)

Since World War II, the importance of science and technology's role in the economic prosperity of advanced nations has been recognized. As a consequence, policy makers have paid increasing attention to science and technology issues. In the past decade this attention has been focused upon two issues: first, developing in citizens, the science literacy that will enable them to make informed decisions concerning important scientific and technological issues such as genetic engineering, acid rain and nuclear power and second, ensuring an adequate supply of qualified personnel necessary to enable the country's economy to remain competitive.

In Canada, policy makers in government and education have recently implemented a number of initiatives to increase scientific literacy and to make science and engineering careers more attractive. One component of scientific literacy is knowledge of scientists and their work. Among the government initiatives addressing this issue are programs where scientists and engineers visit schools giving presentations to students (e.g. the B. C. 'Scientists in the Schools' program). In other programs (e.g. work study programs) students meet scientists and other technical professionals in their place of work .

When scientists talk to students in schools, their visits are usually short and emphasize dramatic demonstrations that illustrate the phenomena that scientists study. Therefore very little time is available to follow the recommendation of The Science Council

of Canada (1984) "...(to present) a more authentic account of science" (p. 37) and to address "the inadequate representation of the scientific enterprise.... " (p. 37). However, in work experience programs students meet scientists for an extended period and see scientists and other staff at work in a scientist's setting. Watts (1983) defines work experience programs as those in which students experience work tasks in work environments, without taking on the full identity of a worker" (cited in MacDonald and Black, 1987 p.1). As a result, students have both the time and the opportunity, not only to meet scientists informally and see the work of scientists, but to do some of the work for themselves. Thus, because students in a work experience program have a greater exposure to scientists and their work, one would hope that students in such a program would develop a richer understanding of scientists and their work compared with students only exposed to a short classroom presentation. Because of this, the work experience students should be able to come to a more informed decision about whether science is the appropriate career choice for them and make more informed decisions about scientific and technological issues.

Work experience has usually been organized for students going directly into the work force from high school. Few programs are directed at university oriented students and little research has been done on them. As a result, very little is known about student ideas about scientists and their work and about the effect of a work experience program on these ideas. Yet this knowledge should be the basis for the successful design of any work experience program which seeking to improve scientific literacy or encouraging students to consider a career in science. This study attempts to add to this knowledge.

The Study

The purpose of this study is to understand more about the effect of a work experience on student ideas about the people and work in a scientist's setting. This will help us understand the contribution of work experience to students' scientific literacy and

whether a work experience placement will encourage students to consider a career in science.

The students in this study had completed Grade 11 and were enrolled in a new high school course titled 'The Nature of Science'. This year long course was intended to provide students with an understanding of science as a process and as a career. For the first part of the course, the students had a three week summer placement in research laboratories at the University of British Columbia where they worked in science and engineering laboratories.

This study involved interviewing students in-depth about their ideas about the people and work in their placement. The students were interviewed before and near the end of the experience. Interview transcripts were made and analyzed.

'Scientist' is used in the broad sense and is intended to include engineering and other related technology careers. 'People Working in a Scientists' Setting' (PWSS) means all the persons in the laboratory that a student might consider to be scientists, including professors, graduate students, post doctorate students and some senior laboratory technicians.

The overall research question is: In what ways does a work experience placement influence student ideas about scientists and their work and student commitment to science as a career.

The following sub-questions provided the focus for this study:

1. What did these students find most significant about the work experience?
2. What were the students' ideas about the people in the scientist's setting before and after the placement?
3. What were the students' ideas about the work in the scientist's setting before and after the placement?
4. What were the students' ideas about their own ability to be a scientist before and after the work experience?
5. What were the students' ideas about the desirability of being a scientist before and after the work experience?

Scope and Limitations

The limitations of this study come from three factors. Firstly, as a study of twelve students, the data base for this study is small. Secondly, the students in this study were from one course in one high school and were among the top science students in the school. Though the results from this study cannot be generalized to the whole population, this study will be of interest to policy makers, because 'top' students are the type of student that many policy makers wish to attract to science careers. Thirdly, the students in the study spent three weeks working in a scientists' setting, a situation that is not available to many students.

Educational Significance

> "... it is important to know how to improve basic science education for everyone and how to encourage young people to embark on careers in science and technology." SSHRC Background Paper: 1991 p. 1

The results of this study will provide policy makers with more knowledge about student ideas about PWSS. In particular, it will provide information about the ideas about PWSS that were held by students considering science as a career. It will also provide information about which ideas about PWSS were revised as a result of a particular kind of work.

Because of the difficulties of giving all students a work experience, if the changes in student ideas are seen as useful and desirable, educators will need to devise alternate experiences to achieve similar results.

The study should provide data which could be used to evaluate and design other programs that enable students to meet with scientists whether at school or at their work by providing an understanding of ideas that are important to students and/or can be revised as a result of this type of experience. This study will assist others who wish to design other kinds of programs that attempt to achieve similar ends and will assist textbook writers and curriculum designers by indicating the ideas about PWSS that were held by some students. Finally, information about what students found significant in a scientific work experience setting will also assist in our understanding of work experience courses in general.

As a result, this study improves our understanding of the two issues raised in the SSHRC Background Paper. It will provide information that can be used to improve the understanding of science, which is part of basic education for everyone. It also provides

information that can be used to encourage young people to embark on careers in science and technology.

Overview of the Rest of the Thesis

In chapter two, I will present a review of other work on student ideas about the people and work in a scientists setting, I argue that knowledge of the producers and production of science should be part of scientific literacy. I describe work experience and some research on it and suggest that it should be an ideal way to learn about PWSS.

In chapter three, I will describe the methodology of this study and the students and the situation of the case under study.

In chapter four, I will outline the results of the study. I suggest that the students' ideas about the people in a scientists' setting were changed during the experience, while their ideas about the work in a scientist's setting were largely maintained.

In the concluding chapter I summarize and discuss the results. Then I suggest the implications for education and for policy makers. I suggest that programs which encourage students to consider science careers should emphasize the friendly nature of the people in the scientist's setting, as well as the range of knowledge, skills and jobs that are present in the scientist's work place.

CHAPTER 2: REVIEW OF LITERATURE

Many researchers interested in scientific literacy have investigated student ideas about the nature of scientific knowledge. In this chapter, I suggest that they have not considered student ideas about the producers and production of science. This should be studied as an important part of scientific literacy, because of its importance in student decisions about their careers. Next, I describe some student ideas about science as a career from other studies. Then I will define and describe work experience programs and describe research on some other students in work experience programs. I suggest that work experience is an excellent way to learn about the producers and production of science.

Knowledge of the Production and Producers of Science is Part of Scientific Literacy

Many national science organizations (eg. National Science Teachers Association, 1982, Science Council of Canada, 1984)) have been concerned with developing scientific literacy in citizens, to enable them to make informed decisions concerning important scientific and technological issues such as genetic engineering, acid rain and nuclear power.

Knowledge of the nature of science is considered to be required for scientific literacy. Lederman and Leidler (1987), for example, defined scientific literacy as follows: "The scientifically literate individual possesses an in-depth understanding of scientific facts, concepts and theories as well as a clear understanding of the nature of science" (p. 17).

While it is well accepted that an understanding of the nature of science is part of scientific literacy, much of this literature has focused upon the nature of scientific knowledge. As a result most research into student ideas about science has also focused upon student ideas of the epistemology of science.

For example, in a series of papers, Lederman and co-workers (Lederman, 1986, Lederman and Leidler, 1987 and Zeidler and Lederman, 1989) investigated the relationship between teachers and students' conceptions of the nature of science. For their investigations they defined the nature of science as "the values and assumptions inherent to scientific knowledge (e. g. representativeness, parsimony, empirically based, amoral, etc.)" (Lederman, 1986, p. 3).

Lederman and others in this paradigm derive their analytical categories from the philosophy of science and are mainly concerned with epistemological issues, that is, the nature of scientific knowledge rather than with the social and personal aspects of its production. Yet, knowledge of the social and personal aspects of the production of science are a part of understanding the nature of science.

As La Follette (1982) suggests, all aspects of science need to be communicated to students. This includes not only results, but the 'production and producers' of the results. Because of the lack of emphasis on the producers and production of science in schools, many students must make important decisions, especially career decisions, based upon little information, or faulty ideas.

There are probably as many aspects to the 'producers and production' of science as there are to the results of science. What is relevant to this study however, are the characteristics of the people and work in a scientists' setting.

Fortunately, some aspects of the people and work in the scientists' setting have become a focus of study by researchers interested in Science-Technology-Society (STS)

issues. The major work in this area which considers student ideas is the Aikenhead, Fleming and Ryan (1987) survey on Views on Science, Technology and Society (VOSTS) in which student ideas from an STS perspective were analyzed.

Student Ideas about Scientists

Ryan's (1987) analysis indicated that most students felt that scientists were concerned about the effects of their work. Ryan concludes, on the whole, that students thought that scientists were being responsible for their actions. Ryan reported a variety of views about the honesty and objectivity of scientists and suggested that students were able to differentiate between the traits scientist's display at work compared with their behaviours in their daily life. Opinions about scientists' behaviour varied. Some felt scientists were inherently more honest and objective, others felt the work 'ethics' would transfer to daily life, while others felt these ethics would be 'left at work'.

The results of the VOSTS study indicate that students held the idea that scientists were ethical i. e. honest, objective and concerned about the effects of their work. This suggests that science is an honourable and perhaps, an attractive career.

However, the study does not address what students felt that scientists were like as people and as potential co-workers (such as whether they were friendly, helpful, or formal). In other words, the study was concerned with the character of scientists, rather than their personalities. The study also did not address the students' ideas about the nature of scientists' work in terms of job demands, variety, or hours spent at work, for instance.

In addition to being part of an understanding of science, these issues would appear to be important to students when choosing a career, yet there has been little study of student ideas in this area.

Fraser (1977) and Schibeci (1986) examined the 'normality of scientists' using a scale developed by Fraser. Their studies examined student perceptions of scientists' 'normality' using health, outside interests, family life and working conditions sub-scales. They found that girls perceived scientists to be 'more normal' than did boys. However, both boys and girls rated scientists as normal. Unfortunately, Schibeci (1986) indicates some doubt as to whether the students in the study were rating science teachers or practicing scientists.

Dorkins (1977) found that students believed scientists to have the following personal characteristics: "withdrawn, remote, secretive and cautious individuals with few interests" (p. 523). And while Schibeci (1986) suggests that students' images of scientists focus on stereotypes which are extremes of characteristics that all people have, these images no doubt have some influence on student decision making.

For example, Brush (1979) found that students who feel closer in personal characteristics to their image of scientists enrol more frequently in science courses. This suggests that if students were to change their image of scientists to one more like their own self image, they would be more likely to consider science as a career. Head (1979) also suggests that if science is not to be self perpetuating, with particular personality types dominating the subject, changes need to be made in the way scientists are perceived.

Science as a Career

A study involving 112 young Canadian students in small group discussions (6-9 per group) (Generations survey 1989) found awareness of careers in science is very narrow limited mostly to the medical field. With the exception of medicine, there was generally not considered to be a high earning potential in the sciences. A common image of

a science career involves working in a laboratory, wearing lab coats, peering through a microscope and doing tedious work.

The participants thought that while opportunities in science and technology are growing, but most thought that business and commerce offered the most opportunities and widest range of options. Many participants thought that a career in science requires an investment of a large amount of time. Some participants thought that the extra time and effort invested in a science degree (compared to the arts) would not be an advantage in the job market. Some participants thought that there is a very high degree of competition for the highly specialized areas of science. Students did not want to be forced to take post-graduate work to get a job in the field.

The study suggests changing the negative stereotypes of science, informing about what a person in a science related career does, that science has practical applications and that there are a broad range of career opportunities available in science.

Sawyer (1989), in a study of over 3000 Canadian first year university students, found that most Canadian students do not agree that future scientific fields will be male dominated, or that men are more interested in science. She also found that 94% of respondents thought that both men and women make good scientists and 54% agree that opportunities for men and women are equal in science.

