AN INVESTIGATION OF

A PROJECT-BASED PARTNERSHIP

APPROACH

TO SCIENCE EDUCATION

THROUGH A TEACHER'S PERSONAL NARRATIVE INQUIRY

by

Robert R. Adamson

A Thesis
Submitted to the Faculty of Graduate Studies
in Partial Fulfillment of the Requirements
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An Investigation of a Project-Based Partnership Approach to Science Education Through a Teacher's Personal Narrative Inquiry

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Abstract

This study focused on the use of project-based partnerships to provide for meaningful learning in senior secondary science education. A research design of personal narrative inquiry incorporating three case studies was used to trace the development of the teacher-researcher's own personal beliefs and teaching practices as well as interpretations of the students' ways of thinking, their attitudes toward science, and the impact that these projects had on their personal lives. Personal reflection was promoted through the use of journal writing, interviews and field notes. The meanings and insights constructed by the teacher-researcher, other teachers, and the students involved in project-based activities, form the basis of the data analysis in this study.

Data from this study provided insight about: (1) the use of project-based learning to make science meaningful and relevant to students, (2) the development of specific objectives to guide projects in order to meet educational and scientific goals, (3) the incorporation of projects into existing science programs, and (4) the use of cross-grade partnerships to enhance learning through meaningful dialogue.

In addition, this study augments my theoretical understandings of secondary science learning, confirming for me that students' positive attitudes are strongly evident in situations where they construct meaning collaboratively, find direction for inquiry, and create solutions to authentic problems. Through my iterpretaton of the results I have extended my pedagogical knowledge regarding how to use project-based learning to

enhance student motivation, to facilitate opportunities for students to take ownership of their own learning and to provide clarity and a sense of the opportunities science may hold for them in the future.

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Chapter 1
Nature of the Study

One area of recent interest in science education and teaching has focused on the use of project-based activities and partnership methods to provide for meaningful learning. Project-based activities are those which have a wider context than most typical high school laboratory experiments which have definite timelines and specific formats for finding predictable answers. A further description of project-based activities occurs in Chapters 2 and 3 as well as being found in Appendix B and D. Partnership methods refer to the collaboration between individuals who may be able to provide support for a specific project investigation. Bruner (1990) sees meaningful learning evolving from the conflict which he believes exists between "meaning making" as opposed to "information processing". The search for a better understanding of the learning process has resulted in a significant paradigm shift towards "meaning making" as an essential component for learning. Bruner views "meaning making" as the way in which individuals construct their view of themselves and others as well as the world they live in. On the other hand, information processing in a school context usually refers to a more traditional textbook-centered and content-oriented form of teaching and learning.

Conflict arises when teachers and students both struggle with the application of curriculum content to real-life problem situations. Gardner (1991) attributes this conflict to the poor transportability of content-based learning to real-life problem solving. The experiences which most students gain in their school science investigations are limited because most junior and senior high science labs typically have a narrow context, focusing on finding a specific right answer within a limited amount of time. As a result of these experiences being limited by both time and context, the vast majority of students and teachers have very little opportunity to make meaningful connections between content and application. If one does not make meaningful connections or is unable to visualize the problem, application and relevance to real life problem situations may result in conflict.

Science courses should reflect the variety of goals of the curriculum documents including relevance to real life problem situations and most importantly the needs and interests of all students in the classroom. Courses of study which actively engage students within the learning process would seem to fit well with such goals. Glynn, Yeany and Britton (1991) see meaningful teaching for understanding as involving not only the traditional approach of teaching facts but one that also reflects an emphasis on thinking and the use of scientific processes as well. To achieve a "minds-on" approach, the processes of science must be emphasized as well as content mastery. The learning process should be an interactive one in order to engage students and teachers in meaningful dialogue. To this end the authors propose that:

> "teachers and students should become collaborators in the process of scientific reasoning. Together, teachers and students should construct interesting questions about scientific phenomena: simply telling the students has little lasting value." (Glynn, Yeany, & Britton, 1991, p4)

The concerns related above are relevant to my own teaching beliefs and practice. An opportunity to stand back and examine my beliefs and explore my questions about science education was presented to me in the Fall of 1993. At that time I had the good fortune to be working with a group of students in their final year of teacher education. These students were enrolled in a Curriculum and Instruction (Science) class in preparation for elementary school teaching. As part of their studies they were asked to complete a "Science in My Life" assignment in which they were to reflect on their past science experiences. My expectation for the reports was that I would read a range of experiences expressing both the positive and negative aspects of their formal science courses.

Shortly after reading the twenty-eight student journals, it became clear to me that there was a great disparity between what I had expected and what I was reading. I was captivated by the similarities of experiences and the degree of emotion which students were sharing. An altogether unexpected trend was becoming apparent to me: ***The vast majority of students reported a very positive early years experience, followed by a more mixed junior high review and a less than complimentary senior high experience.*** The emotions which the students shared were especially revealing. The following terms and phrases were commonly used; "negative experiences", "rote work", "never understood", "little relevance", "stressful", and "turned off". The one phrase that has certainly stuck with me was voiced by Dr. Hal Grunau, one of the course instructors and my faculty advisor. The phrase "science is a necessary evil" was one which had been shared with him in a previous course related to a similar assignment which we were doing (personal communication). This particular phrase certainly encompasses all of what I too was hearing. What remains of key concern and interest to me is that there doesn't appear to be much correlation with the marks which the students claimed to have received in their science courses and their attitudes. Although they were apparently scoring well on science tests, they were not making personal or meaningful connections to the "facts" they were learning. Gardner (1991) emphasizes how common such feelings are:

> "even students who have been well trained and who exhibit all the overt signs of success; faithful attendance at good schools, high grades and high test scores, accolades from their teachers-typically do not display an adequate understanding of the materials and concepts with which they have been working." (Gardner, 1991,p3)

There seems to be an underlying emphasis in modern schools on the "abstractness of science" which teachers/students recall from their own school experiences. In my opinion, the students seemed to have an especially difficult time connecting real-life events to the contexts of science as presented to them in a textbook-centered approach.

In order to make connections with the students and the communities in which they live, science must be taught in a way that ensures meaningful learning is taking place. A project-based, partnership program is one possible method for developing meaningful learning. It is a model which I decided to undertake in order to facilitate "meaning making" in my senior high school science course. This is a program where students begin to understand the ideas, applications and the role science will play in their lives. Partnerships here refer to the collaboration between students, teachers and other professionals on common problems or project activities.

Statement of the Problem

This research project was designed to study how the use of projects in a project-based approach to senior secondary science teaching can impact on my own personal beliefs and teaching practices as well as my students' ways of thinking and their attitudes towards science.

A case study methodology was employed to trace my personal professional growth that has taken place over the past five years as I have explored the use of projects in a project-based approach to science education. It was conducted on a philosophical premise that as an experienced practitioner, I would be able to document the actual events of my teaching; reflect meaningfully on my own practices and beliefs; and make changes based on my assessment of the outcomes.

The study was designed to carry out an intensive investigation regarding the use of a framework for developing a project-based partnership model in science education. In this case study I, as the researcher, collaborated with various teachers and students to provide opportunities for project based learning and inquiry through partnerships.

Stemming from this overall goal, the following questions were formulated to guide the direction of the inquiry:

1. How can I as a teacher encourage in students the development of positive attitudes towards science while teaching the mandated curriculum?
2. How can I teach science in a manner which students will find meaningful and relevant?
3. How can I incorporate project activities into existing science programs which will allow for a collaborative inquiry approach to science?
4. How have my own science teaching beliefs and practices changed over time and to what do I attribute these changes?

My perception in regards to student attitude changes and to whether or not students find a project-based approach more meaningful for their own learning will be based on the interpretation of the student journals and interview responses which are collected.

Scope of the Study

This case study is a journal of my own professional growth as a science educator as a result of my involvement with various student partnership projects. Through the study I will able to explore my own teaching practices and to examine how the methods which traditionally are used in the teaching of science impact on student attitudes towards science. Through the recording of my own experiences and changes in attitude, I will attempt to contribute to the knowledge base addressing the use of project based activities in senior secondary science teaching. In turn, this may allow other teachers to see themselves and/or future possibilities for their own growth and development in similar directions.

Significance of the Study

This study documents a process where a classroom teacher in collaboration with teachers and students works towards developing strategies involving partnership opportunities through project based learning in an attempt to positively influence the attitudes of students towards science education. The study also documents the professional growth of the author in regards to curriculum beliefs and instructional strategies. In the form of a case study, the findings add to the existing body of knowledge on the importance of developing strategies such as project-based learning and collaboration for effective science instruction. As such, the account may provide a kind of "transferability" in that others may see themselves and or possibilities for their own growth and development in similar directions.

Overview of the Thesis

This thesis consists of six chapters which describe and interpret selected teaching experiences which have contributed to the professional growth I have enjoyed as a science teacher and science department head throughout this inquiry. Chapter One deals with the background to the study and the nature of the problem being addressed. Chapter Two reviews the literature which supports the questions, while Chapter Three outlines the design and methodology of the research. Chapter Four provides the data interpretation and analysis of the case study. This chapter is arranged into sections which look at the different projects which have provided me with the important student and teacher feedback to support the study. Chapter Five builds on the previous chapter but focuses on tracing the growth I have enjoyed throughout the study. It is arranged in a thematic pattern beginning with the early question and evolving into the current form of project inclusion into my courses of study and into the school's science program. Chapter Six is a short summary of the thesis along with some final thoughts on the development of project-based learning, the research process and the outcomes and implications.

Chapter 2

Literature Review

This literature review will address a number of the components which are essential to an understanding of my personal beliefs for science education. These include:

- student attitudes
- textbook-centered/transmissional learning
- constructivism
- authentic science/meaning making
- case studies in the support of inquiry/project based science education
- mentorship/partnerships
- narrative inquiry

It is clearly indicated that literacy in science and technology is essential to our success in the technological world in which we live. Eggleston (1995) expresses this belief on a global setting:

> "Throughout the world, educational systems at many levels are striving to promote science and technology education in order both to enhance the quality of life of individual citizens and to aid the survival and prosperity of national economies." (Eggleston, 1995)

Unfortunately, this priority is not afforded the same respect by the majority of students in today's schools (Atwater et al. 1995). Studies have shown consistency in the measurement of student attitude towards science over the past three decades. This attitude being one of students expressing positive attitudes towards science until the sixth or seventh grade and then this attitude falling off dramatically (Bohardt 1975; Randal 1975; Linn 1992). This trend is recognized by Kuhn (1993) who reports that "teachers of middle and high schools feel students are already 'turned-off' to science by the time they reach their classrooms."

The promotion of a "mythic, textbook science" as reported by Martin, Kass and Brouwer (1990) can certainly be considered as a reasonable starting point. Stinner (1992) alludes to the preference for textbook science in the English-speaking world since the early 1800's. As a result the majority of science teachers have been taught by this method and thus are most likely to use a textbook-centered program focusing on specific facts as science education. From my teaching experiences at both the junior and senior high school levels, I too would support this notion that science in the middle and high school years is taught chiefly by way of the established "scientific fact" and finished product.

Yager (1992) refers to the attempts in the 1960's at science reform. The materials which arose through that particular reform were constructed in a manner that encouraged transmission style teaching. Ausubel (1968) would support this approach reasoning that students at any age do not have the capacity to discover all that is required to know and that decisions regarding relevant materials must be made for learners. Supporters of transmission style learning might use the argument that knowledge can be transmitted by language and that students are capable of receiving this information. Good & Brophy (1990) would use the phrase "tell them what you are going to tell them, then tell them, then tell them what you told them" (Good & Brophy, 1990, p201). Unfortunately the evidence suggests that as a result of textbook-centered teaching and a "transmission" style of presentation of facts, students generally see little connection or relevance between themselves, the world around them or science (Aufshnaiter, 1989). Jon Miller's studies on scientific/technological literacy (see Appendix A) reveal that in the United States the illiteracy rate is at 90% and growing (Miller, 1989; Miller, Suchner & Voelker, 1980). Knowledge and interpretations are clearly not as transferable as some would have us believe:

> "knowledge and interpretations cannot be given to students, and students do not accept knowledge from outside because it was never there in the first place." (Yackel et al. 1990)

As we approach the millennium, students will certainly require an understanding of science and its practical and technological implications on an increasing basis. Glynn, Yeany and Britton (1991) concur with this view as they feel schools must encourage the development of scientific literacy in students:

> "if the students of today are to prosper in the 21st century, they must understand the basic facts, principle procedures of science. In other words, the students must be scientifically literate."
> (Glynn, Yeany & Britton, 1991, p3)

On close examination of the teaching methods currently being used in our classrooms, it appears that the most commonly employed approach could best be described or classified as a "traditional method." These approaches rely heavily on a textbook-centered methodology for teaching the concepts and content found in the curriculum. Activities are usually arranged to support the content of the particular topic. Bettencourt (1992) states that many of these activities are presented in a manner which is not connected to the lives of children or the communities in which they live:

> " The presentation of the natural sciences is, in general, textbook bound aimed at the memorization of vocabulary and the algorithmic resolution of quantitative problems. The student side of the picture is constituted by young persons that can, at best, parrot definitions, solve numerical problems, but have little understanding of ideas, very little notion of the applications of these sciences and even less critical awareness of their role in causing and /or solving societal problems." (Driver et al. 1985; Osborne and Freyberg 1985; Gallagher 1989, 1990, as quoted in Bettencourt, 1992, p. 76)

The feeling seems to be that science can be organized into concrete "knowledge blocks" or perhaps collections of "scientific facts" which then can be taught or transferred to children. Students generally rely on rote memorization techniques in order to account for the subject content. Stinner (1992) states that the emphasis is on the accumulation of scientific facts as though they represented a finished product. This implies that there is an accompanying" understanding" of the scientific concepts as well:

> "science teachers seem to emphasize the finished product of 'scientific fact' and mathematical formulation in the teaching of

> physical science. Students, in turn, are trapped by the efficiency of memorizing the "scientific fact" and the efficacy of applying the "formulas" in solving exercise problems. The correct solution of the exercise problems then provides evidence for the teacher of the success of his/her teaching." (Stinner, 1992)

Osborne sees the memorization of the curriculum content being accepted as the task at hand for students and teachers alike. Tests are then constructed to ensure that students are accountable for the right amount of "scientific knowledge" in order to receive passing grades and the credits which accompany them. Osborne feels that:

> "the curriculum and the textbooks are taken as givens and the task becomes how to prepare students for the test. The purpose of education becomes not worthwhile learning, but the accumulation of credits." (Osborne, 1991, p120)

Gardner (1991) agrees with the above statements by Osborne. He states that there is an overwhelming concern for content memorization and the subsequent testing required to provide evidence for achievement in this regard. The content-driven curriculum has inhibited learning for some students rather than facilitating it. He has proposed the concept of multiple intelligences, identifying eight categories. These include language, logical-mathematical analysis, spatial representation, musical thinking, the use of body to solve problems or to make things, an understanding of other individuals, an understanding of ourselves, and an understanding of nature. Gardner feels that the "intelligence" which is associated with the ability to compute with logical and mathematical tools, namely logical-mathematical analysis has been stressed by the schools to the extents of ignoring the other seven intelligences. Gardner also believes that all students possess the ability to learn. What differs amongst students, however, is the ways in which they may best learn. Therefore to measure learning that is based solely on rote memorization of content is seldom reliable. In order to understand the progress in students' learning, disciplines should not only be presented in a variety of ways but should also be assessed through a variety of means. Formal testing by itself will not ensure that those who pass will be as successful when it involves applying the concepts in natural contexts. Gardner states:

> " I still conclude that formal testing has moved much too far in the direction of assessing knowledge of questionable importance in ways that show little transportability." (Gardner, 1991, p134)

Gardner (1991) emphasizes the importance of "projects" and apprenticeship/partnership methods to provide for meaningful learning. He believes that all the tests which students write in schools develop a test writing skill which will never or infrequently be used again after school. In order to make meaningful connections he recommends that students go beyond developing skills used for test writing and be engaged in project activities. Referring to the role of such project activities Gardner says:

> "when these are pursued over a significant period of time they should lead to an education that makes sense to the various

participants and that leads to more robust and more flexible forms of learning." (Gardner, 1991, p219)

The question which now arises is how such project activities can be incorporated into existing science programs and structured in order to allow for a collaborative inquiry approach towards science. Wells (1993) also recommends similar integrated programs where collaborative inquiry allows students' ideas to surface as lessons unfold. He says that for this to occur there must be a change in the learning opportunities which schools provide for students. This process, according to Wells, is about:

"...changing the learning opportunities provided in schools and classrooms so that students are better able to develop the skills, knowledge and understanding needed to live productively and responsibly..." (Wells, 1993, p1)

Wells sees these opportunities for project and partnerships evolving as teachers incorporate learners' ideas into the lessons or projects. At present, many classrooms are teacher-centered and controlled. The teacher traditionally is responsible for the learning process, content as well as the methodology. This teacher-directed learning structure may result in a closed or narrow viewing of the science processes and concepts by both teachers and students. To provide a more learner-centered and interactive environment, students must have means for input. The benefits of including the ideas and questions of learners in the development of project activities are emphasized by Wells and Chang-Wells:

> "...all these ideas had come from the children," the teacher added, "and the project had taken off under their direction in ways that far exceeded the more limited aims she had in mind." (Wells & Chang-Wells, 1992, p5)

Clearly the authors believe it is important for teachers to recognize the beliefs which children have of science. Children/students of all ages have questions and beliefs of science which they hold true. When given the opportunity to explore these beliefs, the scope of science investigations take on a much greater meaning for all of those involved. These early conceptions or misconceptions will determine to a large degree how new scientific information is understood. Traditional teaching methods have produced students who hold certain beliefs or misconceptions about the nature of science and yet limit their exploration of them. It is critical to begin with children's prior knowledge and develop their scientific understanding through meaningful dialogue and activity. Projects and the collaboration which is associated with them is but one means for providing students with opportunities to explore their personal beliefs.