In conclusion, some studies indicate that students thought scientists were ethical and normal, while others found an emphasis on characteristics of scientists that were not normal such as secretiveness and remoteness. Brush (1979) indicates that these images of scientists do affect course selection and therefore career choice. The studies indicate some ideas about science as a career. Students have ideas that science careers do not offer the opportunities and options of business and commerce, require a large investment of time and are highly competitive in some fields. The students thought that science will not be male dominated and that both men and women make good scientists. However, there has

been little research into student ideas of scientists as co-workers, or of the nature of the demands and rewards of the work.

Work Experience

Work experience is an obvious way for students to become informed about the world of work. As a result, work experience programs are part of the proposed graduation requirements in British Columbia Ministry of Education's recent 'Year 2000 document'. As this study will investigate how work experience programs might affect students ideas about people and work in the scientists' setting, this section will define and describe work experience and summarize the results of some other studies of work experience programs.

The ideal work experience should provide students with the opportunity to reflect critically, individually and as a group, on the meaning of their activity, that is, on the significance and consequences of their participation (Dollar and Rust, 1983). They suggest that the students' reflection must be related to theoretical knowledge in an integrative cycle of learning. The theoretical knowledge should grow out of the concrete experience that proceeds it.

The learning in a work experience can be described as experiential, that is learning by personal experience through observations, questions, discussions, trying things and watching others trying things. David Layton (personal communication, August, 1989) suggests that the experience of being in a new situation with an adult other than a teacher is one of the most important features of a work experience.

The purposes of work experience include "preparing them for the world of work, providing them with references, allowing them to sample specific jobs and to learn valuable life skills"(MacDonald and Black 1987, p. 44). MacDonald and Black reported that students found the vocational aspects of work experience programs most important, while the social aspect of the program was the most enjoyable.

MacDonald and Black (1987) state that relatively little research has been undertaken to assess the effects of work experience and to see whether work experience serves any useful purpose. They suggest that most of the literature on work experience has been of the 'how to' variety.

The acceptance of students into the work situation will have an important influence on the success of the placement. Bottcher (1971) investigated the attitudes of 32 students who worked for eight weeks in various scientific laboratories at the University of Iowa. He reported that 74% of the students thought they were accepted as team members, 81% thought the experience furthered their interest in research. 40% of the students worked by themselves, while only 20% preferred to work by themselves. Bottcher infers from this that the students would have preferred more assistance. The students in Bottcher's (1971) study indicated that for 80% of them, the scientist had a hand in the selection of their research project. Only 2 of 32 students thought the experience was as they had expected.

While the student experience proposed in this study seems very similar to the one in the Bottcher (1971) study, his investigation was not an indepth one for it involved two multiple choice questionnaires, one with seven questions and one with nine questions. Of the 16 questions almost all were factual questions such as 'Have you started your project?' rather than questioning the students about their ideas. Only one question directly addressed the students' attitudes toward science research. The study therefore was an inadequate investigation of student ideas, although the paper does give some indications about the things students might do on a work experience.

The relationship with co-workers is a central part of a work experience (David Layton, personal communication) and so the student ideas about this relationship will be important to the success of the placement. MacDonald and Black (1987) used interviews to study student ideas of work experience. They investigated a Scottish work experience program and interviewed supervisors, teachers and students. They reported that before the

placement, concerns about the relationship with the other staff (whether they were friendly, etc.) were the most common fear for students. However, during the placement this relationship became the source of greatest enjoyment for the students. Students learned that they could "mix with and get on well with adults. "(p. 37) and were surprised with the "wide range of tasks that were involved in particular jobs (p. 37). " The students also saw the value of "letting ...(students) see what it was like to work with adults, to get up early and work longer hours and to experience travelling further afield than schools. (p. 42). However, they report that few pupils changed their job intentions during the experience.

The long term effects of an intense summer experience are illustrated by a study of the Student Science Training Program (SSTP). The National Science Foundation funded SSTP, from 1959 to 1982. The program was not a work experience, but an intensive summer course for talented students. The programs was conducted on university campuses, with lectures, seminars and weekly presentations and discussions with research scientists.

Druger and Borgstede (1984) surveyed participants in 1982 about the effects of the SSTP program for personal development and career choice and received 114 responses: 98% had completed a four year degree and 88% went on to do some graduate work. 69% of those who replied were involved in or headed toward science related occupations (although only one of the 114 talented students chose to teach secondary school science). 80% said the program influenced their choice of career and 88% said the program had a positive or very positive influence on their life.

When asked for the influence on their careers the students commented (Druger and Borgstede 1984, p. 130-131): '...(it) opened up a vast area', (now an assistant professor of biology); '(it) opened my eyes to what research was like...'(physician), 'I decided I had a strong interest in biology and science.... '(physician), 'It confirmed my interest in

biology.... '(professor of biology). Many students mentioned that the program had a positive effect on their confidence (p. 131): '... this program gave me self-confidence and academic direction.... '(physician), 'It gave me a lot of confidence in my abilities. '(professor of biology).

Druger and Borgstede's study indicates that an intense summer experience can have profound and long lasting effect on students. This is an important consideration, because the time consuming nature of work experience programs make them expensive and will only be justifiable if there is a sufficient long term payoff.

Summary

MacDonald and Black's study indicates that before the placement, students were apprehensive about the way that they would be accepted in the work environment. While following the placement most student felt they were accepted by the staff and this relationship became the most enjoyable part of the experience. Few pupils changed their job intentions during the work experience. Druger and Borgstede's study indicates that students felt that an intensive summer program in science had a positive or very positive influence on their life.

This review of the literature reveals that there has been little investigation of student ideas about scientists. What work has been done in the area, notably the VOSTS study, has been from an STS point of view and focuses upon student ideas about scientists' characters. There is little information about student ideas about scientists' personality (friendliness, cooperativeness, formality) or about the student ideas about the demands of the work place (tediousness and requirements for abnormal hours) affecting the quality of family life. Knowledge about these student ideas is important because the student ideas about scientists' personality and the demands of scientists' work will influence student career choices. The next chapter will present the way in which this study proceeded.

CHAPTER 3: METHODS

A high school in the Lower Mainland of British Columbia had begun offering a course that involved students in a work experience with scientists. The program offered the opportunity to learn about the effect of a work experience on students' ideas about the people and work in a scientists' setting. This chapter describes the research process, the subjects, the setting for the study, the interview schedule and analysis.

RESEARCH DESIGN

The experience was part of a year long course for students entering Grade 12. The course began with a three week placement at the University of British Columbia where the students worked in science and engineering laboratories. Student ideas were investigated before and during the placement because the intent was to find the effect of the work experience on the student ideas. A semi-structured interview format was used as it would enable me to explore student comments that occurred during the interview, yet provided a format that ensured that the same topics would be covered in each interview. Other researchers investigating student ideas about science or work experience (Aikenhead, 1988; MacDonald & Black, 1987) found the interview to be the effective method.

According to Borg and Gall (1989), the semi-structured interview differs from the structured interview in the amount of direction and restriction imposed by the interview schedule. They suggest that the semi-structured interview is the most appropriate interview form for studies in education, as it "permit(s) a more thorough understanding of the respondent's opinions and reasons behind them, than would be possible using the mailed questionnaire" (p. 452).

The first interview took place prior to the placement, at the students' high school. The students were interviewed one at a time in their science classroom. The students knew very little about the research labs they were to visit, except for two students who had briefly visited the lab to meet their supervisor on the day of, or the day before the interview. All of the students were interviewed again during the second or third week of their three week placement. Four students were interviewed for a third time at the end of the placement. One student was also interviewed on the second day of his placement.

The second set of interviews were conducted at the site of each students' placement in a quiet area away from the other people in the laboratory. The interviews were tape recorded and the interview tapes were transcribed. The transcriptions were analysed for the ideas about people and work in a scientists setting that were significant to the students. Excerpts illustrating this analysis were selected and are presented in Chapter Four.

CHARACTERISTICS AND CONTEXT OF THE SAMPLE

The study involved the in-depth interviewing of seven male and five female students from a large urban high school situated in a lower middle class neighbourhood of a west coast Canadian city. Two students in the program did not participate in the study because they were not available for interviewing, one because the placement site was off campus and the other because the placement followed the time available for data collection. The teacher of the course made every attempt to ensure that there was an equal or almost equal number of male and female students in the program. She sought out likely girls and encouraged them to participate and encouraged the boys to find girls who would enter the course, so that an approximately equal number of males and females would be achieved.

Students who participated displayed a substantial commitment to the course. They committed three weeks of their summer to the placement that would otherwise be available for employment. In addition, most students needed to take an additional course in summer school to replace the regular school time used for the course. These demands served to select out all but a few students. A further selection factor may have been self-selection by other students who decided not to take the course because of perceived competition from some of the school's very best science students. The group was mult-ethnic, which reflected the student population of the school. In scholastic terms, the judgement from the teacher of the course was that these students were among the top science students in the school.

The Career Preparation Course

The study was conducted during the first part of a year long course titled 'The Nature of Science'. The course was organized within the school as a Career Preparation course.

In the school district that was the site of the study, Career Preparation courses have traditionally been used in the vocational area. They were used to introduce students to potential careers and were usually used for students who were unlikely to go on to post secondary education. Career Preparation courses include both school classroom work and a placement involving at least 100 hours of practical work experience. The Career Preparation course that was the focus of this study was one of the first in an academic subject area.

The purpose of the course was to teach students what science is and how scientific investigations are carried out (see Appendix I for a course description). The placement formed the first part of the course and was organized in the summer, while the classroom work for the course began in the fall. Before the placement began, the students only knew their prospective supervisor's name and the general field of study (microbiology etc), of the laboratory that they were to have their placement. During the placement, the students were to conduct a project that they would present to their class during the school year.

Some examples of the students' projects include: measuring ion concentrations in Blue Heron egg shells taken near the Vancouver Airport, glassification of hazardous materials as a means of safe disposal and rebuilding a computer controlled robot arm.

DEVELOPMENT OF THE INTERVIEW SCHEDULE

The interview schedule (see Appendix II) was developed to elicit information about student ideas about people and work in a scientists' setting. The next section will explain the objectives of each phase of the interviews.

Initial Interview: Before the Placement

Course Choices.

This section sought information about the school experiences that students might bring to their placement by finding out the extent of the students' exposure to science through science courses and other courses that might be similar such as electronics or computers.

Experiences with Science Past and Present

This section sought sought memorable positive and negative experiences that students had had with science both in school or out of school.

Expectations about the Experience

This section sought information about the expectations the students had about the people (the scientists) and the work (what the scientists did and what it was like to work there).

Inquiry into Science as a Career.

This section sought information about the career expectations the students had, especially related to science.

The Interview Schedule for the Interview during the Work Placement

Inquiry into the Significant Events in the Experience

This section sought to identify the strongest impression that students had gained from the experience through an initial non-directive question. Follow-up questions sought information about any differences from their expectations,

Inquiry into the Problem Set the Student

Each student (or in one case a pair of students) was required to do a small research project which was to be presented to the class later in the course. This section sought to find out about the work the students were doing as well as provide another setting to probe the student's ideas about the people and work in a scientists' setting.

Questions about the People in the Scientists' Setting

The questions in this section focused upon the student's perception of the people of the people of the laboratory, what they were like to work with and the motivation and skills of people in a scientist's setting.

Questions about the Work in the Scientists' Setting

The questions in this section focused upon the student's perception of the work of the people of the laboratory, such as their ability to do the work, the desirability of the work, the workload and so on.

Overall Questions about Scientists Career and about Becoming a Scientist.

This section inquired into the difficulty and desirability of becoming a scientist and their ideas about science as a career.

Gender

This section sought to find out whether the students thought their gender had any effect on their experience.

This interview schedule was also used for a third interview. A complete series of interviews was not conducted because of a lack of time and because there seemed to be little change in ideas since the second interview.

The interviews were subject to on-going development during the series of interviews. Because of the semi-structured nature of the interviews, the interview schedule was easily adapted.

Analytical categories

This study derived categories from the student's ideas and experience. The categories that emerged during the analysis of the data reflected the ideas that were of importance to the students.