In this way one sees the learning process as taking place within a community of learners. The teacher's traditional role is changed from that of a distributor of knowledge to that of a collaborator in the learning process.

The question then becomes one of how do students view scientific knowledge. Songer and Linn (1991)state that there are three ways in which students view science:

1. static view - if it is in the textbook it is true.
2. dynamic view - there may be other explanations available which may disprove accepted norms.
3. relative view - it may be true, but there is room for other explanations.

The "static" view of science is one which has been promoted and sustained by a traditional textbook approach to science. In this way, science is in many instances viewed as a collection of "facts" which when memorized indicates an understanding of science. This view supports the notion of a right answer to science questions and does little to change the meaning which students have of the subject. In contrast, a "dynamic" view of science is one which supports the notion of multiple explanations for various scientific problems and that science is constantly changing as new knowledge is brought to light. It includes the ideas that:

> "science proceeds by fits and starts, that scientists seek to explain diverse phenomena with broad principles, that conclusions are based on evidence, and that the way to learn science is to make an effort to understand complicated ideas." (Linn, 1992, p. 825)

Duschl (1990) expands on this by talking about the different faces which science appears to have. He characterizes them as being either the "products" of science which include the theories, facts and principles or the "processes" of science which emphasize the means by which scientists develop meaning. This includes the methods by which data is collected, analyzed and reported. The difficulty he expresses with the related teaching of these types is that the processes of science type is portrayed in the majority of science textbooks in a similar fashion as that of a product type. This would most likely be comparable to what Linn has termed the "static" view of science. This is unacceptable to Duschl as he states that it is not a complete or true representation of science. He further states that a curriculum which focuses primarily on conventional knowledge is merely teaching facts which supports students memorizing for the benefit of higher test scores. The difficulty lies in not only teaching what is currently known but where it came from and how it was derived. Science must be represented as "dynamic" view with the benefits truly worth the distinction and effort which is required:

> "Knowledge about science, as opposed to scientific knowledge, is knowledge of both why science believes what it does and how science has come to think that way. In a knowledge-about-science curriculum the interactions among science, technology, and society are much more relevant and thus are more easily appreciated.
> (Duschl, 1990, p10)

Wiggins further points out the difficulties involved in developing meaningful science programs around a textbook-centered approach. This type of approach tends to emphasize the rote memorization of factual content:

> "...there is simply too much for any one of us to know, never mind teach to dozens of students in a crowded day. Such a tragic fact leads to a liberating realization: wisdom matters more than knowledge."
> (Wiggins, 1989, p58)

Clandinin and Connelly (1990) see these types of connections occurring when students explore their personal beliefs in attempting to understand an event pertaining to science application and societal impact. They argue that:

> " a constructivist view of learning is one in which the learner actively constructs meaning according to what he or she already knows and believes." (Clandinin & Connelly 1990).

Graham Hendry in Constructivism and Educational Practice (1996) identifies seven key principles of constructivism.

1. Knowledge exists only in the minds of people.
2. The meanings or interpretations people give to things depend on their knowledge.
3. Knowledge is constructed from within in interrelation with the world.
4. Knowledge can never be certain.
5. Common knowledge derives from a common brain and body which are part of the same universe.
6. Knowledge is constructed through perception and action.
7. Construction of knowledge requires energy and time.

The underlying foundation for a constructivist position is that knowledge rather than being given or transmitted directly to the learner is actively built up by the learners as they encounter more experiences which add to their current beliefs. This may occur as personal construction of meanings and theories as individuals experience natural phenomena. From this perspective, well designed activities must be set to challenge individual needs and conceptions within the classroom setting. Lemke (1990) sees a different tradition where the knowledge construction process occurs when learners are encultured into science discourses. Of most relevance to this review is the appreciation for the importance of creating opportunities for the involvement of scientific apprenticeships into science practice (Rogoff & Lave, 1984).

In order to facilitate science learning in a way which promotes personal meaning making through active involvement and apprenticeships, an exploration of a social constructivist perspective is required. Bruner (1985) in an introduction to Vygotsky's work states:

> "The Vygotskian project [is] to find the manner in which aspirant members of a culture learn from their tutors, the vicars of their culture, how to understand the world. That world is a symbolic world in the sense that it consists of conceptually organized, rule bound belief systems about what exists, about how to get to goals, about what is to be valued. There is no way, none, in which a human being could possibly master that world without the aid and assistance of others for, in fact, that world is others." (Bruner, 1985, p32)

Vygotsky's (1986) belief in the importance of culture in shaping development becomes the core of this authentic science education. He viewed instruction as being part of a larger interaction between adults and peers. He rejected Piaget's notion for instruction and learning being independent of each other or in Piaget's words, "development explains learning" (Piaget, 1967, p171). Vygotsky's belief was that teaching and nurturing move ahead and are essential for development. Here he recognizes a "zone of proximal development" where development is more feasible and productive. Vygotsky describes this potential learning range of an individual or zone of proximal development as:

> "the distance between a child's actual developmental level as demonstrated through independent problem solving and the potential development as determined through problem solving under adult guidance or in collaboration with a more capable peer." (Vygotsky, 1978, p.86)

Vygotsky's theory and its complex implications stress the inherent social nature of all human activity. The theory of social constructivism is based on the assumptions that knowledge is constructed through an individual's interactions with sociocultural environment; that higher mental functions are social and cultural in nature; and that knowledgeable members of a culture help each other.

A Vygotskian perspective for instructional practice would see teachers treating students as participants in joint enterprises. Through talk and activity, one develops knowledge and meaning about problems or tasks.

Studies have been undertaken that support the notion that scientific knowledge is not something to be given. Hendry, (1996) believes that this giving of knowledge results in students memorizing answers which are just as quickly forgotten without ever constructing new knowledge or understanding of a task or concept. Rather it is socially constructed by groups of scientists as they go about their everyday activities. Collaboration and dialogue are key ingredients to the formation of new knowledge (Bleicher, 1996, p1116).

The challenge which is currently at the forefront of science education reform is to present "real" or "authentic" science in schools. Martin, Kass & Brouwer (1990) express the opinion that "science teachers are being challenged to present science as it "really is". Marcia Linn (1992) states that those concerned with science education are united in calling for such reform and that reform in whatever form it takes must address key beliefs. They are:

- the need to reach students who do not intend on taking science programs after high school. Students must be able to see the relevance of science in their lives and to be able to make sense of what they already know.
- to encourage and move students towards a more "dynamic" view of science where students will be able to build more relevant views of science phenomena.
- that students must be involved in more collaborative programs if a dynamic view of science is to be obtained.

One direction that may be followed in pursuing these beliefs is to look at inquiry based learning as an alternative form of instruction. Krajcik et al. (1994) identified five components for inquiry based learning:

1. Creating a driving question or problem statement
2. Designing investigations
3. Collaborating with peers and other
4. Conducting of authentic assessment
5. Using cognitive tests

Inquiry based learning, if structured suitably, can satisfy the Minds-On Learning Goal of the National Research Council:

> "Learning science is something that students do, not something that is done to them...Hands-on activities, while essential, are not enough. Students must have 'minds-on' experiences as well." (National Research Council, 1996)

Heath (1990) recognized the need for partnerships for students to appreciate the work of scientists:

> "Education reform must be collaborative to succeed. In the case of science, mathematics, and technology education, the scientific community must enter into partnerships with the education community." (Rutherford and Ahlgren, 1990)

Science mentorship projects and activities could help to facilitate student exploration of the enriching and most relevant curriculum extensions which are so often neglected. Hurd (1991) states that science courses must be developed around themes similar to the current mandated extension activities. These themes tend to encourage higher-order thinking as opposed to content recall:

> "...integrated science curriculum must reflect modern content that teaches higher-order thinking, learning to learn skills, and the uses of science in human affairs." (Hurd, 1991, p33)

Mentorship/ inquiry project activities and involvement allow students to integrate new skills into their learning as well as to develop "higher-order" thinking skills in partnership with other members of the community (Hurd, 1991). This position is supported by Lawless and Rock (1998) who state that inquiry partnerships introduces students to hands-on, minds-on science which is real and authentic. Students are also exposed to the rigours of science and the true nature of scientific investigations. Spencer, Huczek, and Muir (1998) have identified five generalizable objectives which could be applied to projects for the meeting of educational and scientific goals:

1. Students must be involved in projects which require them to actually do science.
2. Students will be required to reliably collect, analyze and interpret field data for others.
3. Students must have access to a wide range of activities in which to become involved in.
4. Data collected by the students will be made available to other students and the scientific community at large.
5. Partnerships with scientists will be encouraged and developed for mentoring purposes as well as to develop a greater understanding of what scientists do.

Fougere (1998) adds emphasis to the educational importance of sharing information with our relevant community groups. She also believes that inquiry projects have the added benefit of developing in students the realization that science is a long term process quite unlike the normal school science lessons.

What are the benefits to students being involved in project based partnerships? Lawless and Rock (1998) summarize many of these as follows:

- Students are introduced to hands-on, minds-on science which is real and authentic.
- Students are introduced to the rigours of field science.
- Students are involved with data acquisition, analysis and sharing aspect of research which supports creative thinking.
- Students are given opportunities to work with the "tools" (innovative technology) of the trade and to have the collaboration and mentoring of field scientists.

Nixon (1997) adds to this list by emphasizing the excitement which can be inspirational to both teachers and students through the direct exposure to field science.

The partnership projects on which this study was based involve both a collaborative and mentorship component. Collaboration here will be facilitated through the involvement of others. This collaboration will not be in the form of instruction but in assistance to make what is to be learned understandable and meaningful. All participants are thus engaged in meaningful learning activities. Smith describes such a process as:

> "Teachers and their own collaborators must engage in enterprises in which students can join - rather than expecting to organize learning situations amongst the students themselves." (Smith, 1988, p72)

There is a common connection or link between what Smith describes as "enterprises" and what this paper describes as " A Partnership Approach to Science Education". Partnerships here refer to the activities in which students had the opportunity to join and take active roles. These activities or "enterprises" were of a voluntary nature and open to all students based on their own personal interests. The roles which individual students chose to assume varied in regards to the amount of time commitment required and to the level of responsibility assumed. This study also features a mentorship component in that students may be linked with "experts" who take on a role of a counsel that may assist by providing guidance. Such a role model feature may in turn help shape the direction and outcomes of the projects. I agree with Blackwell who describes mentoring as:

> "...a process by which persons of superior rank, special achievements, and prestige instruct, counsel, guide and facilitate the intellectual and/ or career development of persons identified as portages." (Blackwell, 1989, p9 as quoted in Jacobi, 1991)

Waltner (1992) has helped to develop a mentorship work program within the Indianapolis Public Schools where students interested in science or technology can turn to professionals for help concerning available careers.

This particular program links secondary school students with adult professionals. The students chosen to take part must meet rigorous entrance requirements which indicate previous interest and success in science. This program reflects the direction some educators feel science should take in order to meet the needs of students destined for scientific careers in the future. The opportunity to work directly with scientists gives opportunities for students to make future career choices based on first hand experiences.

The Boreal Forest Watch Partnership (Spencer, Huczek, Muir, 1998) was funded by the U.S. National Aeronautics and Space Administration. The purpose of the project was to involve students and teachers in scientific investigations pertinent to global change research on the boreal forests of Canada. The partnership involved science professionals from the University of New Hampshire, the Prince Albert National Park, as well as students and teachers from a number of schools in central Saskatchewan. The primary goal of the project was to enable students to participate in research activities which have a global significance as well as a local community impact. The overall research goal was to obtain data which would allow for the understanding of the relationship between the boreal forests and the interaction with climatic change.

The design of the project enabled the students to collect data on a regular basis from permanent study plots to assess tree and forest conditions. Students were introduced to real research methods used to collect the data as well as the current research tools used by scientists such as the state of the art image processing to view and manipulate Landsat Thematic Mapper satellite datasets for their study area. Workshops were arranged to prepare teachers to support the students in the field. As well teachers were assisted in incorporating the project into the science curriculum.

Gardner (1991) states that education for understanding should be a goal of science education:

> "the process of achieving such an education ought to be challenging and enriching, far more so than the implementation of the less ambitious education with which we have been saddled" (Gardner, 1991, p19).

These decisions will no doubt have a major impact on our lives, lifestyles, and job opportunities. Villa (1991) discusses the importance of empowering students by including them in decision-making processes. These processes include how instruction is delivered and the provision of peer support. Villa feels that the education system must include and empower students if we are to best prepare them for their future endeavours. The rationale for a greater student involvement and empowerment presumes that enhanced motivation will generate higher levels of interest and commitment.

With inquiry projects however there seems to be an increase in the amount of active learning by the student. Benjamin (1989) supports this notion and states that it is a necessary component in education, especially for the twenty-first century. Students become empowered as they make choices involving the types of extension activities they wish to pursue. Students also become decision makers with the curriculum design. In this way, their interests will direct and drive a significant part of their learning. In short, the empowerment provided to students to make real choices is an excellent means of providing a motivational component to science education.

Chapter 3

Design and Methodology

The rationale for a case study

Early on in my program of studies, I knew that my interest in the study of teaching science would lead to that area of research involving the use of authentic science opportunities as the basis for meaningful learning. Being interested and experienced in secondary science teaching and knowing the concerns of my colleagues in this area, finding a means to teach science in a meaningful manner where students would begin to understand the ideas, applications and the role which science will play in their lives became the focus of my inquiry. I wanted to improve my science teaching, work with other colleagues in this area, and improve the learning experiences of my students.

After reading the literature and talking with colleagues, professors and students both at the high school and university level, the nature of my study began to focus on project-based partnerships which I felt would reflect an authentic approach to science education. The idea of a collaborative case study with a teaching colleague which would explore and extend understandings of science teaching through interpretations of shared experiences evolved. The three other teacher(s) in the study, a male teacher with twenty-two years of teaching experience at both the elementary and junior high school levels, a male teacher with twenty-eight years teaching experience at the junior high school level and a female high school teacher with eight years teaching experience had to be also interested in:

- inquiring into their own teaching beliefs and practice
- reflecting on the teaching events within their classrooms
- employing project-based partnerships
- modifying previous teaching practice as needed

As collaborators in the project, we were able to frame the various project opportunities in a manner which would most suit the level of the students involved. We were also able to monitor and modify the various activities as they progressed so that we were able to meet our timeframes and overall project objectives. As the teacher-researcher my responsibilities would have to be similar to those of my colleagues but also needed to include the identifying and framing of the critical problems of practice, suggesting strategies for implementing the project-based partnerships and supporting changes in practice through an on-going reflective process.

Methodological Framework

The study is a personal narrative using a case study approach where I began to examine my own teaching beliefs and practices in order to improve my own science teaching. Through looking at my past practices and the meaning which I had placed on them, I hoped to be able to make those teaching changes which would have the greatest positive impact on the attitudes which my students construct of their own science experiences. A personal narrative case study was chosen as a means to accomplish these goals as:

> "Narrative can be considered as a basic metaphor for understanding human experience and behavior. Narrative is such a daily activity that Hardy (1987) describes it as our primary act of mind. By constructing our narratives we make sense of our world and our place in it. If we are to control and direct our own thinking and teaching lives, we must begin by becoming more conscious of them." (Diamond, 1991,p90)

I decided to look at one aspect of my teaching which I believed could have an impact on my students' attitude towards science. As the teacher-researcher, I chose to focus my attention on the effects of project based learning and with the collaboration of teacher/student participants have looked at meaning making in science through the use of cross grade project partnerships. The study also looked at the developing views of students and teachers in regards to science education through reflection based on their own personal journals as well as my field notes and interviews. Through collaboration with the teacher/student participants, the teacher-researcher attempts to make personal meaning based on these individual experiences. As a participant observer my role continued to be one of helping shape the projects in which the students chose to become involved.