The categories first emerged during my reflections on the interviews and were strengthed and refined by initial readings of the transcripts to search for themes. Next, the complete transcriptions were entered into Hyperqual, a Hypercard program which facilitated searching for key terms and words and by keeping the records of the origins of the excerpts that were used in the analysis. Using this program the interviews were analyzed for the ideas about people and work in the scientists' setting that were significant to the students. Finally, the drafting of this thesis required further analysis of pertent parts of the transcripts.

My initial intent was to study students' ideas about scientists and their work. Questioning in the initial interviews was based upon this intent and asked for information about scientists. However, during the analysis of the second interviews it became clear that the students saw little of the professor who was in charge of the lab and often spoke of other people in the laboratory as scientists. The students were also unclear as to who was and who was not, a scientist. Finally, it seemed that the students ideas about all the people in the laboratory and their work was more likely to influence things like career choice and their ideas about science.

I therefore reframed my analysis to look for student's ideas about the people and work in a scientist's setting (PWSS).

SUMMARY

The decision to proceed with this study was made because the subjects' ideas about the people and work in a scientists' setting would be important, since most of these students were intent on a career in science. The interview was the selected methodology because of the small population size. The semi-structured type of interview was selected because it allowed the investigator the flexibility to explore interesting responses.

CHAPTER 4: RESULTS

In this chapter, I will present the results of the analysis of the interviews. The presentation will approximately follow the organization of the research questions. The information presented will provide the context of the study, what students found most significant about the experience, their ideas about PWSS, then their ideas about their ability to be a scientist and finally their ideas about the desirability of becoming a scientist.

I have differentiated between the work habits of scientists and the personal characteristics of scientists. For example, the work of a scientist might require one to be patient (a work habit), but it need not require one to be friendly with other people (a personal characteristic). That scientists need to be patient is then a characteristic of a scientists' work. Personal characteristics are presented first, then I will describe the student ideas about the scientists' work habits. I am using this distinction as a means to organize the presentation of the analysis.

THE CONTEXT OF THE STUDY

During the work placement the students worked a full eight hour day in the laboratories under the direct supervision of a professor, or with a supervising professor checking on their work each day or two while the students worked directly with a laboratory director or graduate student. As part of a brief orientation the students were usually given some background reading for the first day, and then assigned to learn basic techniques that would later be important to their project. In most cases they were quickly started on a small research project suggested by their supervisor. During the three weeks of the placement the students were responsible for completing this project and were

required to present a seminar on their project and its results in the fall. The seminar was given to the rest of their class and was open to the rest of the school. The students appeared to take the project seriously and focused effort on fulfilling this responsibility. Many continued to visit the labs after the formal placement was completed to get final or additional results for their presentations.

Most of the students were given specific instructions about how to carry out the techniques required for their projects. However their was no supervision in the high school sense of 'watching over' the students. They were free to set their own schedules, although most kept regular office hours.

The students did different things each day, so their schedules varied. As one student said: "some days it's hectic, some days it's nothing. "(F 6942 A*).

The students had a great deal of free time between reading instruments or other tasks for their project. "...basically my lab is like, I'll work for ten minutes and then I have to wait for three hours, so there's a lot of waiting, so I just ... work for ten minutes and I just read. " (M 6469 A).

After a few days in the laboratory the students were able to carry out many of the routine tasks required for their project themselves and began to work with without direct instruction.

As a result of having more free time, several students began to assist the graduate students with small routine parts of other experiments as they became familiar with the

* Each excerpt is identified first by a letter: M for Male subject, or F for Female subject, then by a record number, and then by a letter: B for Before the placement or A for After or during the placement.

techniques. "...sometimes I enter data for them and help them to do their experiments..." (F 4679 A)

Students' Past Experiences with Science.

In School

All the students were taking senior science courses. Seven students, five males and two females, took or planned to take Chemistry 12, Physics 12 and Computers 12, while four students, all female, took or planned to take Chemistry and Biology 12. All of the students were beginning the Career Preparation 12 course.

The students ideas about school science were varied, but most students indicated that they liked experiments and demonstrations but disliked note taking and memorization. Other comments were: School did theory and on this placement they would learn the practical side of science; that unlike the scientists, the teachers in school were not learning; and that school was more primitive, simpler and crowded than the university labs.

Out of School

Only two students reported any memorable experiences with science outside the classroom. One of these experiences was doing 'chemistry' experiments in the kitchen as a child and the other was trying to build a laser during his early teen years. No students mentioned any recent experiences. When asked about past experience with science most students only described portions of courses that they liked, or didn't like.

Did School Prepare Them for the Experience?

Before the placement, all of the students felt unprepared for the experience. Most knew almost nothing about what they were to do and knew only that they were 'working with Dr. Smith in Forestry', for example. They did not know what activities they were expected to do, but knew that compared to the people they would be working with, they were untrained. As a result the students were sufficiently unsure of themselves to hope that the people they would be working for were sympathetic. Many students expressed the 'hope' that the people in the scientist's setting would be friendly. The students were apprehensive about whether they would be able to successfully complete their placement in an environment where, as one student put it: "...(There are) really, really totally intelligent people, that its like Ph. D.'s everywhere. " (F 13140 B).

The lack of information about what they had to do contributed to their feeling unprepared. For example, before the placement one student said:

R* How well prepared do you think you are for this?

A Not very, I'm not sure what it is I'm doing so I guess that doesn't make me very prepared for it. (F 12517 B)

Following the placement the students consistently stated that their high school courses had helped prepare them for the experience. Here is the same student commented following the placement:

R OK, how well prepared do you think you are for these activities?

*R= researcher, and A= answer from the student.

A Knowledge wise ? I think I was very well prepared.

R When I asked you that before, you didn't think you were well prepared at all, why do you think that is?

A Because this is university level and all I had was grade 11, so I thought the gap between what I was going to do and what I know was a lot larger.

R But it wasn't?

A No. (F 6121 A)

Reasons for Participation in the Program

All of the students except two (see Larry and Lance, later in this chapter), viewed the work experience placement as a way to gain experience which would help them decide whether to choose a career in science and if so, what to choose as a career within science:

"I think it'll help me decide on my future occupation. " (F 13340 B)

"Well, if its interesting and enjoyable, it'll probably push me towards science but then if its boring and dull... I wouldn't want it.... "(M 10635 B)

All of the students saw themselves as university bound and saw the work experience program as an opportunity to prepare for and get a preview of life as a student in that institution: "...I thought it would help me, prepare me for university and what I may encounter. " (F 13340 B).

Some students were curious about science and took the course to find out more about science. One student mentioned being interested in Science-Technology-Society (STS) issues and saw this as a more demanding course than STS 11 a course that unfortunately has become a course for those not interested in a career in science: "(I want)... a broader view of what science is like... (I have) sort of a curiosity... (about) how science is arrived at. "(M 10901 B).

Two of the students who took the course were interested in computer programming and viewed the placement as an opportunity to work with more powerful hardware and software than was available in high schools.

The opportunity to work on a science project for an extended period of time rather than in one hour blocks was attractive to several students.

WHAT DID STUDENTS FIND 'STOOD OUT' ABOUT THE EXPERIENCE?

All of the students found the friendliness of the people in a scientist's setting to be a significant feature of their experience and it was the strongest and most consistant idea that emerged during the analysis of the interviews. However, in response to my initial nondirective question about what 'stood out' about the experience, the responses differed according to the student's gender.

When asked about what 'stood out' for them about the experience, all of the boys except one mentioned things related to their own task first and then mentioned the friendliness of the people. The comments by these students reflected an emphasis on the equipment, on the task at hand and on the freedom that the work experience gave them:

R ...overall, what stands out for you?

A One thing you have to have all equipment sterile, you know if it's not then you're going to ruin the whole culture.... (M 2193 A)

R What stands out for you about the experience?

A Doing things on your own rather the teacher outline.... (M 2418 A)

In contrast, all of the girls and one boy, commented first about the friendliness of the people in the work environment. This group said little about their equipment or their task in response to these questions. This girl's comment to the first question in the second interview is representative of many:

R OK and first, I'd like to ask you about your experience, what you found interesting, important or different from your expectations. Overall, what stands out about the experience?

A The people are very friendly . . . . (F 5392 A)

There were many similar comments:

R What about the people, are they like you expected?

A No, I . . . (didn't) expect that they're so friendly. (F 5237 A)

R What else about the atmosphere?

A Pretty friendly. . . .

R Is that what you expected?

A Not really, I thought they'd be like always working and things, but then they fool around, and joke around and take breaks, and stuff like that.

(M 8556 A)

All of the students were relieved to find the level of friendliness that they found during the placement, perhaps because of their apprehension about their performance. This friendly nature, implying an acceptance of the students, was the most important feature of the experience for the students as a group. MacDonald and Black (1987) report similiar findings.

WHAT WERE THE STUDENTS' IDEAS ABOUT THE PEOPLE IN A SCIENTIST'S' SETTING BEFORE THE PLACEMENT?

'I Hope the People will be Friendly'

Before the placement the students had tentative ideas about the friendliness and varying ideas of the formality of the laboratory. They had no direct knowledge of the people and work they would be seeing and had to rely on their own ideas about science and scientists to enable them answer my questions.

The students did not have a firm idea of the friendliness of the people in the lab, yet hoped they would be friendly:

R What do you think the people there will be like?

A They're certainly experienced, they should know what they're doing and hopefully they'll be friendly.

R Do you think they will be?

A If they're willing to accept a couple of high school students....

(M 13689 B)

Formality

Many students thought the people in the laboratory would be formal, but the others held various ideas about the formality of PWSS. These included 'more formality than school', 'formality varying with the situation', 'less formality than school', and 'informal or relatively so'. As we will see this variety of ideas about the formality of the work environment contrasts with the consistent idea after the placement that the work environment was informal:

> The (scientists) I met I thought would be formal but like I said they joked around .... (M10901 B *)

> R How do you think ...(that the placement is) going to be different from school science?
>
> A Cause its so formal, its going to be really, like its important....
>
> (F 13140 B)

However, not all statements indicated that the placement would be more formal than school. One student expected the environment to be less hierarchical and therefore <u>less formal</u> than the school environment:

> A . . . yeah I would be on a student-teacher level but it'd be more, not peers, but it wouldn't be so far apart as like a teacher and student.
>
> R More informal than formal?
>
> A I think so. . more informal. (F 13340 B)

* This student had been on a brief visit to the laboratory on the day of the first interview. The excerpt indicates that this student did think that scientists were formal before meeting them.

One student expected the formality of the work environment to vary with the size of the project: "(The)... work may be more informal, but if it's a large or difficult project, it's formal. " (F 11699 B).

The overall impression I received is that the students knew little about the people in the labs and were just speculating. As one student said: "I don't think none (sic) of us do know what ...(scientists) really do. " (F13140 B)

Serious or Grave Disposition

The students thought that the people in a scientist's setting were serious as in: 'grave in disposition, appearance, or manner' (Webster's p. 2073). The idea that the scientists were serious, not much fun and demanding is consistent with the idea that the people in a scientist's setting are formal.

R What do you think the atmosphere is going to be like?

A Serious and not much fun because for science work you need to concentrate. (11699 B)

A (Before SWSS) I thought that they'd be real serious and now everyone's totally, they all joke around in the lab. (F 6469 A)

WHAT WERE THE STUDENT IDEAS ABOUT THE WORK IN A SCIENTIST'S SETTING BEFORE THE PLACEMENT?

A Scientists' Work is Demanding

The idea that a scientist's work is demanding emerged during the analysis. Demanding is used here as "...requiring work, or necessitating work. " (Websters p. 598). While the word 'demanding' was only used once in an unrelated context by the students in the interviews, it seems to best represent the ideas that the students had about a scientist's work.

The students indicated that a scientist's work is demanding by suggesting the type of work habits needed by a scientist: dedicated, serious, patient, hard working. The students made many statements indicating that science was a demanding career: '(it takes) a lot of work to become a scientist', 'scientists must only think of their work' and the work demands 'abnormal hours or work' and 'may interfere with family life'.

Scientists need to be Dedicated, Serious and Hard Working

The students thought that there was a 'lot of work' in a scientist's job and it required scientists to be dedicated or devoted to their work:

> R What do you think it's like to be a scientist?
>
> A I think it's pretty difficult.... . it's a lot of work involved in like you can't be in other subjects because you have to be dedicated to it... and you can't fool around or anything and you have to always think seriously and when ...something goes wrong it could be serious.... (M 10635 B)

Scientists' work requires that they not 'fool around' and must ' 'think seriously' according to this student. These are ideas that are part of and consistent with, the ideas that scientists must be dedicated.