The collaborative partnership between the researcher and participants evolved over the course of the study and became more and more negotiable as the study progressed. Students began to develop their own voices and were able to help shape the projects in which they would take part. Included in this shaping were the time requirements needed for the study, setting the dates and times for the study and deciding which investigations the students would like to conduct and whether they were possible under our school conditions. As well, my role was to help with student and teacher reflections through the use of personal journals.

The methodology falls in the realm of the hermeneutic according to Habermas (1971). Habermas provides an outline for a comparative analysis of three paradigms of inquiry which also includes the empirical-analytical sciences and critical sciences as well as hermeneutics. The hermeneutic field involves practical interests and is organized around interactions among persons. The interest which is served is that of the practical control which can be based on the interactions and the meaning making which may occur as a result of those interactions. This field also sees persons as being active in the creation of knowledge and emphasizes the meaning which may arise as a result of the accompanying reflections. In this study I focus mainly in the realm of "practical control" as the intent of the work is to develop a deeper and clearer understanding of my own personal teaching practices through the use of narrative as well as problem solving at the project level. Student participants are also encouraged to develop their own personal meaning making through the use of a project based inquiry utilizing journals, field notes, and interviews. The development of meaning making may result through the interpreting of the meaning of lived experiences through reflection.

A case study was selected as the most appropriate method to study the effects of a project-based approach to science education because it would be based on a varied collection of artifacts detailing teacher and student interactions which would occur within or outside of the classroom. The case study was further grounded in a theoretical framework which validates and gives meaning to the everyday practice of a classroom teacher. This framework is comprised of the ideas on reflective practice developed by Schon (1983, 1988) and set in the context of "narrative inquiry" based on the work of Connelly and Clandinin (1988, 1990).

Within a narrative inquiry structure, meaning would be made through the examination of an issue from new perspectives. A student or a teacher's thoughts and experiences could be reflected upon through the use of journals and interviews very much in a story telling way. Connelly and Clandinin (1988) define narrative inquiry as:

> "the study of how humans make meaning of experience by endlessly telling and retelling of stories about themselves that both refigure the past and create purpose in the future" (Connelly and Clandinin, 1988.p24)

Donald Schon's ideas on "reflection-in and reflection on-action" identify a particular way of dealing with events which occur in practice. This study examines the reflectivity and accompanying "sense-making" which occurred through project-based partnerships. Through the reframing of these experiences new meaning and learning may occur.

> "in reflective conversation, the practitioner's efforts to solve the reframed problem yields new discoveries which call for new

reflection-in action. The process spirals through stages of appreciation, action, and reappreciation. The unique and uncertain situation comes to be understood through the attempt to change it, and changed through the attempt to understand it." (Schon, 1983, p.132)

As the intent and focus of my work was being formed, the need to identify potential collaborators and then to extend an invitation to a colleague with whom to conduct my case study became important.

General Method

After receiving approval from the Ethics Committee from the Faculty of Education, I proceeded with the study. The study began with a search for the best teaching practices that would allow me to meet the science needs of my students. Of particular interest to me was the development of practices which would have the greatest possibility of enhancing the attitudes which students construct of the importance of science to their lives. As a teacher of chemistry and biology at the high school level I began focusing on creating opportunities for my students to get involved with "real" or "authentic" projects which would support the applicable curriculum of study. The nature of the projects and the structure of the projects would become negotiable with the student participants through a planning phase.

To initiate a project, the "project concept" including the expected timelines and expectations for the particular study was explained to potential participants. This briefing meeting occurred either during a regular scheduled classroom period if the project was applicable to a specific class or during a lunch time period if the project was open to participants throughout the school. During this initial meeting, the students were informed that they would have the opportunity to become involved with an existing project or perhaps construct a research project of personal interest for use in their science program of study. Students were also advised that their participation could involve the assigning of a project mark which then could be applied towards a grade for their particular science course. With the initial project, "Mentorship in Science: Flowering Plant Project" and the majority of projects which have followed such as the Genetics Lab Project, Dalhousie Forest Project, and the Genesis Pond project (see Appendix D), grading has always been an option. This grade option has been one which all of the participants have exercised. The initial meeting which I have held for all of these projects is structured as a brainstorming session where student input is necessary and solicited. What I provide for the students is a general overview of possibilities for their involvement. Subsequent meetings were scheduled as needed to flesh out the formal project design including the problem statement, hypothesis (if applicable), methods, materials and data collection means. Following the completion of a project the students then submit a report of their findings either to their teacher or to their class as a special presentation.

Analysis of the project results could occur as a group or individual endeavor and may not be formalized until the project is underway. As these planning meetings proceeded, contact with other potential participants such as elementary, junior high school, university or research partners such as the Freshwater Institute took place. These contacts could result in students from the different levels becoming involved in the investigative aspect of the project or for others, such as researchers from the Freshwater Institute, or senior students within the project to become involved as "mentors" or act as a research support team.

The research design is a personal narrative using a case study approach. This approach allowed me to construct a descriptive overview of the student projects as well as provide an opportunity to analyze the responses that the student participants shared with me as the teacher researcher through their journals, field notes and interviews.

The model which I have constructed to map my growth and journey integrated three components for data collection. They include: student and teacher journal entries, student and teacher interviews and direct observations and personal interpretations in a journal format. The interviews were conducted using an open-ended question approach. This approach was used in order to illuminate student and teacher understandings and unplanned attitudinal changes towards science education. Some examples of the types of questions asked of the participants, both student and teacher include;
(a) How do you see your chemistry class, specifically and science, in general, being applicable to real life situations, (b) How has involvement in a partnership project influenced your students' attitudes towards science,
(c) Do you feel that project partnerships will have an impact on your classes, and if so how? The intent of the interviews were to allow for the ideas and feelings of the student and teacher to surface. In addition to the interviews and direct observations, both students and teachers were asked to keep a reflective journal of their thoughts and feelings towards the partnership/collaboration process. Journals and interviews allowed me to record and reflect on the interchanges which occurred between the teachers

from the various teaching levels.

The project activities have involved students and staff from Fort Richmond Collegiate, A.A. Leach Junior High School, Acadia Junior High School as well as Bairdmore, Dalhousie, Bonnycastle and Ralph Maybank Elementary Schools. The study has also looked at developing the views which students and teachers have expressed of science education through their personal journalizing. Through collaboration the teacher and student participants as well as the teacher-researcher has attempted to make meaning based on individual experiences. As a participant observer, my role continues to be one of helping shape the projects in which the students chose to become involved. As well, my role was to help with student and teacher reflections through the use of personal journals. It has been my hope that by working co-operatively on partnership projects that science education has been a more meaningful experience for all the participants.

Case Setting - Choosing the Participants

The three teachers who have been involved in this study from the beginning represent the elementary, junior and senior high school levels. They have openly expressed their concerns with student attitudes towards science education and are interested in finding alternate models for teaching science in manner which will foster positive attitudes. To this end, they are interested in developing science courses based on projects which include a partnership component designed to put science into a more meaningful context. The students who have participated in one or more of these partnerships over the past four years have most often volunteered. The marks of the participants accepted into the projects have ranged from that of failure through to excellence. Marks have never been the sole criteria for selection of participants, with attitude, interest and past experiences all coming into play. The elementary student participants were, in some cases, teacher selected based on classroom interests and performance. A few students (approximately four) at the junior and senior high level, were denied access to the program for various reasons unrelated to their science classes. Over the course of this study, ten teachers and approximately one hundred and sixty students have been involved directly in various project situations.

Case Study - Project Setting

The settings for this study involve a high school with a population of just over eight hundred students, two junior high schools with a combined population of about nine hundred students as well as four elementary schools with a combined population of over one thousand students. The classrooms and students involved with this study represent a wide range of abilities and attitudes. The communities selected; Fort Richmond, Waverley Heights and Richmond West are all university situated and feature an average to above average economic base. The student participants have been representative of the cultural and social mix of the communities. The study initially began with one project, "Mentorship in Science: Flowering Plant Project" (see Appendix B) which has now grown to include six projects representing issues related to biology and chemistry. The themes for these projects are covered under the following titles: Genetics Lab Project, Dalhousie Forest Project, Envirothon Activities Project, Genesis Pond Project and the Genomic Center for Cancer

Research Project. (see Appendix E)

Case Study - Teacher Role

The classroom teachers' responsibilities are to provide the time and materials required by the students in order to carry out their particular activity. In some situations the teachers also initiated a group activity which served to introduce the students from various schools to each other as well as to provide time for student presentations within their own class settings in regards to the nature of the various projects. Individual teachers had the option of attending the project activities as a participant or to remain as a classroom facilitator. One task required of the participant teachers was to integrate the project and its findings into the existing curriculum.

Case Study - Student Role

The students involved in the project settings co-constructed a project based to some degree on their own interests and also on the current curriculum guide. Student roles vary according to the individual project designs. All of the projects undertaken within this particular study have featured a cross level approach with students from various grades or classes working together towards a common goal. In some cases the student participants where brought together at Fort Richmond Collegiate for an introductory activity. The field experiences of the participants are pooled for a common report. These field experiences may be of an independent nature, with the common report bringing the two ends together.

Case Study - Data Gathering, Analysis and Conclusions

As a participant observer within the process, I have kept a journal and record of the events which occurred during each activity. A review of the journal was undertaken on a regular basis. Where emerging patterns evolved, such as a change in the amount of science materials read or written about, questions were developed and asked in an attempt to make meaning of the change. Student participants have also recorded journal entries in regards to their partnership experiences. In some situations student interviews were conducted in order to make meaning of their personal experiences.

Analysis was based on an examination of all the collected data, mainly through the student journals and personal observations. Interpretations and observations have been written down and shared with teacher and student participants as a means of cross-checking, validating and further developing the analysis. This involved describing changes, trends and evolving themes. The analysis occurred on an ongoing basis in order to determine the possible need to refine and refocus the activities. Such varying perspectives will aid in establishing validity through pooled judgment.

It is my intent to provide a description of the experiences for all participants within the study. Themes and trends are identified and supported with excerpts as the study draws to a conclusion. It is my hope that the study provides an understanding of how project partnership opportunities may influence student attitudes towards science education and help develop meaning making within science education. The study will also outline how my own personal professional growth as a science educator has developed as a result of incorporating science projects into my classroom. In this way the study may also allow for others to see themselves in similar situations and thus result in some transferability.

Chapter 4

Data Interpretation and Analysis: The Case Study

Chapter Four provides a historical background for the project as well as for the data collected over the time of the study and the meaning which I have been able to make of these experiences - including those of the participants involved and my own as a participant observer. The data which I have collected includes excerpts from the following components: student/teacher journal entries, teacher interviews, field notes, participant conversations, direct observations and personal interpretations within a journal format.

The historical background

This teacher/student and teacher-researcher study has been ongoing since the spring of 1994. As this study evolved over the course of this time frame, so has the methodology and the meaning which I have made of my teaching practice. My role as a teacher researcher continued to be that of a participant observer throughout the study. The focus of the exploratory study was to give meaning to the experiences which student and teacher participants had while engaged in a project partnership and how this personal "meaning making" has given rise to my own professional growth.

Why should providing for greater student involvement in project-based partnerships be a concern for us at Fort Richmond Collegiate? My teaching background as well as recent university experiences have indicated that current student attitudes are best characterized by an overwhelming concern for grades. There is also a clear indication that students are looking at the minimum requirements for class work and a desire to concentrate their studies solely on possible examination material. Perhaps this current state results from students having very little choice or direction in how their courses will be structured. Even when the extension or enrichment activities provided in the Education Manitoba Transitional Curriculum Guides for Biology, Chemistry or Science are included in a science course, they are most often chosen by the teacher. In all appearance, the assumption is that students will find them motivating regardless of their own specific interests or questions. At Fort Richmond the extension activities of the Transitional Curriculum Guides are most often designed and directed by the teacher so that the students can obtain the desired results. These activities are also organized by the classroom teacher in such a way that they can be neatly completed during a class period. It is truly amazing that we, as educators, have allowed this pattern of teaching for grades to exist as long as it has. It is distressing to think that teaching or learning, solely for the purpose of obtaining grades has become an accepted and sometimes demanded approach by the students themselves. Perhaps this grade fixation is a result of the students wishing to achieve high marks and the accompanying student belief that marks and academic success are directly related.

The technological future will also require a citizenry which will know how to learn and how to become lifetime learners rather than memorizers of facts. The inquiry or project initiatives allows students to extend their concern beyond themselves and gain a community service ethic through real experience. For any student, becoming a support person and a collaborator is an opportunity to participate in positive experiences of both an academic and social nature which will leave long-lasting impressions and learning.

This case study is a journal of my own professional growth as a science educator, as a result of my involvement with various student partnership projects. There are three components or goals connected to this particular journey. One aspect of the study was to explore collaboratively with teacher and student participants viable teaching alternatives for meeting the science curriculum requirements. Another feature of the study focused on how students and teachers are able to extend the curriculum beyond the core requirements as stated in the Manitoba Education Curriculum Guides through collaboration or partnerships in projects. Thirdly, I examined how the attitudes of students and teachers are influenced by their involvement within partnership activities.

Chapter Four is subdivided into sections which reflect a variety of partnership opportunities that will be explored in detail as to the meaning making which occurred as a result of participation. This study may allow for others to see themselves in similar situations and thus result in some transferability. Chapter One identified four guiding questions/statements which give each of the projects a common purpose and focus. These questions are:

1. How can we as teachers encourage in students the development of positive attitudes towards science while teaching the mandated curriculum?

2. How can I teach science in a manner which students will find meaningful and relevant?

3. How can I incorporate project activities into existing science programs which will allow for a collaborative inquiry approach to science?

4. How have my own science teaching beliefs and practices changed over time and to what do I attribute these changes?

In the beginning, the journey appeared to be so simple. Create a problem, make it real or at least real to myself as the project designer and then provide an opportunity for students to tackle the questions posed in their own fashion. This process would encourage students to recognize that asking questions when the need arises and being able to answer questions for others are an important part of science learning and understanding. The concept of "team" play would also be included to facilitate dialogue between students and participant schools and organizations. The following sections reflect the various project opportunities explored by teachers and students as mentioned in chapter three and describes the meaning making experiences which have occurred as a result. My reflections on the various projects in which the students have participated, and the meaning which I have constructed in the process will be recorded as the ***bold printed*** and ***italicized notes.*** The projects which have been explored for meaning include; a Mentorship in Science: Flowering Plant Project and A Genetics Lab Opportunity. As we move from experience to experience the change in my way of thinking as well as teaching practice will become evident.

Section 1

Mentorship in Science: Flowering Plant Project

The statement of purpose for this particular project set the tone for my journey.

> "To provide opportunities for students in Fort Garry Schools to experience science activities and research in a collaborative, co-operative, multi-level environment within their regular course of science studies." (Mentorship in Science, Appendix B)

The problems which were set out in this initial project/collaboration concerned flowering plant development and chemical interactions with the environment. These topics were and are included in the Education Manitoba Biology 40S and Chemistry 40S Transitional Science Curriculum Guides. The purpose was to have students investigate through experimentation, the effects on plant growth of flowering plants involving a number of factors such as amount of fertilizer, the pH level of the watering system and the wavelength of light which the plants were exposed to. What sets this particular case apart is that the students involved were not necessarily taking the grade 12 biology course where the topics appear in curriculum guides. The student participants from Fort Richmond Collegiate included members of grade 12 chemistry and biology courses as well as students from a grade 9 science class from A.A.Leach Junior High School. This mix of students emphasized the unique crosslevel "Partnership" factor of the project.

My earliest reflections on the initial project design and topic include the following excerpts as recorded in my personal journal (Feb 1993 - May 1993) as well as the current practices employed as a result of reflection and personal growth in this area:

> -where was it written that the three levels of public education, Elementary, Junior High, and High school could/should not form a co-operative relationship or triad? Had not "Neil" and I always been able to design constructive educational ideas / frameworks in the past when we taught at the same level? (journal entry Feb 1993)

> -The answer was yes we could do it. Initially the goal was to involve students in varying levels of activities that by nature or design were of a highly motivational nature. The premise being that such activities would serve as a motivational tool for anyone involved. (journal entry Feb 1993)

> -The students have been selected not as randomly as I would have perhaps liked but based on personalities more than anything else. I find that they are quite easy to talk to and are more than willing to become involved. (journal entry Feb 1993)

Faced with the prospect of finding suitable student participants within a project setting I decided to initially ask my classes who would be interested in participating in a "hands-on" science activity. I found that many of those students who quickly responded were those students who were already engaging in many classroom or school based activities.