In the next sections I will look at examples of the student's ideas of the type and amount of effort required of scientists.

Many other students used the word 'serious' before the placement. Here, serious suggests "absorption in, concern about, or inclination to purposive or important work, deep thought, or earnest care rather than frivolity or levity. " (Webster's p. 2073). The following students suggest that scientists must be serious and work hard because their work is important work, perhaps with dangerous consequence if errors are made.

A. ...and you can't fool around or anything and you have to always think seriously and when you...something goes wrong it could be serious...

(M 10635 B)

A . . . they'll probably be very quite serious about whatever they're (doing).... (M 12127 B)

The students thought that scientists needed to be hard working.

A First, they have to be hard-working people and then there has to be experiments which have a lot of research through and a lot of work was put through... (M 10635 B)

F (A scientist is)... always curious about things, not always trying to, not a lazy person and someone who'll work hard to find out ways to improve life and technology for us. (M 11436 B)

Next we will see that the students thought that scientists must not only work seriously and hard, but that their efforts extend into abnormal hours.

A Scientist's Work Demands Abnormal Hours of Work.

Before the placement the students thought that the work demands of a scientist were abnormal. Many refer to twenty-four (24) hour day work schedules and while this may not necessarily mean literally '24 hours a day', it does suggest that the students expected a scientist's work to involve abnormal hours of work: "...it's kind of a 24 hour job, you know even though you're not in the lab, you're still thinking about it." (F 11903 B).

While the next comment was elicited in response to a question about the Nobel Prize, which presumably does demand extra-ordinary effort, the excerpt indicates that the student thought that at least some scientists certainly did put in abnormal hours.

R When you said in order to win a Nobel prize you had to be dedicated. How would you tell when someone's dedicated?

A He'll be working day and night, possibly twenty four hours, no sleep, all that's on his mind is the project and he'll make a lot of self-sacrifices in order to achieve that goal.

R Do you think that most scientists are like that?

A Most? I'm not sure, but some certainly would. (M 13689 B)

Later, this student stated that most scientists typically work 9 a.m. to 9 p.m. The idea that 'being a scientist' took more time than other jobs, was common among the students before the placement.

Scientists need to be Single Minded about their Work.

The students thought that scientists needed to be single minded about their work. In this sense 'single minded' means: 'to shut out everything but work out of one's mind':

R What do you think it's like to be a scientist?

A I think it's pretty difficult.... . it's a lot of work involved in like you can't be in other subjects because you have to be dedicated to it.

(M 10635 B)

A all that's on his mind is the project ....

R Do you think that most scientists are like that?

V Most, I'm not sure, but some certainly would.

(M 13689 B)

Another term to describe the public image of scientists is 'absent mindedness'. This is an extreme form of single mindedness. It implies that the scientist is so single minded that he or she forgets about other 'worldly responsibilities'. The students did not use the term 'absent minded', although it was implicit in some of their statements. For example: "(Scientists were) concentrating on their work and not really aware of what's going on around them..."(F 11903 B).

The idea that scientists need to be single minded about their work is consistent with other student ideas that were presented earlier. For example, a person who thought only about his or her work would not likely be a sociable, friendly person and the students did not expect scientists to be sociable and friendly. In other words, the idea that scientists need to be single minded forms part of and is consistent with a web of similar ideas about scientists and their work.

To be a Scientist you Need a Ph. D. and be Very Intelligent

Before the placement the students did not have an idea about the range of jobs in a scientists' setting. They thought that everyone had a Ph. D. and was very intelligent.

> Like I always think they're really really totally intelligent people, that its like, Ph. D.'s everywhere. (F 13140 B).

These two ideas are very important as they serve to differentiate scientists from the average person and discourage many student who 'self select' themselves out of science. A student's reasoning might be as follows: A career in science is only available to very intelligent people with many years of education. If I am not one of the very best science students and/or do not wish to spend many years in university, then I probably should not consider a career in science.

Summary

Before the placement the students were unsure of the friendliness of the scientists, held a variety of ideas about the formality of the lab and thought scientists had serious and grave dispositions. They thought that a scientist's work was demanding, that it required dedicated, hardworking, single-minded, serious, work and that it required abnormal hours.

WHAT WERE THE STUDENT IDEAS ABOUT THE PEOPLE IN A SCIENTIST'S SETTING AFTER THE PLACEMENT?

The People in a Scientist's Setting are Friendly and Informal

As mentioned earlier, before the placement the student held tentative ideas of people in a scientist's setting as friendly. After the placement the students strongly held the view that the people in a scientists' setting were friendly. This friendliness was a surprise and perhaps a relief for the students. But there were other changes in the students' ideas about the people in the scientists' setting. Before the placement many students thought the people in the laboratory would be formal. Following the placement, many students thought that scientists were not formal. One student I visited was just introduced to his supervisor (scientist) the day before the pre-placement interview.

R How do you think the scientists and grad students talk to each other?

A I didn't meet many, like the one's I met I thought would be formal, but like I said, they joked around and... (M10901 B)

Later, in the same interview...

> ...if I didn't go yesterday, I would have thought ... scientists were really formal . (M10901 B)

The students' ideas of the informality and friendliness of the people in a scientists' setting were also indicated by their use of words like 'Joking' or 'joking around', which were used to infer kidding, lack of ceremony, or informality:

> R What else about the atmosphere?
>
> A (Its) pretty friendly because next door they come in here and joke around.... (M 8556 A)

> R What about xxx?
>
> A He's nice, sometimes jokes around with you but he makes sure you get your work done and he explains to you step by step....
>
> (M 8556 A)

The People in the Scientists' Setting are not Serious

Before the work experience, students thought that scientists were 'uptight and serious'. However, after the placement the student's ideas were that the people in a scientists setting were not serious but 'mellow and really nice'. Here, the students mean that the people did not get nervous or flustered when the students were working.

A (Before the placement) I thought that they'd be real serious and now everyone's totally, they all joke around in the lab.

R What do you mean by that?

A Like everyone's just really mellow and really nice, like they're not all like uptight, serious all the time.

R What did you expect?

A Well I though they'd be like work and only half hour for lunch or something, (and) work, work, work. (F 6469 A)

This observation was an important one for the students' enjoyment of the placement, because they were apprehensive about their abilities to perform in this environment and did not want to work with people who were 'serious and uptight'.

WHAT WERE THE STUDENT IDEAS ABOUT THE WORK IN A SCIENTIST'S SETTING AFTER THE PLACEMENT?

Scientist's Work is Demanding

The students' ideas of the demands of the scientist's work were both confirmed and modified following the placement. The confirmed ideas were that 'a scientist's work is demanding', that it requires dedicated, serious and hard working people.

After the placement students maintained the idea that a scientist's work was demanding. This is indicated through the continued use of words such as 'dedicated', and serious, and by other statements related to the nature of the scientist's work. The ideas that were modified following the placement were that 'Scientists do not work abnormal hours' and ' Scientists do not think only about their work'.

Scientists Need to be Dedicated and Serious

Before the placement the students thought that scientists needed to be dedicated. Following the placement the students maintained the idea that the scientists were dedicated and 'serious about their work' in the sense of having concern about or earnest care for their work. The student viewed scientists as serious about their work, but not serious in disposition.

R What do you think about that, the amount of work compared to other professions?

A It seems to me that to be a scientist you have to be dedicated....

R So you think you have to be dedicated to be a scientist.

A I think so. (F 5392 A)

A I think he (a scientist) should be willing to sacrifice the time for work, ... your lab could go on for 24 hours and you have to stay like maybe a whole day and you can't just like go home,... you have to be dedicated to your work. (F 6899 A)

R How ...(would) you describe the scientists you work with?

A They're all generally laid back but they were all serious about what they were doing. They would spend their entire lunch and coffee breaks discussing the problem and then they stopped discussing it for volleyball and what not, generally they're easy going and they're serious about the problem or experiments. (F 8294 A)

The idea that scientists must be dedicated to their work is consistent with the theme that the scientist's work is a demanding one, as one would expect that a demanding work would require dedication to carry it out properly.

Scientists Need to be Patient and Precise

The students thought that scientists need patience to do their work well. This is an idea that was not mentioned before-the placement.

A I think you need a lot of patience because if something goes wrong, you shouldn't get frustrated and start again, you can't just give up. (F 6899 A)

A .... what do you think you'd need to develop to become a good scientist?

A More patience.

R Why do you say that?

A Because you sit around all day, like, I kind of want to move around, I can't sit in one spot for very long. (M 6394 A)

...you have to be very careful and precise. (F 6899 A)

Although demanding work does not necessarily require patience, work that requires patience is likely more demanding. This idea's emergence from the after placement data does support the idea that a scientist's work is demanding.

Scientists are not Single Minded about their Work.

The students revised their ideas during the placement to 'scientists are not single minded about their work'. For example, this student mentions that she had thought that while scientists worked they 'wouldn't notice anything else'.

R How is it different from the way you'd imagined it?

A Well, I'd imagined the people to sort of like if they start to work on something to just work on it and not really notice anything else that was going on and like basically like disappear, they wouldn't notice anything else... (Now I see that they're) working hard on it ,but they know what's going on around them and they go for lunch and all that.

(F 5392 A)

This is an important observation because it challenges the stereotype of scientists as single minded or absent minded workers, who are immersed in their work, not concerning themselves with the 'normal, outside' world.

A Scientist's Work does not Demand Abnormal Hours of Work.

As we have seen above, the idea that scientists need to work hard was maintained after the placement and the students thought that a scientist's hours of work were greater than those of most other professions.

However, for the students the idea that scientists worked abnormal hours was changed by the placement. Several statements were made which indicated that while the students thought that a scientist's work did sometimes involve a lot of hours, it did not normally involve 'abnormal hours' and was similar to other professional work. In other words, for some students, the perception became 'scientists sometimes have to work abnormal hours, just like other professions':

R How has this experience affected your ideas about scientists and their work?

F (I) Sort of learn(ed) more that they're not always working twenty four hours a day, but now I see that it's just a regular job....

(M 2296 A)

The student's idea that scientist's work requires hours much like other professions is an important observation, because the demands of a career in science were a concern of the students.

There are many Different Kinds of Work in a Scientist's Setting.

During the experience, some students mentioned that the work in a scientists setting was carried by a different people. These people had various responsibilities and training from professor to lab technician. In general the students seemed to categorize most of them as scientists. Like several other students, the following student expected to be working 'at the elbow' of the scientist, but found that there was a hierarchy and that there were many people working in a scientist's setting:

R What did you expect when you were told you were going to meet professor so and so? What did you expect he would be like and how does he differ?

A First, I expected that I would work with him, I thought I would do some experiments with him, but after I came here, I thought, oh, he's... head of the department, and he organizes different kinds of people to do different kinds of things, ...if he wants to ...do research ...on a particular thing, ...then he tells people to do that, and if those people have questions, they ask him.... (F 5237 A)

(This student was a new Canadian with poor spoken English and the excerpt has been edited to eliminate a torrent of brackets and 'sic. s').

SUMMARY

Following the placement, the students were confident that 'scientists were friendly'. In addition the students thought that the people in a scientists setting were informal, that they were 'not serious' and were often 'joking around'. The students maintained their initial idea that a scientist's work is demanding. The students thought that scientists needed to be dedicated and serious about their work, but like other professionals scientists sometimes worked 'abnormal hours'. While scientists did concentrate on the job, they were not 'thinking day and night only about their work'. However, the students thought that becoming a scientist took more work than other similar careers.

STUDENT IDEAS OF THEIR OWN ABILITY TO BE A SCIENTIST.

Before the placement, all the students thought that becoming a scientist would be difficult. Unfortunately, I can only infer that the five students (three males and two

females) who stated that they were intent on a career were confident of their abilities as a scientist.

R What do you think it's like to be a scientist?