There was the occasional exception to this rule but, on the whole, those students who had identified themselves as potential participants did not surprise me. The choices which I then made for project inclusion were based to a large degree on the personality traits of the individuals. With a significant response from the students I found myself not having to approach students who may have been better served by the opportunity for project work. (journal entry June 1998)

My most recent project reflections on the Genesis Pond Project and the Genomic Center of Cancer Project Study indicate a much different approach to student selection and participation. The approach which I now use in selecting student participants for a particular project is based on an inclusion rather than an exclusionary selection practice. I believe that this shift in thinking is a direct result of seeing first hand the insights and understandings which the majority of students from the class display while engaged in the project process, regardless of science background.

Students are now given a list of topics or ideas for their possible involvement. Where numbers are not an issue, all who volunteer are accepted. Where numbers are limiting, criteria are set based on the particular project at the time. Group activities and interactions between students representing grade six, seven and nine as well as the grades ten through twelve all work extremely well. The grade and age differences have not been an issue for the projects engaged in to date as each level has its own agenda and needs. It appears that the students in the higher grades relish the opportunity to assist, advise or "mentor" the younger students. Of the twenty-four students working on the Genesis Pond

Project this past year there was never a question of why were we working with younger students not from our school. Over the course of the studies, there have not to my knowledge been any negative comments made by any of the participants or teachers taking part in the various projects, in regards to the age and grade differences between students. (journal entry September 1998)

To prepare the students for the Flowering Plant Project, I introduced them to the MINET system and gave them an overview of what I envisioned "mentorship" to be and what their involvement might provide for them. MINET is the name given for a telecommunication system designed for the Manitoba Information Network Distance Education. This province-wide telecommunications network electronically linked Fort Garry schools with each other as well as with other schools within the Province. The initial system also provided a communication link to a variety of educational support facilities such as the University of Manitoba, Fort Whyte Nature Center and the Museum of Man and Nature. The system was one which was capable of providing a wide range of communication services. The services allowed staff and students to access:

- Electronic Mail
- Conferencing
- Faxing
- File / Data transfer

We initially practiced sending messages over the next few weeks to the junior high students whom we would be working with. One of the first participants sent a special e-mail to his father asking for money - the wonders of technology! The other students were quite taken by the fact that they would have access to my computer at school for their own educational purposes. Reflections on the initial meetings and briefing follow:

> -all students should be trained to use the computer for communication purposes. Perhaps one should book the computer lab so that all the class would have the same opportunity in the future. The students are extremely keen and easily motivated by the availability and requirement to use the computer for e-mail communications. (journal entry Feb 1993)

Over the past five years we have been able to train students and provide more extensive computer use to our increasing understanding of computer applications and access to appropriate technology.

The use of technology has been facilitated by the courses now offered in computer science and computer awareness. All students enrolled in Fort Richmond Collegiate have the option of taking computer courses based on their learning level and experiences. All students within the school regardless of whether they are enrolled in computer courses or not have access to email addresses at a minimal cost. The classes which I have taught since this time have had a computer/Internet project component as a regular classroom and subject assignment. The students who participate from junior and elementary school all have taken computer courses within their schools and have access to computers at school or home. These students from the other levels also have access to e-mail through their home or school accounts.

The next week had the students checking for responses to their questions and information offered through the MINET system. In retrospect, with the technological advances of the past few years, the MINET system itself has become a kind of antiquated e-mail correspondence system.

> -The task for me is to remind the students to check for mail on an ongoing basis and to begin to keep a journal with their own personal reflections on the project. This is a very exciting experience as I can really see a change in how I teach science. (journal entry March 1993)

> - I would like to think that I can practice the fact that teaching is a two way system, where reflections, questioning and research all play an integral part. (journal entry March 1993)

One of our earliest communications was to Churchill Mb. in an attempt to include students from various Manitoba schools in our project. Weeks went by with no answers from Churchill. This was very disappointing for the students involved at the time as they were most excited by this prospect of communicating with the students from such a unique community. As it turned out, it was the first of a number of obstacles that (students and teachers) we were forced to overcome.

> -Perhaps I should forward a MINET user booklet (see Appendix C) to the school in case they were not familiar with the operation of the system. A problem I now foresee is that many teachers as well as students are not familiar with how to use computers for telecommunication purposes. It is clear that many classroom teachers

will not have access to computers and thus will not be able to participate in these forms of projects. (journal entry March 1993)

Today the vast majority of schools in Manitoba not only have computer access for all students but Internet access as well. The students of today are far better equipped in regards to technology and understanding of technological applications than the students of only six years ago. Current projects involving communications are not a barrier to overcome for a majority of Manitoba students.

Another obstacle to the project would soon become obvious as a result of the project format. The type of interaction called for within the project breaks with the traditional teacher and student roles. Teachers and students alike find it hard to account for the time required on the computer and perhaps are not accustomed to a new sense of ownership that "mentorship" as defined provides. (journal entry March 1993)

The time factor for computer usage is not an issue at present with the number of computers available not only in the school computer labs or classrooms but with the widespread use of home computers. The students with whom I have been able to work over the past four years now have ready access to computers for message purposes. The e-mail format is also very user friendly with most students having prior experiences.

Another concern which arose concerned the generation of ideas for projects. The students had initially expressed their wishes that the projects to be set up by the classroom teacher as this is what they are most used to and therefore most comfortable with:

> -I will have to formalize the process of project selection. Perhaps I will have to provide a list of topics for possible consideration. These topic ideas should vary from short and long term investigative studies, help sessions for the various grade levels participating in science contests such as science fairs, chemistry Olympics, robotic games or classroom demonstrations. (journal entry March 1993)

> -The key I believe is to get the students interacting, not only with their classmates but with others as well! Science education has to be an active process not the passive process it has become. We have to get away from the concept of right answers. As long as we stress "right" we emphasize "wrong". Logically, no one wishes to be wrong so why should students take risks. Is not the very essence of science calculated risk taking? (journal entry April 1993)

This is still an issue which I have to face. Students have few opportunities in schools to present their own ideas and to assume the responsibilities and risks associated with decision making. The only real choices science students appear to make are those dealing with science fairs and these very seldom will reflect risk taking on the part of the students. The very nature of science, especially field science where one spends countless hours accumulating data in field journals is practically nonexistent. When it rains, field studies or trips are usually postponed. Why wouldn't one cancel the outdoor field study or trip rather than expose

students to the reality of science? There are few individuals who are willing to get wet in the name of science teaching. One has to get involved, be committed and be willing to get "wet or dirty" sometimes. During the past few years, I have tried to arrange as many outdoor opportunities for students to participate in as possible. Very rarely has an opportunity to be involved with an outdoor science activity ever been canceled due to factors such as inclement weather. The cleaning of boots at the end of the day can sometimes be the highlight of the trip. This is a true problem solving exercise, how to get past the bus driver when one is wearing boots caked in mud with no access to a water hose. The in-depth analysis, chemical or otherwise on the samples collected can be accomplished in the classrooms at a later date if the weather and conditions dictate.

As the flowering plant project progressed, I found I was spending less and less time with the students involved. They are becoming more and more independent and more open to discussing real issues with myself and the other teachers involved:

> - Student A is using the computer more and more to find answers to the many questions arising from the flowering plant project. I am most impressed with the fact that I have been able to get to know Student A in a totally different way than I would have expected. I treat him with more respect and provide him with more ownership of his learning. I trust his judgments and increase the responsibilities he is given for his learning inquiries. (journal entry April 1993)

The projects provide opportunities for collaboration and, in turn, student empowerment.

I feel more like a coach than a teacher with all the answers. We develop game plans and analyze the results of our efforts. The dialogue is quite different from that generated from the normal classroom activities which quite conveniently fit into our seventy minute periods. Participants quite frequently drop in between classes, at noon hours or after school to discuss ideas or to just chat. The nature of the dialogue has changed with the correct answer rarely being asked for. We have become collaborators in our science experiences.

At the conclusion of the first project, I conducted interviews with the students and teacher involved using a series of open-ended questions. These questions were designed to provide me with feedback in regard to the four guiding questions as stated in chapter 4, page 42 and 43.

STUDENT INTERVIEW QUESTIONS AND RESPONSES

The following interview responses were gathered from the eight student participants, four from Fort Richmond Collegiate and four from A.A. Leach Junior High School who were active participants in the flowering plant project. The responses from the participants have what I believe to be the key words highlighted.

1. **How do you see your chemistry class, specifically, and science in general being applicable to real life situations?**

- "I think science is very **important** to society and that we should know as much about it as possible."
-"Chemistry is **enjoyable** but I am not putting the effort into it the way I could."
-"I am **hoping** that my class will be an **interactive one** with as many **hands on activities** as possible."
-"It is very **difficult to imagine working in a chemistry field** when one has had **little if any contact** with chemically related fields of work."
-"**I suppose it is beneficial** when we do experiments and then go over the results of the experiments and see how the answer is worked out."
-"It allows us to see the **basic concepts** of science. It gives us some **interesting topics** which we can **sometimes relate** to each other."
-"The course is **interesting** but I do not see much **practical use** for it yet in my life."
-"There is a real lack of **practical things** to do in the course."

Students at the grade nine and twelve levels appear to have an interest in continuing their studies in a science related field which may be expressed through future enrollment in related science courses of study or perhaps by their looking at the possibility of pursuing a future career in a science related field.

The critical question raised by the majority of student respondents asks, how one can grasp the importance of the science field of studies

when one does not have an opportunity to become engaged in the processes of science. Students at these levels are interested in the practical aspects of their life, needing to be able to grasp or at least visualize what they are doing and perhaps where they are heading.

2. What benefits do you see in having an interactive project component as part of your course?

-"The best part is that it **changes the format** of the regular chemistry and biology classes which I am taking."

-"I sometimes **leave the classroom with a problem** which was **brought up by someone else."**

-"Given a problem, we can **help in finding the solution**. It gives me an **opportunity to choose** the subject which I am most interested in. I also like being able to design and carry out labs to find solutions or possible answers."

-"I find myself going home, and rather than watch television, I will try to **think** about a possible answer to some problem which came up in school."

-"I find myself **looking to other students for help** to solve mine or someone else's problem."

-"I have always had a tougher time with the math in school as I have a **difficult time applying** many of the concepts outside of the classroom. I am finding the sciences much easier for me as I can see how they can impact on me **personally**."

-"I find I learn something much easier when I have had the **opportunity to talk about** it with others."

-"I find learning to be so much easier when I have to **reflect** on what I have done. This is emphasized even more when I am given the **responsibility** to help others with the concepts."

-"My **involvement** has allowed me to view biology and chemistry quite differently. It has taken on a more business-like approach."

The challenges which a "real" or an "authentic" problem brings to students is seen as an important link between theory and practice by students.

Students overwhelmingly enjoyed the creative problem solving that the problem based activities provided them with. Perhaps it was the ensuing dialogue which students engaged in while searching for possible solutions and planning which is the key. Students have so little opportunity to just talk about science. Projects by their nature, require collaboration with others which is so different from the classroom transmission of facts and formulae that students typically find themselves facing on a daily basis. Students when given the opportunity to talk or write about their experiences, results in the construction of personal meaning. This contructivist process engages the students in the central activity of learning.

3. What were your thoughts when you were asked to take part in a project involving cross-level age groups and computer communication technology?

-"I was eager to become involved for a number of reasons. One, I am very interested in computers. Another is that I really enjoy working with other people."

-"I think it is neat to be able to **communicate** to other schools and students about science activities."

-"If I can help someone else learn a concept it also helps me to learn it as well."

-"It really gives meaning to what we do in class."

-"To be able to do this in chemistry and biology allows me not only to have fun, but to learn something as well in a very **interesting way**."

-"I think it is a much more interesting way in which a student can learn about the sciences."

-"I have never really been asked before to develop **my own projects** based on what I enjoy doing. I have always been in science classes which go by the text or teacher notes. I thought it would be interesting to integrate the textbooks with ones own ideas and interests."

-"Its also nice to work out problems with others rather than by always being told the right or wrong answers by the teacher."

-"I really liked the idea of **working with students** form other schools."

-"I think it will allow me to cover more topics and material than I would be able to do otherwise."

-"I like the opportunity to work with computers and to use them within my courses for more than writing papers."

-"I really liked the idea of getting **feedback** from other students and schools. As well, the chance to get feedback on topics or questions which I may have about certain concepts is a great idea."

-"I can see how you could have other people do things for you which you may not be able to do for yourself."

-"A mutual **sharing of knowledge** is very useful. Helping someone else is as important as getting help yourself."

Communication, dialogue, student talk and collaboration are all appearing as central themes in the student responses to my questions regarding their project involvement.

The need to question and to be actively involved in the processes of learning are clearly critical to the attitudes which students are developing through their current science programs.

Dewey (1938) also believed that experience must be followed by reflective analysis if qualitative changes in growth and development are to occur. He believed that the teacher's essential task is to learn how to create knowledge not merely receive it - knowledge is emergent and ever-changing. Projects appear to be one means of providing students with common or shared reflective experiences. I believe the power and importance of these forms of experiences are evident in the student responses.

4. Has working on this project with the computer communications influenced your attitude towards chemistry in any way?

-"Yes - I have really enjoyed **being able to talk** about chemistry. Not only do I talk with my lab partners about the activities or possible projects, but I am now communicating by computer with others as well."
-"Honestly I am very excited. I am not saying that for marks or anything as you are not even my teacher."
-"There are so **many opportunities** which this project provides for. It really increases the **hands on component** which is what I personally really enjoy."
-"I really look forward to the **interactions** I have developed with other

students both in my school as well as other schools."

-"I would probably say yes. I think I can do a lot more in chemistry and biology when I am working on projects."

-"I enjoy **communicating** with other students who have the same or similar interests to mine."

-"This project has allowed me to cover more material and therefore know more stuff in chemistry."

-"Yes, it has changed the **context of my science class**. You leave the classroom with a problem which may or may not be your own. You then become responsible for finding a solution to that particular problem."

-"Working on problems this way, I find to be very satisfying. One reason is that I have some control over the types of problems and activities which I will become involved in."

Students clearly are stating that the ability to talk and communicate their beliefs and ask questions changes the context of their science classrooms.

Meaning making or understanding is developed through the act of dialogue. Being encouraged to explain your beliefs to others and to listen shapes knowledge. When one is an active partner in the learning process as opposed to being an information recipient, knowledge development is encouraged and enhanced.

Diamond (1991) supports this position that knowledge is a result of our meaning making of the world around us. In order for this to occur, teachers must be not only aware of the importance for students to take ownership of their learning but also to control the activities in which they choose to become involved with as well. When one is encouraged and provided the opportunity to inquire and reflect, a transformation in a way of thinking is most likely to occur.

> "Knowledge is not something to be consumed but is to be made and remade." (Diamond, 1991, p3).

John Dewey (1938) places great emphasis on the importance of reflective practice and clearly states that all learners should not only be both producers of knowledge but consumers of knowledge as well.

5. What are your impressions so far, disappointments as well as the positives?

-"the project has allowed me to meet far more people who can help me solve problems which I may have in science. In a regular classroom, your classmates are usually the only students you can talk to about the subject. The class makeup will then determine the type of help or activities that you can do."

-"Another really positive idea is that in the past I used to go home and watch television after school. Now I go home with a chemistry/biology problem for me to think about. Because it is my problem, I find myself trying to solve the problem rather than watching television."

-"I really enjoy working with younger students. Being a **mentor** really makes you think about the stuff you are taught."

-"I find myself asking older students for help with science problems. This is something I know I would have never done without being involved within the project."

-"I would really like to come up with more of **my own problems** or questions to explore. I find it hard to think of problems which we can study about. I think this is because we have never really had to do that in the past."

-" I think working with the computer is the best thing so far. It is a lot of fun to be able to communicate with other schools."

-"I also like the idea that you are giving us **more responsibility** to become involved. By allowing us to use your computer shows me that **you trust me** and that means a lot."

-"A disappointment so far is that there are not a lot of other schools or students who are also involved in projects using computers for communication."

-"I have really enjoyed the opportunity to do extra labs. I find the labs very **interesting** and hope we can do more. Experiments allow you to see how you get the answer rather than by just being told the right answer. I really don't enjoy taking notes on things which should happen. I like to see for myself how things work. If this project allows me to do more labs and activities then I want to be involved as much as possible."

There are many aspects of a project partnership that students have indicated as being positive experiences.

Students enjoy the mixed role which a project affords. They are put into different situations which traditional science classes usually do not afford them. Students may become mentors which requires them to reflect on their practices, make personal meaning of an event and then to share

that particular event with another individual. Students certainly appreciate the opportunity to be part of a design creating labs to solve real questions to problems which they themselves may develop. This certainly supports Smith (1988) who would see these positive experiences being the direct result of participating in meaningful learning opportunities.

6. Do you believe that project partnerships has a place in the classroom? What feelings do you have about its potential?

-"Most definitely. What has happened here is that you have radically changed the function/structure of the traditional classroom. It is no longer limited to the classroom in which you are taking a subject."

-"To be honest, I never even considered how other schools and industry could be part of my learning environment."

-"Thinking about how one can now **collaborate** on labs or experiments with students from other schools is almost unbelievable. The possibilities are almost endless."

-"I really think that being taught in this manner would help one to adjust to university much quicker."

-"Next year when I am in university full time, I would like to be able to still be part of the projects if possible."

The student responses throughout the interviews, consistently emphasize the importance of inclusion and collaboration in regards to the meaning which they construct towards their science beliefs. Their attitudes towards the sciences appear to be greatly influenced by the nature of these forms of activities

TEACHER QUESTIONS AND RESPONSES

The following interview responses were gathered from my teacher collaborator who participated in the flowering plant project. The responses have what I believe to be the key words highlighted.

1. How has involvement in a partnership project influenced your students' attitude towards chemistry?

Teacher A. -"the biggest change appears to be outside of the normal classroom. The individuals involved in these projects come in before and after class to work on the problems. The **time they have committed** to the project **is** quite **remarkable**."
-"they ask to take lab equipment home in order to familiarize themselves with the operation so that they can explain it to the younger grades with which they are working. The also are looking at ideas, concepts not yet taught in my class because they see a need for them now."

Students and teachers alike are faced with the common question of finding time to complete all of the possible tasks that confront us on a daily basis. As teachers the question will typically revolve around the curriculum and whether or not it is possible to address all of the stated learning outcomes. Similarly, students continually try to balance their schedule by allotting the minimum amount of time they deem necessary for each of their courses. How can we as teachers cover the curriculum in more depth in the same amount of school time available and how can students be convinced that science studies are important enough to warrant the extra time spent on course? (journal entry September 1998)

Teachers continually try to reinforce for students the importance of putting time and effort into one's studies. This commitment of time is seen as being necessary for students either to develop a level of mastery of the topic or to develop an appreciation for and a basic understanding of the topic. Most often the message is lost in a typical classroom setting despite the frequency of the message. Projects appear to be one means of motivating students to make this time commitment. Marcia Linn (1992) would support this belief A "dynamic" view of science could be developed through the use of a collaborative approach to teaching which would focus on developing projects which represent "real or authentic" science questions.

2. Do you feel that project partnerships will have an impact on your classes, and if so how?

-"Most **definitely**! The students who are currently working on the project have **already acquired a solid foundation** of concepts which we will be looking at over the next few weeks. I see them being a **real asset** to the class in being able to work with students have difficulty."
-"I believe that they will be **models** for other students in the sense of showing how **science is interesting and real**."

These statements reflect the beliefs as stated by Hurd (1991) who believes that students must have the opportunities to explore topics in a

manner which challenges their higher order thinking skills. By being involved in projects requiring thinking and collaboration, students begin to acquire the background knowledge and ideas that support the curriculum topics. These topics now have a true value or meaning as a result on how they were initially presented.

3. Do you feel that you will use project partnerships as part of your teaching strategies in the future?

-"**Most definitely**! I would like to see all my students involved in projects in some way. The question of course is how."
-"Having a computer in my lab would be a real benefit in regards to having students becoming involved. Not only for accessing information but for collecting data and communication."
-"All my students are interested in the idea."
-"I believe that by doing more on their own that, not only will they learn more, but that it will be retained much better. It allows for students to **take ownership and responsibility** for their own learning and that there is a real need for this at the grade 10 level."
-"I see nothing but **positives** with project partnership activities."

The sense of ownership was the key word which stands out in these responses. Students need the opportunity to be engaged in activities where the development of the question becomes part of their responsibilities. Through the sense of ownership, participants develop commitment to the task at hand, putting in the time and effort which is required to answer the question.

4. Do you have any comments that you would like to make about partnerships?

-"I wish that I would have had opportunities like this when I was going through high school."

-"My teachers usually used only notes and a lecture approach to teaching."

-"Students gain a **real sense of accomplishment** when they are **given the responsibility of working with others."**

-"The **ownership** that they gain focuses on **collaboration, co-operation** and **communication skills**. I believe they learn to appreciate the powers that these skills can provide them."

-"I will have to work with the other grade levels much differently. Being aware of the concepts and outcomes the elementary and junior high science course involve are important."

-"I really think that this is a very exciting concept and one which I have every intention of using in my classroom."

Section 2

Genetics Lab Opportunity

The purpose of this mini-project was to provide junior high students within a grade nine classroom the opportunity to be involved in a personal research project on a genetics topic. This particular partnership with a grade twelve biology class (students) was classified a mini-project due to the limited number of exchanges (three classroom periods). Even with the limited number of exchanges, I believe it addresses the purpose of my initial project (The Mentorship in Science, Appendix B**)**. The opportunity for students to experience science activities and research (genetics labs) in a collaborative, co-operative, multilevel environment (grade nine and twelve students) is clearly evident.

The project was to look at the themes involved in the development of DNA science. This project involved a number of components to develop these topic themes. To this end the eight students from Acadia Junior High School who were involved in the project were to journal, view a video, share a number of readings, perform a number of labs involving techniques required for genetic manipulations and to look at using the Internet as a communication tool. The readings included an **overview of molecular biology** as well as a **history of** the development of DNA science. The labs which were worked on involved using the micropipette, sterile techniques, bacterial culture techniques and restriction enzymes and gel electrophoreses. The Internet was used for e-mail communications. The lesson plans for the project included:

- Day One
    - a) Handout - DNA Science which included the topics of DNA literacy, Biotechnology, the Bacteria: E-coli, the Plasmid Vector, Restriction Endonucleases, Electrophoresis, DNA Recombination, Induced Transformation and the Isolation and Analysis of Recombinant Plasmids.
    - b) Video - Cold Spring Harbour
    - c) Lab 1 - Measurements, Micropipetting, and Sterile Techniques

- Day Two
  - a) Lab 2 - Isolation of Individual Colonies of E-coli
  - b) Journal entry
  - c) Internet activity
- Day Three
  - a) Lab 3 - DNA Restriction Analysis
  - b) Journal entry
  - c) Internet activity

The journal entries involved a series of **open-ended questions** dealing with the nature of their science experiences. The journals were to provide me with feedback in regard to my four guiding questions found in chapter one as well as restated near the beginning of this chapter. The journal questions and the responses received from the eight student participants follow: (Key words are highlighted.)

1. What do you like best about the science courses you have taken?

-"I like the courses which bring up ethical questions where discussions follow. It is neat going into these issues and coming up with one's own ideas and opinions on them."

-"I liked learning new things about science which I am interested in. I also like to receive high marks as well as out of class projects."

-"What I liked about the science courses I have taken is that it gives me a better understanding of the world around me."

-"I like to build things that I can see. The engineering week and activities associated with the event were great."

-"The thing I like best about the science courses I have taken in the past are when we have done labs and experiments." (journal entries April 1996)

Students have expressed their need for activities that are real and challenging. Whenever they have been invited to be a partner in an initiative, they have been more than able to meet the challenge. Students show an increased interest in science when they are able to extend their inquiries into personal interest areas. Providing students with alternative activities to participate in should be an important feature of all science programs. Personal meaning making can only be enhanced when students become active in their own learning. The voices of my students are know heard in a much different manner than they were when this study was first initiated. Providing students with the opportunity to be involved in special events takes on a much greater importance now than ever before. What I have found is that once students have been introduced to their options, they provide such positive feedback that you continue to try and find other opportunities for them. Unfortunately, the choices one can provide are still limited and many students still find themselves detached from what science should really be.

2. What are the criticisms you have of the science programs / courses you have taken in the past?

-"I have found that my classes in the past have been too easy with lots of recall questions and problems. Many of the topics and concepts have been quite logical when it comes to problem solving. As a result, I have found the topics not very interesting."

-"I find many of the topics irrelevant to my way of thinking."
-"Many of the courses have been designed in a way where one sits and reads the text to find the answers someone else has already developed. There are not enough labs or activities which would help to clarify the concepts."
-"I think that much of the work has been mindless busy work-boring and irrelevant to the course of studies. There are not enough hands on activities which would help me to clarify the concepts. We seem to go over the same concepts over and over again."
-"The courses usually move too slow with many of the textbooks presenting a watered down version of information. Most years with the exception of this one, I was unable to advance at a faster pace than the rest of the class if I wanted to." (journal entries April 1996)

3. What do think about the opportunity to work with other levels of students on a project such as this one?

-"I think it is fine. I get to hear other opinions from students and teachers from other levels. My ideas will not be influenced by only one person."
-"I am really happy to be working on this project as I get to use equipment and learn other techniques which may not have been available otherwise. I love the opportunity to do hands on work in genetics."
-"I am excited about learning information which may not have been available to me through my regular course of studies. I am very interested in genetics and it peeks my interest to be able to gain more information."
-"Its a new experience with lots of hands on stuff which I like."
-"I am really interested as I thought it would be a greater challenge than my regular class and of course this made me feel excited and nervous."(journal

entries April 1996)

Challenges which force students to problem solve, or to be reflective practionares continually surface as importance aspects which students see as motivational.

4. What would you like to achieve by working on this project?

-"I would like to gain a better understanding of genetics , DNA and the manipulation of the genetic code. I would really like to learn how DNA can be manipulated for individuals with disorders such as cystic fibrosis."
-"I would like to gain more knowledge in genetics and to achieve a better understanding of how DNA can be manipulated in humans."
-"Hopefully I will be able to clarify and see the relevance and practicality of the genetics field to what I study in school."
-"Perhaps I will be given a glimpse as to a future field of study for me." (journal entries April 1996)

Personal Reflections:

-"What am I afraid of? I suppose that if I do not present DNA science as a field of dreams which is open to each individual's imagination - that once again I will have structured the time and lessons in such a manner that any learning achieved will be done in a narrowly defined way - that being what I see as being important - not what they see." (journal entry April 1996)

-"I really enjoy presenting topics to the varying levels of students. I only wish that I had a few more of my students involved. These experiences to me emphasis what education and learning are all about. -sharing, communicating, enjoying, reflecting, discovering and ultimately learning. (journal entry April 1996)

-"I find on days like these that I forget about the role of "teacher" as a defined model. We "all" become part of the process - each adding to the others repertoire - learning from each other." (journal entry April 1996)

-"It was great - once again the students involved show their true personalities and interests. The quality of each student comes to the surface, their enjoyment of science and learning, an openness to suggestions and variety of approaches they may pursue all led to a lot of fun and I look forward to tomorrow." (journal entry April 1996)

I believe the following journal entry which I made as the activity moved to day 3, our last day on this particular project demonstrates my belief and faith in the benefits of such activities.

-"Today should be a good if not a great day. Our computer technician will be available to assist with the Internet aspect in regards to the project and data collection. I guess the focus (approach) I am taking is for the students to be able to ask their own questions and to collaborate with others (experts) in order to develop their knowledge base. I have avoided any notes to the present but perhaps we can now start to develop our knowledge chart. The guiding question being - DNA - Understanding our Capabilities. With this we should be able to draw from a wide variety of experiences such as videos, books/journals, handouts, labs, Internet, and personal interactions. I hope that the students realize that knowledge is what we are and defines who we are. I also hope that these students see the power in collaboration and dialogue." (journal entry April 1996)

The preceding collection of data from interviews, journal entries and reflections has provided the basis for my analysis of both teacher and student reactions to project based learning and the effects it has had on their beliefs and attitudes toward science. It has become increasingly evident to me that empowering students through project-based learning and providing opportunities for collaboration with a wide variety of people are critical elements in creating positive attitudes towards science learning.

Chapter 5

The Overview

In the Beginning

Chapter Five focuses on tracing the growth I have enjoyed as a result of embarking on my studies. The thematic structure I have used here will link the early questions and approaches to the evolving project based learning partnerships which are a focal part of my courses of study as well as the school's science program. The study which I undertook explored my own teaching practices and examined how the methods which traditionally are used in the teaching of science impact on student attitudes towards science.

In order to promote positive attitudes towards science, extend the understanding of scientific concepts and provide opportunities for practical application, it is essential that science teachers examine their current practices of teaching and assessing and look for methods that enhance the science education of all learners.

There are clearly weaknesses in how science is being taught in schools not only with the curriculum content but with teacher methodology as well. The literature review which was conducted and reported on within Chapter 2 as well as the direct student feedback received supports the belief that students feel that they do not have a good understanding of the science concepts which they have been taught. Not only do they believe that they do not have a good grasp of scientific concepts but they also display negative attitudes towards science courses in general. This is noted by their own voices which express disinterest and disillusion with their personal understanding of science education. These beliefs and attitudes appear to stem from the traditional approach taken to science education. This traditional approach is generally textbook-centered and focused heavily on content. Tests based on factual recall are quite commonly used to determine the successes which students receive within specific courses. Students who experience difficulties with a transmission style of teaching are often seen as poor learners. Over time this teacher belief becomes embedded within the students themselves who feel that they are unable to understand and thus do science.

The program entitled "A Partnership Approach to Science Education" was designed around the question of how teachers could effectively encourage in students the development of positive attitudes towards science. I was concerned about my style of teaching at the time and the effects it appeared to be having on my students. I, like many other teachers had become a master of the overhead and textbook assignment. The student notes which I had developed over time were indeed impressive. I had rows of binders, all easily accessible with organized topics for all subjects which provided me with a wealth of activities, facts, worksheets, assignments and tests which I could use to keep my students focused and busy. All of the topics were clearly laid out so that almost anyone could come into my classroom and easily find and present the "information" to the students. The science department was quite consistent in this "delivery method" of instruction. Department meetings which were held weekly focused on consistency of not only instructional techniques and assignments, but also on similarity and consistency of student responses. Common assignments, quizzes and tests shared between teachers of the same subject were the norm.

The atmosphere was one where it appeared that teachers believed that student results would reflect to some degree on them. Some of the teachers within the department were hesitant to attempt something new in the fear of poor test results.

> "if I become involved in a project which requires any classroom instructional time, I will not be able to focus on the curriculum outcomes which the students are expected to know. If my class average drops as a result of this, then I will no doubt hear about it in the form of administrative accounting. If I do this activity which is not directly linked to the curriculum my class will not be able to spend as much time on test questions. Their marks will most likely drop and they (administration, school and division base) will use poor marks as a means of teacher assessment. They always use test marks in this manner." (teacher B journal entry, January 1994)

I responded in a manner which assured him and that stressed that this would not be the case, and even if the marks were reviewed, that I would be taking the same approach and therefore all should balance out. I was trying to help this teacher take a chance and this time I was successful. As Teacher B had predicted, following the semester exams, the marks which our classes received were used to draw inferences towards perceived effective teaching practices. The marks appeared to be a few percent below the expected. It seems that the relevant, enriching opportunities we had provided our students were not included in the multiple choice assessment. The "static" view of science had once again been reflected in the assessments over the "dynamic" and thought provoking view. It would take three years before this teacher would trust my beliefs and curriculum approaches again. Unfortunately, like failing eyesight, the shift was so gradual that we failed to recognize what we had become.

In defense of myself and the department, it was not all bad or undesirable. We had identified what we believed to be the core requirements for students to master in order to be successful in their future studies. We had also emphasized and developed strategies to prepare students well for their exams both locally and provincially. Most students were excelling academically, not only in science but in the school as a whole. Obviously, they had mastered the art of copying notes and providing the right answers to all of our questions. Student marks were high, the graduating class was almost to a whole pursuing some form of postsecondary education... what more could be asked? Perhaps they asked it for me. A response pattern seemed to have developed whenever I would attempt to introduce some novel story or relevant science activity into the classroom. The same question would continually be asked of me. "Is this for marks?" and "Will it be on the final exam?" If the answer was no to either one, they were hesitant to participate or at the very least question why they should be doing something that would not reflect on their grades.

The final realization that perhaps my teaching methods were not allowing for a positive attitude towards the sciences to develop arose out of my involvement with a group of University of Manitoba education students in their final year of certification. This was a group of individuals about to enter the teaching profession, all having average to above average transcript secondary school marks which to me indicated positive experiences in their education. It was only after reading their responses to a journal assignment asking them about their prior science experiences that my eyes were truly opened. What I had expected as responses and what I read was totally unexpected. The vast majority of the group indicated that their senior high science experiences were less than memorable. Few had been able to make any real world connections between the facts and the relevance of science to their lives. The marks which I believed to be so important appeared to have little or no correlation with the marks which the students received. Good grades did not necessarily reflect positive attitudes towards the subject, in this case, science. What we had clearly failed to do was to provide students the opportunities to appreciate science.