A I think it's pretty difficult.... . it's a lot of work involved in like you can't be in other subjects because you have to be dedicated to it. (F 4371 B)

Unfortunately, I do not have data on whether the three students who were not planning a career in science thought that they had the ability for a career in science. I assume that those considering a career in science did feel they had the ability. The others may have been less sure of their ability, but it is difficult to understand why they would participate in this demanding science program if they felt they had no abilities in science.

During the placement, the students changed their ideas about the level of ability needed to be competent in the scientists' setting.

"...what I basically learned is that you don't have to be an absolute genius to work here.... " (F 6121 A)

R How difficult do you think it is (to become)...a scientist?

A If you're interested in the job, it shouldn't be that difficult (to become a scientist)... it just depends on if you want to. (F 6121 A)

The students learned about which courses to take and what the courses were like through informal conversations:

"they tell you what the courses are about, they were really helpful in telling me what it was like and what they found their first and second year was like." (F 6121 F)

When given the choice of any job in the laboratory, most students selected the person with whom they had spent the most time. Only two of the students were interested in the supervising professor's job. It may be that the selection of the supervising professor by the student was more due to personal self confidence or the lack of it, rather than any other factor. There was no apparent gender difference however. Several students who spent a lot of time with their professor did not select him or her. They thought the job was too demanding:

R OK, if you could have any of these jobs in the labs, whose would you prefer?

A I guess it would be Anne's, she does a lot of analytical things,... it's very interesting ... the stuff she's doing.

R What about some of the other people?

A I definitely would not like (the supervising professor's) job, he's got like 10 thousand projects, it's really busy sometimes and I'm not eager to do that. (F 6121 A)

Before the placement, students thought that becoming a scientist would be difficult. Following the placement they thought that it was not as difficult and most students had increased confidence in their abilities as a scientist.

STUDENT IDEAS ABOUT THE DESIRABILITY OF BEING A SCIENTIST

The Social Significance of Science.

Several students mentioned the term 'making a difference', meaning that it was significant that the work of scientists has some positive impact on the wider society. Mitchell (1975) suggests that a fundamental need of adolescents is to register an impact upon his or her society and physical environment, so it is not surprising that science's impact on society made it attractive.

Several students mentioned that they might 'discover' something during the work experience and the possibility that they might be able to make a contribution to science and to society was attractive to them.

> "Because you can make a difference, like right now, they're doing cancer research and searching for a cure for AIDS ... it is because I wanna make a difference, I want to help society. " (F 13140 B)

Before the experience, most students thought science was a rewarding career. Most thought that the main rewards were recognition, self satisfaction from helping society and money.

R Do you think science is a rewarding career?

(Break)

A You get recognized when you do something significant and you try to help and basically if it works, you're happy, you get that excitement in there, you keep thinking, it works, you 've actually done something .

(F 13140 B)

A You get recognized when you do something significant and you try to help and basically if it works, you're happy, you get that excitement in there, you keep thinking, it works, you've actually done something .

(M 13689 B)

R What do you think scientists do everyday?

(Break)

A Figure out, and they do labs all the time and they get paid lots of money.

Career Choices at the End of the Work Experience

Of the five students (three male, two female) who intended to pursue a career in science before the placement, four students (two male, two female) described increased commitment to science as a career after the practicum. Of the four students (two male, two female) who were unsure of their commitment to science as a career, one increased her commitment, two (one male, one female) were still not committed and one (male) decided against science as a career. Two (male) students who did not intend to pursue science before the placement maintained that intention. Lance, who wanted a career in science before and after the placement, did not feel capable, he stated that: 'There's a slim chance (for me to succeed in science)'.

For those who increased their commitment to science as a career, the reasons given included: 'not as dull as I expected', people assume you're intelligent', 'lots of opportunity', different sections of science, so I can select', 'it seems actually related to the real world'.

Another comment on science as a career was: '(it) takes too much time'. This comment was also found in the Generations survey (1989). Two of the three (Larry and Lance) who said they were not interested in science were interested in computers instead. The other, female, was interested in sports and a career in physiotherapy. Both Larry and Lance were working on their own, programming with computers during their work experience and did not see much of the people or work in a scientists' setting.

One female student was not considering science until the program was announced and decided to investigate science through the career preparation program. She completed the program undecided about whether a career in science was for her.

The status and earning power of a science career were important to students' families. Parents were supportive of the choice to go into science: "My mother's excited because she (says) 'You'll make a lot of money (in science).' so as long as it makes a lot of money, it's okay with my Mom."(F 13140 B). Head (1979) reviewed the literature and found considerable accumulation of evidence indicating that more science students tend to come from lower class socio-economic backgrounds than student from other similar careers. Suggesting that "the vocational advantages of a science degree might also influence a student and his parents, from a working class home in selecting the subject for higher education" (p. 33).

Gender Issues did not make Science Less Desirable for the Girls.

The girls were aware of the dominance of science by men, but did not feel it would be a problem for them because there were many girls taking science courses in university. They felt that while their gender had been a problem in the past for girls seeking a career in science, it was not any longer. These findings agree with Sawyer (1989) who found that about half of the respondents thought the opportunities for men and women were equal in science.

> A Dr. xxx she's a female ... and she grew up in different times than I did and it was even worse, now, it's like, pretty liberal for both men and women .... (F 6899 A)

The increasing numbers of women going into the sciences gave these girls contacts with others in the sciences and re-assurance that they would not be alone if they chose to take science classes.

> A ...friend(s) of mine, they both finished first year at UBC and they both finished sciences and they were telling me there were a lot of other girls (there). (F 6899 A)

*The Influence of Gender: The Case of Linda**.

Linda was an interesting individual case because she was female, from an East Indian ethnic background that traditionally has not seen women in a professional role. She did her work experience in what has been a traditionally male profession: engineering.

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* a pseudonym

Linda's mother was very important to her decision to pursue a science career. "Since my Mom's understanding, that's all that matters." This was important because there was social pressure from others in her family to marry early and have children but "my Mom's very lenient when I say I don't want to get married very young, I guess she's seen many people burned out 'cause of early marriages and lots of children."

Linda's female cousins had a positive influence on her. "My female cousins, they're generally very, very intelligent, at least the ones that I get along with very well, so when I said I was considering going into engineering, they said 'Sure go for it.' (but) the guys are a totally different matter." Her brothers were mentioned as a source of chauvinistic influence. "My home background is very chauvinistic. It's like females cook and get married by the time they're twenty-five, but guys can marry any time they want, as long as they have children." Male cousins also display similar attitudes toward her: "Most of (the guys)... wouldn't care what I do as long as I get married before I'm twenty-five...."

Linda would be uncomfortable in classes without any other girls: "...like in my computer class, it wasn't until I sat down and looked around that I saw it was all guys except for this one girl. Well, (I thought) do I really belong here? The fact that the other girl was there was reassuring, ... if you were the only girl, you'd feel out of place."

However, Linda did not appear worried about the proportion of girls in her engineering classes, as long as there were some girls in the class: "I'd like at least two or three (girls) because you can relate more to them, I can relate more to a girl in a class than a guy, I can talk to them but when it comes to certain things, you can relate more to a girl, so it helps."

Linda did not feel that being a girl has made any difference to her in the program, nor does she expect it to be an issue for her at the engineering school which she hopes to

enter. This may be due to the fact that the teacher of the work experience program is female (as is the high school principal). In addition, she states that "...I've seen more girls than guys here.... more girls are coming into engineering, so I don't worry about this. "

The cancelling of an annual student event in which a naked women rode through the campus on a horse, called the 'Lady Godiva ride' did make a positive impression on Linda. "(it) shows they're mature about women's rights and things like that.... I get very impatient when people get very chauvinistic...the fact that they got rid of it reflects very well on them...I thought that was very admirable. "

Linda had looked at the number of girls taking classes in engineering and "it looked pretty much even...". She had seen more girls than boys in during her work experience. As a result, at the time of the interviews she had no hesitation attending the engineering school.

WORK EXPERIENCE

The Importance of Personal Contact: The Case of Larry and Lance*

Larry and Lance are interesting because they both were interested in computer programming rather than 'classic' science and had a very different work experience setting from the others, first, because they worked in pairs and second, because they seldom saw any other people in the laboratory. While I have used the term science very broadly and would have included research into new areas of computer programming part of science, I did not consider that these students' work was science. They did not work on any programming ideas, but rather used their existing skills to complete an assignment. They

* both are pseudonyms

did not spend time in the engineering laboratory, but spent their time away from the laboratory working together on their programming assignment. As a result these two students did not have much contact with the people and work in a scientist's setting.

Both students stated they entered the program because they would have the opportunity to work with computers and hoped that they would get to use advanced computers or programs. However, both students did not learn much about programming through the experience. The task they were given was to make a graphics program that would display a part that was being distorted by a stress. The computer that they were given to work on was not as powerful as their high school computers and the language they were using was one they had not used for a few years. This was disappointing for them: "But the only (disappointing) thing is the computers, it's not as advanced as I thought it would be.... "

Before the work experience, both students seemed to lack of confidence in themselves (compared to the other students in the group). Both students mentioned that the heavy competition in other faculties was one of the reasons for selecting computer studies. This did not change during the work experience.

These students did not find the placement a learning experience:

R what do you think you're going to learn here?

A So far, I haven't learned anything really, but I'm hoping that if I finish the project, I'm currently working on, I'll be given more advanced stuff.

However, the most striking feature of this placement, was that it lacked contact with the people and work in a scientists' setting. The students worked together in a small cubicle that was part of a larger room. One person, presumably a Graduate Student or Post Doctorate Fellow, worked in an enclosed office that was part of the larger room. Usually, there was nobody else in the room. While these students had as much contact with the supervising professor as some of the others did, they worked on their own and had little or no contact with other people in the laboratory. While the laboratory was studying wood, these students had little interest in this. As a result, their project, which was to make a graphic display of the distortion of wood under stress, did not bring them in contact with the other people in the laboratory.

When asked what 'stood out' about the experience, Larry was the only male who responded that the 'people' stood out for him, rather than the task or the equipment as did the other boys (Lance mentioned the degree of free time). The people in the scientists' setting stood out for Larry in spite of the fact that he (and his partner) probably had less contact with the people of the laboratories (other than the supervising professor) than did any other student. Larry did seem to be a person who was genuinely interested in people and his selection did seem quite in character. I think that it is unlikely that a different work experience would have yielded a different reply by Larry.

Larry and Lance's career choices were interesting. Larry was very interested in mixing business with science. Before the placement he saw himself working with computers on some type of engineering project and he maintained this view after the experience, perhaps because this was the type of work he was doing during the placement.

Before the placement, Lance was interested in science because he saw this as a way to work with new and technologically advanced equipment. Following his experience, he was still interested in science but did not see any possibilities for himself. He still saw the competition with other students to be too great in science.

Gender in the Work Experience Program

The girls in the program did not feel gender was an issue during the work experience program. I was firmly told that gender made no difference in their treatment. I gained the impression that the girls considered that it was a 'put down' that I would suggest that gender made a difference and they were therefore favoured.

R Do you think being a girl made a difference in this program?

A Not really, everyone's treated me pretty equal,... one should get preferred treatment, ... in the past they (didn't treat us equally), everyone should be treated equal. (F 6899 A)

The Students Wanted More Information about the Placement

The impression from the students and others in the program was that it was well run. The only suggestion the students had was that they wanted more information about their placement before it began. The lack of information about the placement was not as much of a concern for the students during the placement. This suggests that while the information may not have been essential, it would have been comforting to the students to have more information before the placement began.

SUMMARY

In general, more of the student's ideas about the people in a scientist's setting changed during the experience, while few of the student's ideas about the work in a scientist's setting were changed (a detailed summary is given at the beginning of the next chapter). In the next chapter, I suggest that attempts to improve scientific literacy and encourage students to consider careers in science will need to focus upon changing the students' ideas of the scientists as people, as well as focus upon changing the students ideas of the variety of work in science.

CHAPTER 5: SUMMARY, DISCUSSION AND CONCLUSION

In this chapter I will review and discuss the results of the study, provide some policy suggestions and recommend areas for further research.

SUMMARY

The primary objective of the study was to identify how a work experience placement effects student ideas about the people and work in a scientist's setting and their career choices.

The sub-questions provided the focus for this study. The relevant results are summarized after each question.

1. What do students find most significant about the work experience?

   The most significant feature of the scientists' setting for all of the group was the friendliness of the people. When asked what 'stood out' about the experience for them, the girls, mentioned the friendliness of the people , while the equipment and the task was not a very significant feature of the experience. However, for all but one of the boys, the equipment and the task that they were working on was the most significant feature of the experience.

2. What were the student's ideas about the people and work in a scientist's setting?

   Before the placement the students were unsure of the friendliness of the scientists and thought scientists had serious and grave dispositions. Many thought the laboratory was formal, while others held a variety of ideas about the formality of the lab. They thought that a scientist's work was demanding, that it required

dedicated, hardworking, single-minded, serious work and that it required abnormal hours.

Following the placement, the students were confident that 'scientists were friendly'. The students thought that the people in a scientists setting were informal, that they were 'not serious' and were often 'joking around'. The students maintained the idea that a scientist's work is demanding. They indicated that scientists needed to be dedicated and serious about their work. They thought that, like other professionals, scientists sometimes worked 'abnormal hours'. While scientists did concentrate on the job, they were not 'thinking day and night only about their work'. The students thought that becoming a scientist took more work than other similar careers.

3. What were the student's ideas about their own ability to be a scientist following the work experience?

I inferred that before the placement, most of the students thought they would be able to be scientists.

Before the experience most of the students thought they would be able to complete what was expected of them in the work experience, but did not feel well prepared. Most expected the work they would do to be difficult. After the experience, all of the students felt that with sufficient training, they were capable of doing the work in the laboratory. This increased their confidence that they could succeed at a career in science. Most were not confident of their ability to do the work of the supervising professor, however.

4. What were the student's ideas about the desirability of being a scientist following the work experience?

Before the experience, the students found science as a career was attractive because of its positive contribution to society and because of the recognition scientists receive for their work. The students found the people and the atmosphere of the scientists setting more attractive than they had expected. They found the friendly atmosphere and the variety of jobs and tasks attractive features of a career in science. As might be expected, the program reduced the number of undecided students, although two students still remained undecided at the end of the placement. However, the program did not result in a significant change in career choices.

Students who were interested in a career in science, increased their interest in a science career. Those students who did not intend to follow a career in science, still said they would not select a career in science, while those who were deciding between a career in science and a career in business, increased their interest in a science career. The students had a more informed understanding of the demands of the job, but still considered it demanding. They had an improved understanding of the working conditions and the variety of jobs and tasks in a scientists' setting and this improved their opinion of science as a career.

While the girls recognized that there had been difficulties for women in science in the past and that science was still male dominated, they did not consider these issues would be a problem for them.

LIMITATIONS

As noted earlier, the limitations of this study result from several factors. Firstly, as a study of twelve students, the data base for this study is small. Secondly, the students in this study were from one course in one high school and were among the top science students in the school. The results from this study will not be generalizable to the whole population of students, although this study will be of interest to policy makers, because 'top' students are the those that many policy makers wish to attract into science careers. Thirdly, the students in the study spent three weeks working in a scientist's setting, a situation that is not be available to many students. Finally, in studies of this type the skills of the interviewer and analyst significantly affect the success of the study.

DISCUSSION

The most significant feature about the scientists' setting for the students was the friendliness of the people. This was also the case with the students in MacDonald and Black's (1987) study who were working with professional and non-professional workers other than scientists. They also found that the students' relationship with future co-workers was the greatest source of anxiety before the placement and was the greatest source of pleasure during the experience. They suggest that this is due to the students' apprehension about the placement. It is likely that apprehension is also a significant factor for the students in this study. The students' apprehension about their ability to perform caused them to be apprehensive about the nature of the people in the scientists' setting. The students hoped for a friendly, informal audience that would accept them into the laboratory

community. That the people in the scientists' setting were friendly and informal was important to the students as a result.

However, the students' idea that scientists were friendly was not only an artifact of being in a work experience. The students' prior ideas did not suggest that scientists are friendly people. In other words, I am suggesting that the students ideas about the peoples' friendliness changed in the same way as other ideas did, but that in addition, the students' apprehension made it more significant than it otherwise would have been.

Student Ideas about PWSS

While the source of student ideas was not the focus of this study, the results do suggest some hypotheses about their influence on student ideas. An influence in the creation of the students' prior ideas about scientists are the characteristics of the school classrooms. Brush (1979) suggests that students assume that the scientists in the laboratory have similar characteristics to the characteristics they see in science classrooms. For instance, if teachers' talk in science classrooms emphasizes safe, serious work habits, this may affect the way that students think about PWSS. According to Brush (1979), this emphasis would suggest to students that scientists are safe, serious people.

Science teachers may also have inaccurate ideas about scientists' and their work. Science teachers seldom have the opportunity to be 'practicing scientists' or to see scientists at work in the way the students in this study were able to see them. Undergraduate science courses may be another source of teachers ideas about scientists (Tobias 1990).

Perhaps teachers wanted students who were serious, did not 'joke around', were hardworking and single minded in order that their classes be easier to manage and their

students more academically successful. In order to encourage students to act this way, teachers may have described scientists as having these attributes so that the students might emulate scientists and take on these attributes. If so, the student's image of scientists would be in part, a creation of science teachers and was a result of the teacher's image of the way a good science student should be, rather than the way scientists are in reality.

If this is correct, it implies that changing the image of scientists that is presented in classrooms, may not be in the self interest of science teachers. Consider for example, the observation by students in this study that the people in the laboratory 'joke around all the time'. Is this an image of scientists that high school science teachers would portray to their sometimes unruly classes? Curriculum designers will have to consider these concerns of teachers in order to successfully change the way teachers portray scientists. This will be difficult, if as I have suggested, the teachers presentation of scientists may be bound up in teachers notions of the way to manage classroom behaviour.

MacDonald and Black (1987) found that work experience did not make a major change in students' career choices. This also seems to be the case in this study, although the work experience did reduce the number of undecided students. One questions whether work experience is worthwhile if there are not major changes in career choice at the end of the program. I suggest that the answer is yes. Druger and Borgstede's (1984) study suggests that an intense summer program can have a pivotal impact on the careers of students and while programs such as this work experience may or may not change the raw numbers of students selecting science as a career, it may have a positive impact on the quality of the student understanding of science making them better, more productive citizens, whatever their career choice.

Druger and Borgstede's study also indicates that students who participate in an intense summer program in science have more confidence during their undergraduate years,

a better perspective on science and are therefore less likely to drop out of science. In this way the program may reduce the attrition rate among undergraduate students (ref: Tobias (1990), for the role of confidence in success in undergraduate science classes) and result in an increase the raw numbers of science graduates .

Work Experience

Improving the Work Experience

A key feature of the work experience was the relationship with the other workers and the 'hands on' nature of the experience. Because most of the students in this study did have access to the people in the laboratory, they were able to develop the informal, friendly relationships that were a very significant part of the experience. This led to informal discussions, better observations of the day to day activities of the laboratory and the opportunity for the students to query others about their concerns about university science courses and science as a career. The two students who did not have regular access to others in the laboratory (Larry and Lance) did not enjoy the same quality of experience as the others. Like many learning situations, learners in a work experience learn better in a friendly informal atmosphere with regular contact with their advisers. In this instance, where one of the aims was to have students learn about the people and work of a scientists' setting, this contact was crucial to achieving this aim.

Prior to the placement, the students suggested that the program would be improved by providing more information about what they would be doing. Providing this information in the form of a small booklet describing the program, or through a visit from former participants might reduce the students' apprehension and thus might encourage more students to participate in the program.

CONCLUSIONS

In the first chapter, I suggested that the present study might assist in answering the two questions posed by the SSHRC, namely 'How should we improve basic science education for everyone?' and 'how should we encourage young people to embark on careers in science and technology?'.

In this study, I have provided some answers to those questions. I have shown that even these able students intent on a career in science did not have a very clear picture of PWSS. Yet, it is clear the the students in the study changed their ideas about PWSS. They understood more about what scientists are like, what they are like to work with and the nature of the work. They learned about the demands of some of the jobs in a scientists setting. They asked about university life and learned 'their way around' the campus. They were able to informally ask about science courses and what was required for a career in science. All of these ideas will provide a base for a better understanding of science. To this extent at least, the work experience did succeed in improving these students' scientific literacy.

While it appears that work experience encouraged the students to spend time considering science as a career, it did not result in a significantly larger number of students selecting science. It did increase the commitment of some of those already considering a career in science however.

The key feature of a work experience program is developing a relationship with the workers during the placement. In order to be able to achieve this in a work experience program, the students must be more than passive viewers of the activity in the laboratory.

They should have a task that gives them credibility, that enables them to face challenges and if possible to participate with some of the other projects in the laboratory.

POLICY SUGGESTIONS

Because most students are not able to participate in a work experience program, I would like to make two suggestions that might allow others to gain some of the knowledge these students gained during their work experience.

I recommend that in the media, in curriculum materials and in teacher talk, two messages are presented: First, 'Scientists are friendly, informal, normal, intelligent people'. Second, 'There is a variety of kinds of work in a scientists setting requiring different levels of education, effort and commitment'. By following this suggestion, schools will present a more accurate picture of the nature of science and this will help improve students' scientific literacy. The improved picture of PWSS presented by these two suggestions should encourage more students to select science and technology as a career. These suggestions are similar to those of several other studies (Generations 1989, Sawyer, 1989; Weart, 1988).

I recommend that in the organization of a work experience, it is essential that a high level of personal contact be maintained between the students and the workers. Students should not be allowed to work in an isolated area away from the offices or laboratories of the regular workers. They must have the opportunity to view and interact informally with other workers. This is only possible if they are working nearby.

I recommend that programs which bring students into contact with scientists (in schools for example), should emphasize personal, informal contact and discussions, rather than the 'magic shows' that often are the central thrust of these visits. These displays of 'magic' may be used for entertainment and/or to gain credibility, but should be only used to set the stage for informal conversations with students in order to build personal rapport.

I recommend that a small booklet should be provided to the students, describing the program, typical experiences, quotes from former participants and expectations of the students. Alternatively, former participants in the program could talk to the students and parents about the program. This would reduce student apprehension and provide information for parents and counsellors about the program.

SUGGESTIONS FOR FURTHER RESEARCH.

A student's prior ideas and interactions with the environment of the scientists' setting lent uniqueness to every case. However, the study has added to the picture of a student in a work experience in science. It would be interesting to see how variations in the situation would affect the ideas of the student.

Some questions for further research that interest me are:

1. What would be the ideas and experience of lower achieving science students in this type of placement? Would they find that the variety of roles in the scientists' setting attracted them to a manageable scientific career?

2. What would be the ideas and experience of non-science students? Would they find science less impersonal? Would they be struck by the difference in atmosphere

between school science and laboratory science? Would they be rejected by the people in the scientists setting?

3. After time with PWSS, how do students view school science? How do they react when science experiments are presented very simplistically in school?

4. How would these students find subsequent undergraduate courses? What effect does this type of experience have on the students university experience?

5. What are science teachers ideas about the way science students should behave in their classes and how does this relate to their ideas about scientists?

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APPENDIX I: COURSE DESCRIPTION

CAREER PREPARATION IN SCIENCE (Retyped for clarity)

RATIONALE

At present, science studies are part of the mandated curriculum from kindergarten through Grade 11. This curriculum successfully teaches students many scientific principles and facts, but is perhaps less successful at teaching them how these principles and facts are arrived at. Students, by and large, see science as a static subject rather than the dynamic process that it really is. Students with the potential to work in science as a career often have only a very hazy notion of what this actually entails. This makes it very difficult for them to make an informed decision about whether or not they should continue to study science in order to pursue it as a career.

PURPOSE

The purpose of the Career Preparation course in Science is to teach students what science is and how scientific investigations are carried out. The use of higher order learning skills, such as analysis, synthesis and the integration of concepts is a major objective of the course. In order for students to practice these skills, a variety of learning experiences will be available to them. These will include lectures, group discussions, panel discussions, debate, role-playing, oral and written reports, differentiated readings, films, field trips and guest speakers. In addition, students will be expected to carry out a scientific investigation on their own, as a possible entry in a Science Fair.