The task that emerged was to create and deliver a science program which would encourage in my students the development of positive attitudes towards science. My collaborator and I agreed that for this to be accomplished, we would have to teach science in a manner which would become meaningful for each student. Gardner (1991) paved the way for our approach when he stressed the need and importance of "projects" and apprenticeship methods. Our overall goal which was identified in Chapter 1 and reformulated in Chapter 4 was to provide real and authentic science experiences which would enhance student attitudes towards the field of science, both as a subject and a future career. These experiences would be incorporated into lesson presentations in which students could participate while addressing the curriculum guides of the time. As my collaborator and I taught at two different levels, high school and junior high, we built into our model a cross level approach where collaboration with our students and other professionals was necessary in achieving an end result. This feature was a unique attribute of our project and one which would prove to have a very powerful effect.

Projects as a Choice for Change

I chose projects as a means of achieving a goal for an authentic and real science experience for my students and for those students taking courses at Fort Richmond Collegiate. My belief was that through the development and inclusion of projects for student involvement in the science classroom, a positive attitude towards science would be encouraged. This shift in my teaching philosophy was based on the belief that alternatives to my current teaching practices were necessary in order to best prepare students for their future societal needs. The first model and subsequent models which have been developed in this regard, revolve around the belief that students must have the opportunity to inquire into their own learning. The following elements which were built into the initial project design (appendix B) facilitate this inquiry process. These elements arose through discussions with my collaborator and other teachers within the department:

1. Students should be able to assist in developing a problem statement which would focus on real or authentic questions which I or they may have about the world around them.

2. Students should have the opportunity to take part in the design of the study, its nature and depth of inquiry. The students should be provided the opportunity to tackle these questions in their own fashion.

3. The study should have a meaningful community or field study base rather than a typical classroom or textbook orientation.

4. The nature of the study should be such that there is not necessarily a right answer, but rather a best possible solution or explanation to the problem. The study should encourage in students the recognition that the asking of questions when the need arises and the answering of questions for others as an important part of science learning and understanding.

5. Any evaluation of the projects would be based on student experiences and how they were able to work through any of the difficulties that they may encounter.

6. Students should have the opportunity to work with other partners who may have different backgrounds in regards to grades, interests or courses of study.

This inquiry based project was also founded on the following four guiding questions. The purpose of these questions was to develop a common purpose and focus for any project being considered. These questions were:

1. How can we as teachers encourage in students the development of positive attitudes towards science while teaching the mandated curriculum?
2. How can science be taught in a manner which is meaningful for nearly all students?

3. How can project activities be incorporated into existing science programs and structured in order to allow for a collaborative inquiry approach to science?
4. How have my own science teaching beliefs and practices changed over time and to what do I attribute these changes?

One potential problem with this type of approach to teaching science concerns the aspect of time. How would I as a teacher find the time to introduce new topics or activities into the classroom? There is already a full curriculum to cover and for one to take a different approach requires extra planning and preparation time. I continually make decisions on whether or not the benefits of an activity match the time commitment required of that particular activity. My answer to this critical concern was founded in my belief that as teachers, we continually organize and present topics and activities which students at other levels would find enriching. I also believe that there are many students who find different parts of the curriculum exciting and challenging and would, if given an opportunity, explore the topic on their own time. My role in a scenario like this would be to provide guidance, support and encouragement. The project format would enable students at varying levels to explore topics of interest and enhance their own learning.

Another concern arose with regards to the choice of projects being offered. In order to facilitate the project and to allow for immediate student involvement it made sense to create the initial problem framework for students. As I was planning for an upcoming unit on plant development, the first project dealt with plants and how plant growth may be influenced or controlled. I already had a wealth of information and examples of studies which the students could conduct on their own. Noon hours could be used to carry out investigations and research as well as in class time if we were working on a topic which mirrored the current classroom discussions.

Early Beginnings - The First Project

The first project, "Investigations Into the Factors Affecting Plant Growth" was interesting to say the least. For efficiency (mine), a preset topic had been made available for students to become involved with. It was a novel experience for those students who took part and to a large degree served the purpose of encouraging a positive attitude towards science. The journal entries, interviews and my personal observations as recorded in chapter four attest to this statement. I believe that this particular project and the ones which arose at the same time all had a similar approach. They incorporated many of the identified elements which current literature cites in regards to planning for effective inquiry learning. However, I was having difficulty in letting go of the control which the more traditional textbook-centered and content-oriented form of teaching provided me with. By pre-selecting the topics and arranging the time for project work I had manipulated the inquiry process, blending it with my previous transmission methodology. On reflection, I believe that I was still overly concerned with accountability and whether or not the project was testable. It appears that I had built in steps which allowed me to do just that. I was still shaping the students' choices although in a much different manner. Changes would have to occur.

The Next Step - a Change in Perspective.

With time comes growth and change. This was also the case with the format for my project approach to teaching science. A research of current literature dealing with project-based inquiry partnerships and their effects on student and teacher attitudes towards science education as well as trial and error led me to my current beliefs in regards to project design and implementation. As identified in the literature review, Muir (1998) identified five generalizable objectives which can be applied to projects for the meeting of educational and scientific goals:

1. Students must be involved in projects which require them to actually do science.
2. Students will be required to reliably collect, analyze and interpret field data for others.
3. Students must have access to a wide range of activities in which to become involved in.
4. Data collected by the students will be made available to other students and the scientific community at large.
5. Partnerships with scientists will be encouraged and developed mentoring purposes as well as to develop a greater understanding of what scientists do.

These objectives as set out by Muir (1998) certainly support and reframe the views which I had personally had at the beginning of the project and had stated earlier on in this chapter. Whether I have simply followed Muir in this regard or have developed a modified plan for my personal use is a moot point. The fact is that I believe that a project design protocol may evolve out of this in the near future if it has not already done so. Muir's five objectives are now applied to the design of any student or class run project which currently is in use or being planned for. By using this objectives list as a guide, I have found that one is able to approach the topics and questions without bias and pursue collaborative enterprises with the students. The bigger picture comes into view with less emphasis on the rote memorization of facts, data or procedure.

Genesis Pond - A New Beginning

The Genesis Pond Project is the culmination of my project experiences and professional growth over the past several years. This particular project was the result of the collaboration of the science department team at Fort Richmond and the students and teachers from not only the high school but the neighboring junior high and elementary schools as well. The purpose and overall goal of the Genesis Pond project was to provide students the opportunity to be part of a project from the very beginning. This project had the advantage of having a framework which would provide us with guidance as the project progressed. The five generalizable objectives as outlined by Muir (1998) provided that framework. How the Genesis Pond Project fits those objectives will be outlined here.

1. Students must be involved in projects which require them to actually do science.

Hence, students were given the opportunity to be involved with the overall design of the project. What started out as flat prairie would soon be transformed into a prairie pond which could be used as a field station for students as they monitored the chemical and biological events which would eventually influence the life history of the pond. This early planning included the design of the pond in regards to location and size. As there was a cost to initially establish the pond, students also had the opportunity to be involved with fund-raising for the pond excavation as well as for supplies necessary for the future pond studies. A project plan was formulated by the students for the start up phase as well as the future phases as the pond evolved. Students initially choose the site for excavation based on the surrounding land features and chose a pond size which was partially determined by the grant money received as well as the partnership struck with the excavation company. This partnership involved the company name being associated with any promotional materials developed for the site. Some of the students in the initial group were responsible for the measuring and staking of the excavation site for the construction team, while others moved trees allowing for the entrance of heavy equipment to the site. All of the trees which were removed were replanted as part of the sustainable aspect of the project. Prior to the excavation of the site, students took an inventory of plant life which was present. Students would take subsequent samples following the pond excavation which would then include the physical dimensions of the pond, soil composition and analysis as well as a biological sampling of the area for plants and animals. Documentation in the form of journals, photos and a video would act for record keeping.

2. Students will be required to reliably collect, analyze and interpret field data for others.

The Genesis Pond Project design allowed students to form their own questions in regards to the evolving ecosystem as well as to collaborate with a number of partners. The collaboration aspect was and still is the most rewarding of the experiences as students are encouraged to share their questions, data and conclusions with others. On the field trip to the pond, various groups were arranged to collect specific data for further evaluation and use. All of the data recorded would be later shared with the group as a whole at school. One focus evolved around the processes and techniques use by scientists to collect reliable data. The facilitation of this process was aided by the involvement of scientists from the Freshwater Institute. Scientists had help in the initial preparation for the project by coming to Fort Richmond Collegiate and giving an overview of the protocols used for data collection as well as the types of research currently being undertaken which would feature pond studies. On the first trip to the pond these same scientists accompanied the group and assisted in the instruction of students for the various tasks. Through this connection, one aspect of the study led to the group providing data for a project which was currently ongoing at the Freshwater Institute involving Eutrophication and its Effects. The project required that the students collect specific data and water samples on a regular basis. The students then assumed the responsibility of ensuring the data was made available to the institute within 24 hours of sampling. The data collected has been used by the Freshwater Institute as they study the Eutrophication of ponds in the Red River Valley. A paper was further presented on this topic as part of an English course requirement. (see Appendix F)

3. Students must have access to a wide range of activities in which to become involved.

With Genesis Pond, the student participants divided into groups based on their personal interests. These groups became involved with a variety of studies investigating and observing soils; plant and algae species and populations; terrestrial and aquatic microorganism identification; collecting and inventorying of aquatic vertebrates and invertebrates; and the chemical analysis of both aquatic and terrestrial ecosystems.

The soil studies included several components. Students involved in this task were responsible for completing a journal documenting their experiences beginning with the trip to the sit, those experiences at the site and post site feelings. The activities which were conducted at the site included the drawing of a soil profile using measurements of depth and texture; the determination of the soil structure for the profile map as well as taking soil samples at the site for various tests such as pH and water composition.

From the samples collected, students developed the appropriate data tables. These tables and observations were made available to other interested groups or individuals. Once an e-mail list was established , students were able to share questions, data and other information with each other or myself electronically.

4. Data collected by the students will be made available to other students and the scientific community at large.

Once the data was collected, a variety of options were presented to the participants. They were:

- The data could be used by the individual or group to answer the specific questions they had raised.
- The data could be emailed to other students for use in the classroom.
- The data could be made available to the participants class in the form of formal presentations as to their particular study.

5. Partnerships with scientists will be encouraged and developed for mentoring purposes as well as to develop a greater understanding of what scientists do.

A working partnership was established with the Freshwater Institute which is home to a large number of scientists. This relationship was developed in order to allow for the availability of experts to assist students in their studies. The scientists at the Freshwater Institute possess a wide range of expertise which students could draw upon and learn from.

The Project began with a workshop featuring scientists who shared their interests and current studies at the Institute. The workshop was also an opportunity for scientists to work with the students and teachers in developing questions which the students would like to find answers for, as well as assisting in identifying the steps and the proper techniques or protocols necessary for data collecting purposes.

Scientists from the Institute made themselves available for the initial fieldtrips to the Genesis Pond site. Onsite data collecting and analysis methods were modeled for the participants and then assistance was provided to the students as they began the data collecting process. This assistance was made available for each of the areas of studies and was undertaken in a support role.

The preceding summary of the evolution of project based learning in my teaching demonstrates the importance of specific elements in the planning and presenting of the projects. My personal reflections and those of the other participants have helped me to clarify the essential framework to be used in project design and also to consider elements or details to be altered in future inquiries. The importance of having a student centered program in order to make science teaching and being a science student a meaningful experience is very clear for me as a result of the project interactions. By teaching science in a manner where student voices are not only heard but listened to and acted on has become a very powerful teaching tool. Through the involvement in projects, I have been able to develop connections with the students and the communities in which they live that will help ensure that meaningful learning occurs.

Chapter 6

Summary, Conclusions and Implications

The purpose of this case study was to examine how a project-based partnership approach to teaching science would impact on my teaching practices as well as on my students' ways of thinking and their attitudes towards science.

The study sought to examine how (1) to encourage in students the development of positive attitudes towards science using the mandated curriculum, (2) to teach science in a manner which students would find meaningful and relevant, (3) to incorporate project activities into existing science programs which would allow for a collaborative inquiry approach to science, and (4) to reflect on my own science teaching beliefs and practices as they changed over time and to determine what I think made these changes occur.

This case study documents the experiences and traces my growth as a teacher over the course of the study. It represents my reflections on the various project events and the accompanying meaning making process which I have engaged in. The personal interpretations which I have of the events, and my perceptions of the impacts that project-based learning has had on my teaching, are also addressed. Chapter 4 provides the detailed account of various projects and student/teacher interactions. My personal background is explored and my perception of a need for change in the ways in which science is presented to students is evident throughout. Grades and marks were clearly not at issue with the concerns which I have expressed. What was and still is a concern is that students are not given the opportunity to explore and discover what "real" science is and can be and what science will mean in their lives. Chapter 4 also provides a description of the various projects I have undertaken by myself and with colleagues at Fort Richmond Collegiate since my study began and the responses of my colleagues to their roles within these projects. I would hope that reading the responses which have been gathered from students participating in various projects will promote teachers' interest in looking at the roles which projects may play in their classrooms. In this way this case study may be somewhat transferable to their particular needs and teaching situation.

Chapter 5 provides for my analysis of the impact which projects have had on learners and my personal perceptions of the change of attitudes noted by participants.

Summary

My participation in the project partnerships over these past five years has provided me with a rich source of experiences for reflection. The importance of telling about these experiences is that such telling has given me the opportunity to live out the story and thus make new meaning for myself. Bateson (1989) highlights the importance of this form of storytelling in that it allows us to make meaning of our experiences. Witherell and Noddings (1991) state the importance of using our stories to make ideas concrete and accessible (p. 279) and discuss their significance in the research process:

> "...stories are a powerful research tool. They provide us with a picture of real people in real situations, struggling with real problems. They banish the indifference often generated by samples, treatments, and faceless subjects" (p. 280).

Using stories to share my research findings with colleagues has opened up new avenues of communication. Not only has my own teaching practice changed, but the interest and participation of my colleagues at Fort Richmond Collegiate has developed as a result.

I began with a single notion of using projects to enhance my own science teaching and to impact positively on students' attitudes about science. The initial project was designed to bring students together on a voluntary basis to examine a real issue - the environmental effects on plant growth. Through this project, I have come to believe that when given opportunities students will take charge of their own learning and pursue concepts or issues at a much deeper level than I anticipated. This clearly reflects the beliefs that Wells and Chang-Wells (1992) describe where students given opportunities to explore their own personal beliefs will extend their learning to a much greater level than one would normally expect or predict. I believe that the factors that contribute to this deeper learning were:

1) student ownership of the problem
2) opportunities to collaborate with peers and experts
3) use of technology to communicate with people outside the school community

My enthusiasm was fostered through this process and led me to seek other opportunities for students. Nixon (1997) described similar inspirational benefits for both teachers and students when they enter into collaborative field projects. In the Genetics Workshop, collaboration between high school and junior high students was the essential component. The high school students found the opportunity to share their knowledge and "teach" the concepts to younger students most rewarding. They stated that their own understanding was enhanced through the dialogue with the younger students. This experience was a motivational opportunity for the students participating as it helped them to understand that problem solving in the real world is not only interdisciplinary but also involves a collaborative effort. This new role for students generated a spark of excitement for all those involved that has made me step back, reassess and renew my model for teaching.

As I moved into new projects, I attempted to incorporate the key elements noted by students in each new endeavour. In planning for the Genesis Pond Project I looked at ways of: (a) giving choices to students for project investigation, (b) providing opportunities for collaboration with others, (c) involving students directly in the process of data acquisition and analysis, (d) introducing students to the authenticity or rigours of science (e) creating multi-age groupings which would foster team building, and, (f) enhancing of learning through collaboration and dialogue.

Conclusions

Throughout the study I was able to accumulate and extend my understanding of important elements to be utilized when developing: (1) project-based learning, and the (2) the research process itself.

In the development of project-based learning, Spencer, Huczek and Muir (1998) outlined five generalizable objectives in their Boreal Forest Watch Partnership which are very similar to the six key elements that I followed in the development of the Genesis Pond Project in order to best meet educational and scientific goals.

The students' journal reflections and interview responses presented several recurring themes. The students' positive attitudes were strongly evident in situations where they had to share meaning with one another, find direction for inquiry and create solutions to problems. The active nature of project-based learning facilitates such action in these situations and enhances students' motivation and enthusiasm. I believe that by students taking ownership of their own learning provided clarity and a sense of what opportunities science could offer them in the future. The key elements which I have incorporated into the projects reflect a learning and decision-making process which empowers the students and helps to prepare them for their future endeavours (Villa, 1991).