An integral part of the curriculum will be the placement of students in scientific laboratories for a period of three weeks. This will afford them first hand experience in the day-to-day operation of a laboratory and it will allow them to participate in real scientific investigations.

OBJECTIVES

1. To create an interest and enthusiasm in the study of science.

2. To provide the opportunity for students to pose and solve problems related to the content of the course.

3. To create in students a scientific scepticism and faith in observation before accepting "facts" to be true.

4. To provide students with scientific communication skills-- the ability to record observations, to recall data and to solve problems using an effective scientific vocabulary and the appropriate terms.

5. To provide experiences and information about real-life applications of science.

6. To provide opportunities to meet working scientists.

7. To explore areas of interest which may lead to science as a career path.

APPENDIX II: INTERVIEW QUESTIONS

Students Conceptions of Scientists Study.

Sample Questions for the "before the experience" Interview

Welcome etc.

Review of the study and objectives.

A. Course choices.

First, I'd like to ask you about the science courses you've taken in grade 11 and 12 and how you ended up taking this particular course.

1. Can you tell me what grade 11 and 12 science courses you have taken?

2. There are probably lots of different reasons why students choose to take particular courses. Can you tell me how you decided to take this course?
   (e.g..interesting/uninteresting subject or experience, like science, want to go to the labs, the challenge, etc)

B. Experiences with Science past and present

Now I'd like to turn to your experiences with your science courses.

1. What kinds of things have been emphasized in your science courses?
   Have these things been brought out in your classes:
   - exploration of ideas
   - memorization of facts
   - past discovery of ideas
   - relevance to the rest of society
   - ethical questions about uses and consequences
   - instrumental value
   - worthwhile value
   - enjoyable value

   Any other kinds

2. What has been your most positive experience with science?

   Your most negative.

3. What kinds of activities have you particularly liked/disliked in your science courses?
   (e.g. labs, projects, worksheets, discussions, lectures, group work, individual work)

   Why?

4. How do you think your experience in this program will be different from your experience in school science?

5. What do you think science is all about?

-how do you go about finding out about the world?

C. Expectations about the experience

Now I'd like to ask you about your expectations about the visit to the research lab.

1. What do you know about the place where you are going to work and the research problems they are working on?

2. What do you expect it will be like to work in a lab?
(Hard work?, interesting, routine)

How will it be different from working in a school lab?

3. What activities do you expect to be doing?
(watching others, performing experiments, washing dishes?)????

4. How well prepared do you feel you are to do these activities?

What activities do you feel most/least confident in doing?

Do you expect to be doing the same things all the time?

Are you worried about the possibility of not being able to do what is asked of you? Why?

5. Are there some activities that you would like to do but don't think you'll get a chance to do?

Can you give me some examples?

6. What do you think the people you will work with will be like?

7. Do you think that this experience will give you a sense of what its like to be a scientist?
Can you tell me more about that?

8. Tell me about being a scientist. What do you expect it will be like?

Do you think that you'll be thinking about your work at home?
Why or why not?
Do you think you will want to stay late?
Under what conditions?

9. What do you expect to learn from this experience?

Do you expect it to be useful to you?

In what way?

D. Inquiry into science as a career.

Now I'd like to ask you about some questions about being a scientist as a career.

1. Do you think science is a rewarding career?

2. Do you think you would have to deal with any ethical or moral problems as a scientist? Can you give me some examples?

3. Could you see yourself doing this as a job?

4. How seriously have you considered science as a career?

   What are the advantages and disadvantages?

   What do you think motivates scientists?

   How difficult do you think it is to become a scientist?

5. How will your experience affect your decision about your career?

6. What are you looking for in a career?

7. Are there any recommendations you would make about the program so far?

F. Is there anything that we've missed in this interview that you'd like to add?

Students Conceptions of Scientists Study.

Sample Questions "During and After" interviews.

Welcome etc.

Review of the study and objectives.

A. Inquiry into the significant events in the experience.

I'd like to ask you about the experience, what you found interesting, important and/or different from your expectations.

1. Overall, what stands out for you about the experience?

2. Describe what you do in a typical day. What do you do first?

   Then what?

3. Have the activities in the lab been as you expected?

   How do they compare with the activities you did in school?

4. How well prepared do you feel you are to do these activities?

   What activities do you feel most/least confident in doing?

   Do you expect to be doing the same things all the time?

   Are you worried about the possibility of not being able to do what is asked of you? Why?

5. Are there some activities that you would like to do but don't think you'll get a chance to do?

   Can you give me some examples?

6. Can you describe the overall atmosphere in the lab?

7. Do you work mainly on your own or with other people?

8. Who stands out for you in the lab?

   Is there anyone that you admire, why?

9. If you could have anyone's job in the lab- whose would you prefer?-Why?

10. What is it about this experience that you find interesting?

    What is it about this that made it interesting?

11. How is the workload compared to other jobs you have had, or to school work?

12. What parts are you finding easy?

Challenging?

What do you do when you have difficulty?

How have the others responded to your difficulties and questions?

13. What activities would you like to do if you had your choice?

14. Do you look forward to coming to work in the morning?

15. What do you think motivates some of the people you are working with?

16. How has this experience affected your ideas about science and scientists?

17. How has the experience in this program been different from your experience in school science?

B. Inquiry in to the problem set the student.

Now I'd like to ask you some questions about the activities that you are (have been) doing in the lab.

1. What's the problem you're working on?
   Are other people working on it with you?
   How does that work?

2. Where did the research problem come from? Who suggested it?

3. What relevance does it have to the other work in the lab? How are you contributing?

What is the relevance of the problem to the world outside the lab.

4. Are there any ethical or moral implications arising from the problem?

5. How are you approaching the problem?

6. How is it going? Are you able to do about what you expected?

7. What is the most difficult part of the problem you are working on?

8. What do you think science is all about?

-how do you go about finding out about the world?

9. From your experience what do you think you would need to develop to become a good scientist?

10. How difficult do you think it is to become a scientist?

11. How does science seem to you as a career at this point?

12. Are there any recommendations you would make about this program?

C. Is there anything that we've missed in this interview that you'd like to add?

APPENDIX III: SAMPLE INTERVIEW

Second Interview with Linda

R This is your second week?

A Second.

R This is the end of your second week so you've had about ten days.

A Yep.

R OK, overall, how's it going?

A Very well.

R Can you tell me in general, how things are going,?

A I think it's quite a bit of fun and all the stuff I get to do is neat.

R What kind of stuff?

A The first week, I did some tests on this concrete sample, what they're doing is they're trying to find ways to make it so the heavy metals in the soil cannot be put into the atmosphere and that's what I did the first week, what I'm doing now, is I'm taking soil and trying to make glass from it.

R So you're entrapping the heavy metals in one case in concrete and the next case in glass.

A It'll be a lot safer to have it in the soil and dump it into landfills and over a small period of time it could get into the water and nests and...

R What sort of stood out for you as the most significant thing so far?

A The people are really nice, they go out a lot to make you comfortable cause everybody here is well past high school, they don't even remember high school.

R Can you describe a typical day?

A Actually none of the days are have been really the same, I can get here any time between 9 and 9:30 depending what bus I take and here I ask what we're doing today, and they go today, we're going to measure out samples of soil, just write out what you have learned from this because I have to do a seminar and then they look and then next week I'll do the ??? to see if the process actually works and since the test takes 24 hours I'm going to ??? next week.

R That's exciting, would you say that you know what's coming next, like you know what you'll likely be doing today or do you sort of come in with a blank sheet and they say this is what you're going to do today and you say okay.

A I know most of the work, there might be some changes because some equipment not being available, more or less I know what I'm doing.

R And so they just tell you how?

A They've already told me before but any last minute changes and they go well maybe we should do this instead and because I'm leaving next Friday to go on holidays and I can't come back after that and do it later so.

R Have the activities you've been doing as you expected?

A I didn't know what to expect, it's nothing difficult so I wasn't thinking what in the world's going on there, I guess I was surprised at how much knowledge in chemistry, used my brain chemistry 11 pretty well and knew what was going on and could figure it out, it was a nice surprise, I wasn't lost.

R What other things have been different, just the way it's gone?

A Well one thing are coffee breaks, I love them.

R Why?

A It's just the concept and the time, the ones I've taken have been from anywhere between an hour to half and hour so..

R What are they, what do you mean?

A Well, we all sit down and talk, I thought that I'd just be working here and take a lunch break, come back and work some more.

R Why do you like those things?

A It's a break in the routine and I get to know them more.

R What kinds of things do you talk about?

A We talk about coming events, there's a convention and we started to talk about that and just things you talk about with other people.

R So it's not really work related.

A Sometimes it is, sometimes two of them will get together and then I'll get lost for awhile, generally it's not very much work.

R Generally, whatever the people are doing on their weekend thing.

A Yeah.

R Is this a surprise, you said yeah it is, but if I were to say it to you before, about breaks, what would you have expect?

A I didn't expect any, I didn't even know there were any, I find it very nice that I get to know them better, instead of a name and face and that's that, they're more than that, they're actually people.

R Have the people been different from what you expected?

A They're not so strict about certain things, they're very helpful when I ask questions like sometimes when I have time in between, I'll just walk around and see what they're doing, and I'll ask them a question and they answer me as simple as possible.

R They're not as strict minded, what do you mean by that?

A They're weren't just chemical engineers, they were also open and they explained other engineering and I just found it nice that they didn't go oh chemical engineering's the best and they explain the other types.

R Can you give me an idea of some of the things they said?

A They said that in metallurgy, they deal with the metals the oxide and what not and how it forms and engineering physics sounds really boring, applied math and chemical is where you work with chemicals and they tell you what the courses are about, they were really helpful in telling me what it was like and what they found their first and second year was like... that I work with just got her bachelors and xxx's in third year and two of them are in fourth year so it's.

R Does the professor join in on these conversations?

A I think sometimes he doesn't come until later, sometimes he's there and they told me the hardest part about university life is talking to the professor, so when he's there, I take advantage of it.

R What's he like?

A He's very easy-going, very friendly, he's an interesting person

R So he's telling you about his background.

A Just talking about schools...???

R What did he say about that?

A He's just telling about how the school system went?????the last year is four courses only and it's very interesting because I've never been to another country before.

R Oh, he was telling you about how the English school system was like.

A Uh-huh.

R What do you think of him compared with your expectations?

A He's very easy-going.

R You didn't expect him to be that?

A I expected him to be stricter and the way now, he's more like a person, he's older than most people but he's just another person that I know and I don't find him, that's probably because I'm just with him for the summer and will never see him again, he's not a teacher.

R Well, how do you define that?

A I wouldn't ????, he's pretty easy-going.

R That's kind of an interesting thought that here's a professor with a Ph. D?, academically, this person's got more academic credentials than the typical chemistry teacher, but yet somehow, the relationship between you and, well the relationship between him and his students versus a high school teacher and his students are different, why do you think it is?

A I didn't go to school with him, I went to school with my chemistry teacher, but ?? him during second year while Dr. xxx is doing his masters so I guess that changes the relationship in a way because he's younger there's ?? the four that I worked with the first week because Dr. xxx was away, he's Dr. zzz but I guess there's a difference there.

R SO in their personalities, so have the things that you've actually been doing been as you expected?

A I don't know what it was like, I just know that I might be able to do it and I didn't have all this specialized knowledge, basically chemistry work so it wasn't that surprising.

R The things you had to do as far as the equipment or anything else, what else has been kind of interesting.

A ???

R How are the activities different from school?

A I'm by myself, I don't' have other people at the bench doing the same thing, I'm the only one doing it, the equipments a lot more sophisticated and it's I don't really have another person doing the same thing that's different because here, I'm the only one doing it.

R What affect does that have?

A I'm a lot more careful with the measurements, it's a lot more precise, I get a lot more accuracy, more precise answer where at school you're well that's about right so.

R You mentioned time is that another thing that's different here?

A At school I only have one hour to do the experiment but here i have the entire day.

R OK, how well prepared do you think you are for these activities?

A Knowledge wise ? I think I was very well prepared.

R When I asked you that before, you didn't think you were well prepared at all, why do you think that is?

A Because this is university level and all I had was grade 11 so I thought the gap between what I was going to do and what I know was a lot larger.

R But it wasn't.

A No, there are some calculations that they assure me are strenuous like how many kilograms of this and that, I don't think I have to add?, but the basic steps, how they came up to that, I can understand.

R How do you think you'll look upon your school labs when you go back to grade 12?

A Primitive, a lot simpler and crowded cause there'll be a lot more people there but as much won't be expected of me whereas at school the answers in the textbook and if it's right, it's right, so I won't be under that much pressure here.

R This has some significance...

A It's part of the real world.

R Yeah. Can you describe the overall atmosphere in the lab, what's it like?

A It's first time it's really intimidating and all those equipment and all that, the first time I thought it was intimidating, now that I'm a bit more familiar with it, it's still strange because of all these gadgets and it's a little more familiar now.

R What about the way people deal with each other and talk to each other?

A It's friends, there's joking and it's very nice, friendly.

R Similar to your school friends that kind of thing.

A Yeah.

R OK, can you just tell me again what's your project, what you're actually testing for?

A We're taking contaminated soil, ???? and make it into glass ??? this will be a safe way to ??

R Who suggested this project?

A ???????????and they have a lot of regulations and the company just???.

R Looking at your project, is that what scientists do? Would it be the same as what scientists do, would there be any differences?

A Since I'm been here in the middle of the project, I think scientists do a lot more pre-planning, ??? but I imagine that they do alto more reading, the actual activities are pretty much the same.

R What would being a scientist be like as a job?

A ??? the balance is my pet peeve, it hates me...I guess there would be a lot of reading on what you're about to do, a lot of ?? on new developments, it would also be trying to save your ideas trying to change what's already there into what you want.

R What do you mean by that?

A ??? and we have technology to make glass, so take what you know about glass and apply it to what you have.

R SO that's the kind of things scientists do?

A Taking something and applying it to ???

R And where do they get the knowledge?

A You just I guess, document that experiment and you document what you know and talk to your clients.

R OK, so do you think what scientists do as a daily routine is like what you're doing?

A No, I'm just working on mine right now, a scientist would work on more than one things at a time.

R Do you think they work extra long hours?

A Some jobs they don't really work that long and other jobs they work a lot of hours but I guess because ????????

R How difficult do you think it is being a scientist?

A To become a scientist or to be employed as a scientist?

R First to become a scientist.

A If you're interested in the job, it shouldn't be that difficult because you actually, honestly like what you're doing, it just depends on if you want to.

R What about a job as a scientist?

A It would depend on what your field would be, if there's a need, a demand, so I guess it would be difficult to find a job ????

R Can you give me some examples of some of those that are in demand and those that are...?

A Environment, there's a lot of stuff.

R DO you think chemical engineering is one of those?

A It's no pretty much in demand because...(inaudible).

R Can you give me some that wouldn't be in demand?

A I don't know or not if they're in demand but in civil engineering and all that, you need research, you need your calculus research, I don't know what's not in demand because I'm not familiar.

R OK, what kinds of skills do you think a scientist needs to have?

A Patience, you can't see all the results in front of you you have to have quite a bit of knowledge, so science is not just what you see in the textbook, it's everything ???? just a bit of common sense.

R Anything else? What about knowledge wise?

A Well they tell me there's certain things I cannot do because I'm not familiar with it.

R How do you think scientists learn this?

A From school and experience and just seeing what other people have done.

R DO you think you could do it?

A I'm not sure, I guess if I really wanted to I'd try it.

R How does science seem to you as a career at this point?

A It seems very interesting, it seems actually related to the real world, doesn't seem all that popular at times.

R What do you mean by that?

A Well, ... so unless there's a large demand.

R Well the Expo site is a pretty big area.

A Yeah, but we're also on a budget, we don't want to spend so much money, they have to make a certain profits so they have to have a certain price range.

R Overall, what do you think you'll learn here?

A I guess, what university life is like, I ... what I basically learned is that you don't have to be an absolute genius to work here and the atmosphere.

R Why do you say that, because you think that you were able to do these experiments?

A I knew most of what we were doing.

R You mean the other high school students.

A It makes a career in science more obtainable.

R Why?

A Because you already have the basics, some of the calculations they needed, you need to be on a higher level but the basic groundwork and it's not all stuff that you learn in school is absolute rubbish, once you get to university forget all of it.

R Right. What do you think scientists do?

A I don't know, maybe experiments, seeing (inaudible)

R OK, if you could have any of these jobs in the labs, whose would you prefer?

A I guess it would be xxx, she does a lot of analytical things, she finds how many particles you have and how many you have left, it's very interesting plus the stuff she's doing.

R What about some of the other people?

A I definitely would not like Dr. xxx's job, he's got like 10 thousand projects, it's really busy sometimes and I'm not eager to do that.

R Why is her job different?

A She's not actually doing the project, she's helping other people do the projects, it's like Dr. xxx has a soil sample and wanted to know what was in it exactly and he sends it off to a lab and then look at it and then says well Irene if I did this what would happen and then she would do it.

R So she's running the equipment and experiments for other people.

A She runs all sorts of people.

R Sounds like she's doing lots of different projects also.

A Not so much projects, just little experiments and the thing I like about that is you do different things, not very long term things, but different.

R But is Dr. xxx doing...

A He's doing a lot of long term stuff and he's got a lot of things.

R What is it about long term things that you don't like?

A You keep working at it for a long time and you'd have to keep track of which one is which whereas short ones you could finish it in two days and go onto the next one, you don't have to remember this one's for this one and that one's for that one cause in your long term project, you have a lot of small things in it.

R Do you think Dr.xxx....

A He delegates, takes talent to delegate so.

R I'm curious about, see I'd expected you to say Dr. xxx's job, tell me again in another way, why you would prefer her job over Dr. xxx.

A Dr. xxx is spread out it's not concentrated into one area and there's not enough of me to be spread out and I can't do that.

R What about some of the other people's job, is there any other that's....

A I have no idea.

R What about doing what some of the students are doing?

A It's very interesting.

R What do you think these students will do when they grow up, do they all become Dr. xxx's or what?

A They get jobs really well I guess and I (inaudible)

R How's the work load been compared to other jobs you've had or school.

A It's very fun.

R We're you surprised by that? Did you expect that?

A I wasn't surprised I expected it to be very heavy.

R Overall, has it been a good placement for you?

A Um-hmm.

R What other things would you do if you had the choice?

A I would have like to (inaudible) that would have been interesting to see, the other ones I had because I'm not that great at using the computer, the other ones that I have are more biology related, I didn't take biology.

R What do you think motivates the people that you're working with?

A They enjoy what they're doing and they get a good salary they do well.

R When you said they enjoy what they're doing, what do they like about what they're doing?

A The chemistry and the fact that you're not just doing measurements on the balance, you take it one step further than the measurements.

R What do you mean, you take it one step further?

A You measure, you just take measurements and you get the conclusion and that's that, you take one step further by applying it to something that you're working on.

R Has this experience affected your ideas about scientists?

A I'm not quite sure what to expect from scientists and maybe they're very different.

R How?

A (Inaudible) there's a difference in attitudes.

R Do you think that's the way it is with scientists?

A Yeah, with accountants, scientists...

R What about your ideas, has this experience affected your ideas about scientist work, what they actually do?

A In a way, it's not all heavy duty, extremely complicated science, it's actually some basis on science.

R What ways has this been different from school science?

A My age, I can describe things to my friends, they don't' really understand what I'm getting at sometimes.

R Are you talking about friends in the project?

A No, my school friends, I talk to them in class, how's it going, in that way I can't talk to them

R Why?

A Some of the equipment, and they explain to me oh yeah it rotates, and I go how is it rotated, by a machine that rotates it and they have to try to explain the machine when in class I just put the glass in there and push the button and it rotates it.

R What kinds of things did you tell you friends or the things they asked you?

A What I'm actually doing, my project, the campus itself, I haven't had a chance to look at the campus, they also asked about the attitude here, is it all work, work, work, work, things like that, that you asked.

R Do you think that when you talk to them about this experience like that that it changes their mind about the experience?

A I don't think so because all of them are open-minded about those things and they'll pretty much understand about that. They don't really have any preconceptions about what scientists should be... so I guess you can actually relate to the people here, you can compare them to someone at school.

R Can you give me a couple of other stories about anything that you've talked about at coffee break or things you did in the lab.....?

A That wasn't really surprising because a lot of people aren't into Star Trek, my friends'll be like did you see Mr. ???, whereas here I've actually talked to some people about it, they're not like it's just like you a Star Trek weirdo and.

R You're keen on Star Trek aren't you.

A Yep.

R So it's pretty good when these guys started talking about this.

A Yeah, and I'll go oh yes I know about that episode, very few people I know are into it so you can talk to them about certain episodes and they know what you're talking about, whereas some of my friends I have to explain to them the entire background of the episode and all that.

R Any other stories and things, how about anything working in the lab?

A Well, I told you about the balance that hates me, they don't ask about the lab, some of them aren't going into science so they want to know more of what the campus is like, most of them have something to say about labs, the people that are in other labs, oh yes well I did this.

R What are you talking about, I know that some of you are eating lunch together, are you talking about your projects at all?

A We talk about our projects what we're doing in September, mostly we just talk like if we talk at any place.

R What do you think science is all about?

A It's basically about everything, has some place of science in it, computer science would be taking textbook information changing it and seeing it if it's true, challenging it, just everything.

R From your experience what do you think you would need to become a good scientist?

A Patience, you'd have to be pretty organized and you have to know how to compromise.

R What do you mean?

A When you want to do something but if it's not right or something, you have to compromise, I can't do this, can I change it, you'd have to make a lot of changes.

R What about the program itself, any suggestions for the Career Prep program itself, how it's organized?

A 3 weeks I think you'd have to be prepared because the first few days the professor didn't really know how to deal with me so I guess.

R So what did they do?

A They showed me around the faculty, and then gave me some reading to do and that's basically what I did, they didn't' really know what to do with me and you didn't really how to act because you didn't know what the place was like so I guess meeting beforehand and talk rather than go into it blind.

R Yeah, anything else?

A No.

R Anything else that we haven't talked about that you'd like to add?

A No.

R Do you think it's made any difference being a girl in this, do you think it would have been any different?

A I don't think so because all the people that work here, the students, there are more girls than guys that I've seen so.

R You mean in your career prep program or here?

A Actually both, there is basically more girls, the thing that I found strange was when I was looking through the pictures, there were more males so I guess the only difference that I'm a girl, would be in the actual class like when you go out to do it I might be outnumbered in a way, but then in any class, my computers class, there's only 3 girls in the class, I think more girls are coming into this so I don't have to worry when I'm..

R You mean more girls are going into it.

A Um-hmm.

R Would it make it any difference if there were very few girls in the class?

A I'd like at least 2 or 3 because you can relate more to them, I can relate more to a girl in a class than a guy, I can talk to them but when it comes to certain things, you can relate more to a girl, so it helps.

R SO, are you saying then, it would make a big difference that there are no other girl, it would be a problem if there were no other girl, if you were the only girl?

A I'd feel uncomfortable, like in my computer class, it wasn't until I sat down and looked around that I saw it was all guys except for this one girl, well do I really

belong here, the fact that the other girl was there was reassuring, social air or something, if you were the only girl, you'd feel out of place.

R You said to make a social error, what do you mean by that?

A It's when I go to church and everything, the girls sit in one side and the guys sit in the other and when a friend had a wedding and he had some friends who were white and the guys sat on the girls side and that was considered a major social error because the only guys that sit on the girls side are less than five years old, so when he finally looked around and saw what he did, his face was all red and it was a social error because it was one of those church...

R So you thought am I in the wrong class, is this.

A It makes you wonder if you belong there.

R Do you think it would affect the way you work in the class and ?

A I think there'd be a bias, I'd be patronized, ... they were very condescending so if I have to deal with that, I'd spend more time in the lab, doing something, that's very annoying, guys are very annoying, they're annoying, it's like are you sure you want to be here now, even if it is too hard...

R DO you think the engineering classes will be like that?

A No, I looked in a graduating class and it looked pretty much even.

R So you wouldn't have any hesitation.

A No.

R So you would find that...

A I'd have to deal with it, since it's pretty much half and half, it's one of the rules of (inaudible).

R Thanks.