These conclusions have strengthened my resolve that project-based learning is a powerful tool for engaging students in meaningful pursuits. In order to prepare for future project opportunities, I will be guided by the following objectives: (1) students must be involved in projects which require active participation, (2) students need to collect, analyze and interpret actual field data, (3) students must have a wide range of activities from which to choose, (4) students must have opportunities to share with others, and (5) partnerships with "experts" will be encouraged and developed.

In developing the proposal for the Genomic Center for Cancer Research, I have taken care to ensure that all my students will have an opportunity to play a role in a project. This role will certainly vary for each student, for some it may mean only an introduction to the project concept but all will have an opportunity to explore and gain a sense of what science will mean to them in their personal futures. This inclusive design is a result of my firm conviction about the importance of integrating projects into classroom studies in order to enhance student learning. These curriculum based projects will allow the students involved to elaborate and extend the curriculum document outcomes in ways that cannot be provided for in classroom based instruction.

My own teaching has changed as a result of my involvement with project-based partnerships in my courses over the past five years. The lenses and frames through which I now see science learning occurring have been changed through these enjoyable experiences. My "reflection-in-action" led me to reframe and to understand that the transmission model was not the best way to enhance student learning. It is interesting to know that when I began my teaching career in September 1974, Barnes and Shemilt (1974) in a study of teachers' views of learning found their views to be closely linked to their subject of instruction. The measures indicated that teachers' tacit pictures of learning ranged from constructivism at one extreme to transmission of information on the other. The two extremes were called "interpretive" and "transmission" views. The findings were that teachers of technical subjects such as science were predominantly clustered at the "transmission" end of the continuum. My transformation from a "transmission trained" teacher to one that views learning as "interpretive" has taken a significant period of my teaching career and is a result of my direct involvement in project-based partnerships and the way I now view science education and learning. Barnes (1992) concurs that such a transformation process is critical if changes in teaching are to take place.

> "... teaching can change only when teachers' frames change, and these are in turn dependent on 'subtle and sensitive' changes in schools that will not be easily achieved." (Barnes in Munby & Russell, 1992, p4)

The members of the science department at Fort Richmond Collegiate are more aware of the "interpretive" view of science teaching and learning through our project collaboration and ongoing dialogue with one another. The more opportunities the department members have to share in these forms of student experiences will undoubtedly support them in their thinking and reframing about science teaching and learning.

In my own case, there has been an unexpected benefit due to the time which I have committed to exploring and changing my teaching practices and beliefs. My image as a teacher has changed to the extent that I believe I am more capable of representing project based learning strategies, I have a greater interest in pursuing the development of these strategies and I have greater confidence owing to my new understandings of the overall process. This change in practice and the associated professional growth has provided me with opportunities which otherwise would not have happened. I believe that my ongoing involvement in developing my understanding of how project-based learning impacts on student attitudes towards science has led me to pursue involvement in projects beyond the school level and, hopefully, I have had an impact on other secondary science teachers' ways of thinking. For the upcoming school year, I am involved in developing curriculum dealing with project-based partnerships at the school division level, provincial level for the Manitoba Teachers Society and Manitoba Education and Training, as well as at the international level for the Canadian Teachers' Federation (in coordination with the India Secondary School Teachers' Federation).

In the development of a research process there may be shortcomings in the design and/or methodology. As a narrative inquiry this particular study could have taken many different forms. What would I have done differently in the collection and treatment of the data if given the opportunity to repeat the study? In retrospect, it would have been easier for me to organize the three different case studies into collections of stories each with their own implications and personal understandings or meaning making. A comparison of this accumulation of "stories" would have helped me to more clearly see the developing trends and personal growth which unfolds.

A difficulty could also arise with management of the number of projects presented and the volume of data to be interpreted. I realize that this is a direct result of conducting a majority of the writing at the beginning and near the end of the process rather than keeping a running story line. Keeping the writing process current would have definitely assisted me in the management of the projects and associated data.

At the beginning of my planning for this thesis, I had not envisioned that five years would have been required to complete the study. However, if less than adequate time would have been taken, it would have been difficult to analyze my own professional growth and change in beliefs about teaching practice. My advice to someone planning a study of this nature is to allow for ample time to try out, to reflect on and to change one's current practice. Planning this over two or three years is certainly not out of the question. In my particular case, the five year period was a benefit as it allowed for the ongoing development of my own personal beliefs and teaching practices and actually enhanced the reflective process. The extended time frame allowed for my particular interpretation of specific projects, leading to a transformation in my teaching practice. How students perceive science and the need for portraying science in an authentic manner in order to encourage students to pursue studies in science fields, are ideas of greater importance to me now.

Implications

The interpretations I have made throughout the study suggests implications for teachers, for schools and for curriculum development and implementation. For teachers, the development and use of project-based learning opportunities can help to motivate students and enhance their learning. Teachers must continually reflect on their own practice and strive to develop authentic science learning opportunities which promote student collaboration and empowerment. These learning opportunities must provide possibilities for a diverse student population and, therefore, must be multi-faceted in nature.

For schools, teachers must be provided with the time and opportunities to reflect personally on their teaching, to dialogue with colleagues, and to make necessary connections for project partnerships and other meaningful learning opportunities. Administrators must recognize that implementing curriculum changes in science is a process that must be nurtured and supported for significant periods of time. Time often becomes a limiting factor in the development of project-based partnerships. When science teachers make the commitment to work as a team, time restraints can be decreased through the sharing of the various tasks involved in forming partnerships and accessing new resources for field projects.

There are also implications for Manitoba Education and Training and the committees involved in curriculum development and implementation. Curriculum opportunities for field studies should be expanded to include all grade levels and all scientific disciplines. Presently, Manitoba Education and Training curricula provide time for field studies in the area of Biology 40S, specifically Ecology, but do not provide similar opportunities for chemistry, physics and earth-space sciences.

The development of authentic science experiences requires the involvement of all the stakeholders and must be recognized as the responsibility of collaborative cultures consisting of science teachers, school and divisional administrators, Manitoba Education and Training and the scientific community at large.

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APPENDIX A

According to the National Science Teachers Association (1990), the scientifically and technologically literate person:

- uses concepts of science and of technology as well as an informed reflection of ethical values in solving everyday problems and making responsible decisions in everyday life, including work and leisure.
- engages in responsible personal and civic actions after weighing the possible consequences of alternative options
- defends decisions and actions using rational arguments based on evidence
- engages in science and technology for the excitement and the explanations they provide
- displays curiosity about and appreciation of the natural and human-made world
- applies skepticism, careful methods, logical reasoning, and creativity in investigating the observable universe
- values scientific research and technological problem solving
- locates, collects, analyzes, and evaluates sources of scientific and technological information and uses these sources in solving problems, making decisions, and taking actions
- distinguishes between scientific and technological evidence and personal opinion and between reliable and unreliable information
- remains open to new evidence and the tentativeness of scientific/technological knowledge
- recognizes that science and technology are human endeavors

- weighs the benefits and burdens of scientific and technological development
- recognizes the strengths and limitations of science and technology for advancing human welfare
- analyzes interactions among science, technology, and society
- connects science and technology to other human endeavors, i.e.. history, mathematics, the arts, and the humanities
- considers the political, economic, moral, and ethical aspects of science and technology as they relate to personal and global issues
- offers explanations of natural phenomena which may be tested for validity

APPENDIX B

PROPOSAL FOR FUTURE DIRECTIONS OF SCIENCE ENRICHMENT IN FORT GARRY SCHOOLS

MENTORSHIP IN SCIENCE

PROGRAM OVERVIEW

MENTORSHIP IN SCIENCE

1. STATEMENT OF PURPOSE

To provide opportunities for students in Fort Garry Schools to experience science activities and research in a collaborative , co-operative , multi-level environment within their regular course of science studies .

2. RATIONAL

Wherever possible enrichment should be incorporated within the regular course of studies and should not create an additional burden on the students .

A co-operative program would allow students to discover that science is an interaction between themselves , technology , and their environment . Students need to be aware that science is part of the real world around them.

By utilizing mentors with experience at different levels and in different fields of science , students can be exposed to positive and stimulating role models . As well , it provides opportunities for the students to act as role models themselves .

We should provide opportunities for students to discover that science as much as anything lies in affective areas such as curiosity , persistence , in that these qualities already exist within themselves .

Students need to form intelligent opinions regarding co-operation between all levels of education , industry , commerce , and the community at large so that society can better address the current global environmental concerns that threaten the existence of many life forms on the earth .

Current technology shows us the way of the future and students need to be involved with current and future trends of information gathering and sharing through telecommunications . Students need to be involved in real applications of this technology on a continuous basis

3. TARGET GROUPS

Phase I	**Junior** and **senior high school students** .
Phase II	Addition of **university students** .
Phase III	Addition of **elementary students** and **university staff.**
Phase IV	Addition of **industry , commerce , and community .**

4. TIMELINE - September 12 1992

	Fall 1992 *Phase I*	Spring 1993 *Phase II*	Fall 1993 *Phase III*	Fall 1994 *Phase IV*
			Elementary———>	——>
	Junior High School ———	———	———	——>
	Senior High School———	———	———	——>
		University Students ———	———	——>
			University Staff———	——>
				Industry
	Commerce			
	Community			
Projected Student Numbers	**4**	**4 + 16**	**20 + 32**	**?**

TIMELINE AMENDMENT - September 19 1992

Fall 1992 | Spring 1993 | Fall 1993 | Fall 1994

Phase I | | | *Phase II*

Elementary-->

Junior High School -->

Senior High School-->

University Students -->

University Staff-->

Industry

Commerce

Community

	Current			
	Sept 19	Sept 28	Projected	
Student Numbers	**5**	**13**	**52**	**?**

5. MODELS

Phase I
Phase II

MODEL: PHASE 1
FALL 1992

FORT RICHMOND STUDENTS

BIOLOGY 300

TOPIC -PLANT DEVELOPMENT

RELATED TOPIC
EFFECT OF GROWTH STIMULANTS ON PLANT DEVELOPMENT

COOPERATIVE ACTIVITY 1 AT FRC
To research through experimentation the effects of varying amounts of artificial fertilizer on plant growth and development

ACTIVITY 2
AT A. A. LEACH
To research through experimentation the effect of varying amounts of acid on the growth of plants .

* Possible cooperative outgrowth extension activities

ARTHUR A. LEACH STUDENTS

GRADE NINE

TOPIC: CHEMICAL INTERACTIONS

RELATED TOPIC
EFFECT OF SPECIFIC CHEMICAL POLLUTANTS ON THE ENVIRONMENT

* POSSIBLE EXTENSIONS

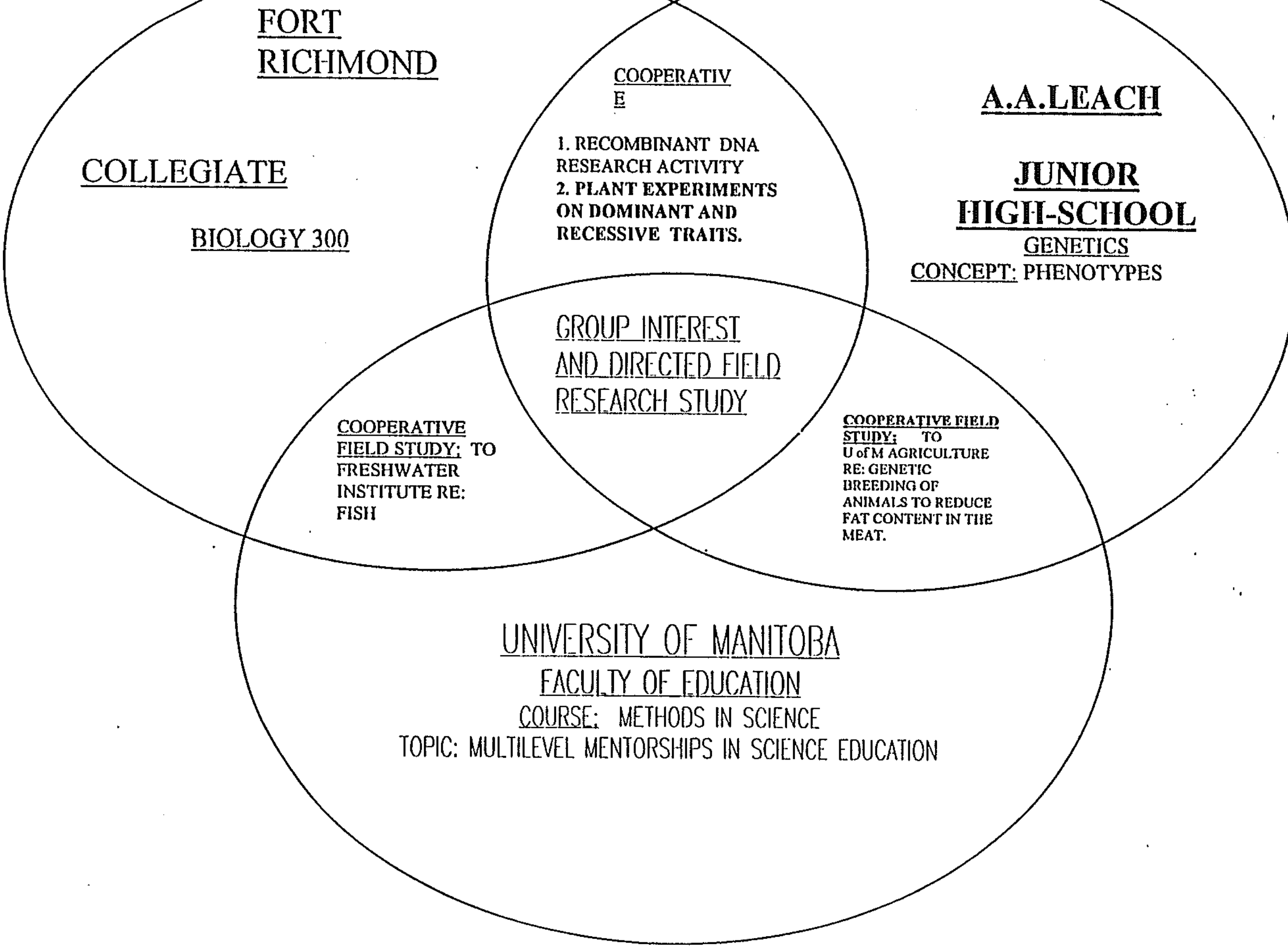
Vary plant typus.

Vary pollutants

Effect of fertilizer on non-target organisims.

Vary light or

MODEL: PHASE 2
SPRING 1993



6. DYNAMICS AND MOVEMENT

Generate co-operative studies between students at different levels via physical meetings at the host schools .

Topics to be based on curriculum activities but extended to the level of student interest and incorporated within the program .

Students are required to be responsible for a journal , log , video / audio presentation , multimedia presentation or a formal lab report.

Meeting time between students at various levels must remain flexible and be at the discretion of the staff involved . This at times could require the co-operation of other subject staff .

Possibility of the need to involve other school personnel and parents to transport and monitor students while engaged in some activities away from their home school .

Funding . Few dollars would be required in Phase I and II . Perhaps only for experimental supplies and transportation . We would anticipate that as the project grows to involve a greater number of students and staff , there will be a requirement for some funding for student projects , telecommunications and technological purchases. Costs will obviously be reflected by the degree of the success of the program.

7. PROCEDURE PHASE I

We propose , as the phase I model indicates , to begin the project with co-operation between two schools , using two Gr. 9 science students from A.A.Leach Junior High (AAL) and two Gr. 12 Biology 300 students from Fort Richmond Collegiate (FRC) .

Initially the two Bio 300 students will host the Gr. 9 students at their school and sit in with their **mentors** taking part in the design of an experimental investigation into the effects of varying amounts of fertilizer on the growth and development of mustard seed (a widely grown agricultural crop in Manitoba) . This investigation dovetails with the

Bio 300 curriculum relating to plant development . During this period of time , using the Bio 300 experiment as a base , the Gr. 12 students would help the Gr. 9 students to design a parallel research activity that would be conducted at A.A.Leach.

This initial contact leads to the sharing of ideas on scientific procedure and experimental design . The Bio 300 students would continue to monitor their own activity , collecting , tabulating and recording their data . At specific times they would invite the Gr. 9 students to Fort Richmond Collegiate to discuss the progress of their activity and to observe the stage of development of their research activity .

The AAL students would host the FRC mentors at their school and have them help set up the research activity that they would have cooperatively designed and presented for approval . This activity will run as parallel research to the FRC activity , using the same variety of plant to see what affect varying amounts of chemical pollutants would have on the growth and development of the plants . This fits as an extension to the Gr. 9 Chemical Interactions topic related to chemical pollutants-Acid Rain .

The AAL / FRC students will be mentors for the students in their class and help other students to construct their own research activities . The AAL students will be responsible for monitoring their activity , collecting data , and inviting the FRC students to share ideas and discuss the stage of development the activity .

Both groups of students will come together at the end of the project to share and compare their data . At this point they will have the opportunity to discuss and evaluate the whole project and to suggest possible extensions to their activities that they might like to continue with further research . eg. A combined pollution / fertilizer activity .

8. EVALUATION

An evaluation model would need to be developed to measure attitudinal changes the students have toward science and its place in society . Two major components of such a model would include :

a. Student viewpoints toward science .
b. Staff viewpoint of changes in student attitudes toward science.

9. AREAS OF CONCERN

A. Some disruption in the regular program with the advantages outweighing the disadvantages .

B. Transportation of students to and from host sites.

C. Timing of the visits due to students at FRC being on the semester system.

D. Lack of facility at AAL to easily carry out plant growth.

E. A need for training of staff and students in the use of a telecommunications system.

F. Meeting time for staff involved in the project to plan , monitor , evaluate , and coordinate the overall direction of the project.

10. SUGGESTED SOLUTIONS

A. Reasonable substitution to be allowed for project time in exchange for regular class work . Project should be related to topics being studied .

B. Extension of the existing data telephone line from the Vice Principals office at
/ AAL into the computer lab , science lab , and library . Generate the MINET
C. telecommunications systems at AAL , Bonnycastle , Dalhousie and FRC . This will allow the students of the schools to exchange data , queries , and proposals on a daily basis and or as frequently as needed . This will eliminate some of the need for students to visit other facilities as often , hence lowering the reliance on others to transport students.

D. A share arrangement between the two schools has resulted in the loan of a plant growth table to AAL for the duration of the project . A work order has been drafted the addition of a permanent plant chamber for future use at AAL .

E. has offered to see that a telecommunications link is activated
between the schools and will inservice the staff and students involved in the

operation of the MINET system.

F. Future consideration for release time as the project expands.

11. VISION - September 12 1992

Phase I is a trial of the project and if successful will lead to phase II , III , and IV . If we move to Phase III The project would involve approximately 52 students and 8 - 10 staff members in 5 different facilities.

We intend to slowly expand the network of staff to include all those teachers interested in being part of the program .

We intend to actively pursue the inclusion of various faculties at the university , local industry , and manufacturing.

It is most likely that we will have to fine tune as we progress , but we see this as a project with foresight and one which will generate excitement and growth for the students involved .

APPENDIX C

MINET
AND
TELECOMMUNICATIONS
MANUAL

MENTORSHIP

FGSD #5

IN SCIENCE

Developed and written by

Bob Adamson
and
Neil Hansen

Fort Garry School Division

APPENDIX D

SECTION B PROJECT PROPOSAL

1. PROJECT DESCRIPTION

THE GENESIS POND PROJECT (GPP) IS AN INITIATIVE OF THE SCIENCE DEPT. OF FORT RICHMOND COLLEGIATE IN THE FORT GARRY SCHOOL DIVISION IN WINNIPEG, MANITOBA. WHAT BEGAN AS INFORMAL "TABLE TALK" HAS EVOLVED INTO THE PROPOSAL THAT FOLLOWS. WE WILL BEGIN WITH A GENERAL DESCRIPTION OF THE PROJECT ITSELF AND THEN HIGHLIGHT THE SPECIFIC OBJECTIVES THEREOF (SEE TABLE 1 FOR THE PROJECT SUMMARY AND TIMELINE).

GENERAL DESCRIPTION

THE GPP INVOLVES THE ESTABLISHMENT OF A NEW PRAIRIE POND ECOSYSTEM. WE PROPOSE TO EXCAVATE A POND IN A NEARBY PRAIRIE ENVIRONMENT IN THE FALL OF THE CURRENT YEAR (1996). THE PROPOSED LOCATION (APPENDIX 1) WOULD ALLOW FOR QUICK CHARGING (FILLING) DURING THE SPRING (1997) MELT. A FULL GENESIS POND WILL REPRESENT THE START OF A SERIES OF ONGOING BIOLOGICAL AND PHYSICAL ASSESSMENTS. THESE WOULD BEGIN IN MAY OF 1997 WITH AN INITIAL ASSESSMENT OF WATER QUALITY (CLARITY,DISSOLVED ORGANICS PH, DISSOLVED OXYGEN ETC) WATER QUANTITY AND A BIOLOGICAL SPECIES ASSESSMENT OF FLAURA AND FAUNA FOUND WITHIN AND AROUND ITS MARGINS. THIS WOULD COMPLETE THE WORK FOR THE SCHOOL YEAR OF 1996/97.

BEGINNING IN THE FALL OF 1997, STUDENTS WILL CONTINUE TO DO WATER QUALITY, WATER QUANTITY AND BIOLOGICAL SPECIES INVENTORIES AT A PACE OF TWO PER YEAR-ONE IN THE FALL AND ANOTHER IN SPRING. THIS WILL CONTINUE UNTIL THE FALL OF THE YEAR 2000 WHEN A SUMMARY REPORT WILL BE DONE.

AT THIS POINT WE WILL BE ABLE TO ASSESS THE NATURE AND PACE OF THE SUCCESSION FROM A "STERILE " EXCAVATION TO AN EARLY-STAGE PRAIRIE-POND AQUATIC ECOSYSTEM. WE WILL ALSO, AT THIS POINT, MAKE DECISIONS ABOUT THE NATURE OF FUTURE FOLLOW -UP WORK THAT STUDENTS MAY INITIATE AND CARRY OUT.

PROJECT OBJECTIVES AND BENEFITS

WE HAVE COMBINED OBJECTIVES WITH BENEFITS SINCE THERE IS CONSIDERABLE OVERLAP BETWEEN THE TWO. STUDENTS WILL;

1. BECOME SIGNIFICANTLY INVOLVED IN ECOLOGICAL/ENVIR. CONCERNS. (HOPEFULLY THEY WILL BECOME PASSIONATE ABOUT IT!)

2. GAIN EXPERIENCE AND SKILLS RELATED TO ENVIRONMENTAL ASSESSMENT.

3. DEVELOP WILDLIFE HABITAT FOR WATERFOWL, WADING AND NESTING BIRDS, MINNOW SPECIES, AQUATIC INSECTS AND COUNTLESS OTHER ORGANISMS WHO WILL LIVE AND /OR INTERACT WITHIN THE POND AND ITS MARGINS.

4. BE INVOLVED IN SETTING UP A COMPUTER -BASED PROJECT RECORD AND REPORTING SYSTEM.

5. BE RESPONSIBLE FOR ESTABLISHING A GENESIS POND PROJECT HOME PAGE ON THE INTERNET IN ORDER TO MAKE THE PROJECT AND ITS FINDINGS KNOWN.

6. PUBLISH REPORTS REGARDING THE COLLECTED DATA AND THE ANALYSIS OF IT.

7. TAKE RESPONSIBILITY FOR DESIGNING, IMPLEMENTING AND FOLLOWING UP ON VARIOUS FIELD AND CLASSROOM STUDIES.

8. BECOME PROFICIENT AT USING PORTABLE COMPUTER INTERFACES, MEASUREMENT PROBES AND ASSOCIATED SOFTWARE DESIGNED FOR ENVIRONMENTAL FIELD STUDIES.

9. PRODUCE A SUMMARY REPORT WITH A FULL ANALYSIS OF THE GENESIS POND PROJECT TO DATE INCLUDING CONCLUSIONS AND RECOMMENDATIONS FOR FURTHER STUDIES.

TABLE 1 PROJECT SUMMARY AND TIMELINE

STAGE #	STAGE DETAIL	TIMELINE
I	PREPARATION -POND SPECIFICATIONS -EXCAV. CONTRACTING -SITE PREP. -SCHEDULING	SUMMER/FALL 1996
II	GENESIS POND EXCAVATION -EXCAVATION/FILL REMOVAL -SITE RESTORATION	FALL 1996
III	GENESIS POND DRY MEASUREMENT -ACTUAL DIMENSIONS -BOTTOM SOIL ANALYSIS -LOCAL DRAINAGE ANALYSIS	FALL 1996
IV	GENESIS POND CHARGING (FILLING) -CHARGE RATE MEASURES -WATER QUALITY (CHARGE)	SPRING 1997
V	GENESIS POND TIME ZERO ASSESS. -INITIAL WATER QUALITY, QUANTITY AND BIOLOGICAL ASSESS. -COMPUTER RECORD SYSTEM SET-UP	SPRING 1997
VI	GENESIS POND-INITIAL FALL ASSESS. -AS PER V -INTERNET HOME PAGE	FALL 1997
VII	GENESIS POND-BIANNUAL ASSESS. -TWICE ANNUALLY AS PER VI	SPRING/FALL 1998-2000
VIII	GENESIS POND 2000! -FOUR YEAR SUMMARY REPORT AND RECOMMENDATIONS	FALL 2000

GENESIS POND - AN ECOSYSTEM CASE STUDY

Genesis Pond - September 30/97

Each day you are asked to complete the following tasks for yourselves, your teachers and for Mr. Adamson at FRC.

1. Complete a detailed entry of your noon hour activities. Include:

- What are you anticipating/ looking forward to about today?

- What tasks you complete at the pond site; include all details including the conditions such as weather, chemical analysis data, biological specimens (vertebrates) including a description and drawing.

- What do you believe that you learned?

- What are you looking forward to on your next visit?

2. Send a participant an Email message telling them briefly some of your experiences and specifically any questions that you may have.

ASK A QUESTION?

For this visit you may send Mr. Adamson a response at:

@

TASKS FOR GROUPS

1. Water Sampling	**- Collect samples for both the new and old ponds on the site.** **- these samples are from the surface/mid and bottom levels** **- take temperatures from these levels and record** **- samples will be used by the pH and Oxygen groups**
2. pH tests	**- when the water sampling group has returned with their samples obtain a test tube sample for pH tests (strips and meter)** **- record results**
3. Oxygen tests	**- when the water sampling group has returned with their samples obtain a collecting bottle with a sample from each level.** **- perform oxygen tests to determine levels**
4. Vertebrate group	**- sweep both the new and old pond sites. (3) times new (2) times old** **- place samples in trays and describe/draw/count relative numbers**

DATE: September 30/97

TO: All participants

RE: Genesis Pond Project

The following working teams have been established for today's event. If I have spelled your names incorrectly please advise me for my records.

TEAMS:

Water Sampling/temperature

Chemistry/ pH

Chemistry/ Oxygen

Vertebrates

Plants/ quadrat study - demo

These teams will be rotated for our next visit so you will have opportunities to test for a variety of factors.

*** AS PART OF THE PROJECT YOU ARE TO EMAIL A QUESTION TO A PARTNER -**

FOR NOW SEND ME A MESSAGE AT:

@

GENESIS POND - QUADRAT STUDY @ DALHOUSIE FOREST

Genesis Pond - October 7. 1997

Each day you are asked to complete the following tasks for yourselves, your teachers and for Mr. Adamson at FRC.

1. Complete a detailed entry of your noon hour activities. Include:

- **What are you anticipating/ looking forward to about today?**
- **What tasks you complete at the forest site; include all details including the conditions such as weather, chemical analysis data, biological specimens (plant clippings) including a description and drawing.**
- **What do you believe that you learned?**
- **What are you looking forward to on your next visit?**

2. Send a participant an Email message telling them briefly some of your experiences and specifically any questions that you may have.

ASK A QUESTION?

For this visit you may send Mr. Adamson a response at:

@

TASKS FOR GROUPS

1. Oxygen tests	**- using the water samples provided, perform an oxygen test to determine the oxygen level.**
2. Quadrat study	**- using the handouts as a guide, complete the quadrat study for the designated map area.**
	- complete Activity 1: Plant Drawings from the plant cover within your quadrat.
3. Journal writing	**- complete Activity 2: Journal Writing for today's experiences**

GENESIS POND - ENVIRONMENTAL FIELD STUDIES

Plant Drawings, Scientific Observations, Sense Surveys and Journal Writing

Abstract:

The activities which we are about to engage in are designed to encourage students to develop personal connections to nature. They will encourage you to: 1) identify scientific (ecological) observations about specific habitats / ecosystems; 2) focus on the details of nature and the power of being a good observer (scientist); 3) gather information using four of our five senses (taste excluded); and 4) to express ourselves creatively and create a permanent record of our activities, feelings and experiences.

ACTIVITY 1: Plant Drawings

Purpose:

To encourage students to develop keen observation skills. To develop and use artistic skills in science learning.

Plant Drawing Guidelines:

- draw in detail one or two leaves including leaf shape, margin, tip, base and venation pattern, and show the attachment to the stem

- identify plant by both the scientific and common name

- describe the location of the plant (wet, dry intermediate, disturbed area, slope, light conditions etc.)

- describe the habitat of the plant (vine, schrub, tree, etc.)

- identify unique characteristics to help remember each plant (smell, color, fruit, etc.)

Evaluation:

Students are required to draw a minimum of 10 plants.

ACTIVITY 2: **Journal Writings**

Purpose:

- **to encourage students to express themselves creatively**
- **to give students an opportunity to create a permanent record of their activities, feelings and experiences.**
- **to encourage students to identify personal connections to nature.**

Activity:
Types of entries include but are not limited to:

- **personal impressions of activities**
- **self evaluations**
- **quote, poem, pictorial interpretation**
- **current issue evaluations and responses**
- **completion of "Thinking Logs" (i.e. What I will remember most about today is............), I still do not understand ....!**

GENESIS POND PROJECT

Wednesday October 23
Day 2: Dry Pond Analysis

To refresh your memories. For those students who were involved in the day one activities this is what was accomplished:

- **site analysis**
- **pond measurements and staking**
- **site preparation**
  - **i) removal of trees for equipment access**
  - **ii) preparing for "fill" to be disposed in a controlled manner**
- **filming and interviews**
  - **i) video**
  - **ii) snapshots/slides**

For today's activities I would like you to complete the following tasks:

- **find a student from Fort Richmond Collegiate who has an e-mail address.**
- **complete a journal documenting your experiences beginning with the trip to the site, site experiences and post site feelings.**
- **Draw a soil profile using measurements of depth and texture**
  (see handout on soil profiles for reference)
- **determine soil structure for the profile map you draw**
  (see handout on soil structure for reference)
- **take soil samples from the different levels in the pond**
  (use plastic bags - label as to their profile location
  - record your name and date)
- **read over the example activities which may be conducted with soil samples.**
  - **i) Separation of Soil Components**
  - **ii) Particle Size**
  - **iii) Hand Texturing Tests**
  - **iv) How do Soils Differ**
  - **v) The pH of a Soil**

Instructors:

Mr. Bob Adamson
Mr. Darryl Wiebe
Mrs. Catherine Birch

GENESIS POND - AN ECOSYSTEM CASE STUDY

Genesis Pond - October 21, 1997

Each day you are asked to complete the following tasks for yourselves, your teachers and for Mr. Adamson at FRC.

1. Complete a detailed entry of your noon hour activities. Include:
- **What are you anticipating/ looking forward to about today?**
- **What tasks you complete at the pond site; include all details including the conditions such as weather, chemical analysis data, biological specimens (vertebrates) including a description and drawing.**
- **What do you believe that you learned?**
- **What are you looking forward to on your next visit?**

2. Send a participant an Email message telling them briefly some of your experiences and specifically any questions that you may have.

ASK A QUESTION?

For this visit you may send Mr. Adamson a response at:

@

APPENDIX E

Re: Genomic Center for Cancer Research Partnership

The enclosed proposal was developed as a planning and budgeting document and as a road-map for the project start-up. In January 1999, the project was informed that the Division would support the project as requested; with $4000.00 being made available for the Planning Phase as well as Phase I and Phase II of the project and a further $9200.00 being made available for Phase III. Based on the original proposal and the Fort Garry School Divisions approval of funding support, it is time to put the projects action plan to work.

1. Vision, Goals and Objectives

2. Project Model
A model for this program would include:

A) Development of a generalized cancer biology program for all grade 10 students enrolled in Science 20S. This program would support and enhance the topics of Cells and Cancer which form a third of the core curriculum guidelines. The subtopics of this program include:

a) Mechanisms of cancer development
b) Genetics of cancer
c) Advances in cancer diagnosis
d) Basic principals of treatment
e) Future for cancer research

In collaboration with both VMC and FRC the project coordinator would facilitate the development of a curriculum document which would support the current Science 20S Transitional Curriculum document. This document would be designed around the curriculum outcomes, both general and specific as stated in the Pan Canadian Frameworks document. This particular section of the model would include the following components:

- prepared student notes with an accompanying teacher guide
- power point presentation covering the listed subtopics
- slide presentation to support written materials
- photographs, diagrams and charts to support written documents

- appropriate student lab activities to support the subtopics
- establishing an Internet activity site to support the stated outcomes per the Pan Canadian Frameworks document
- coordinate a visiting lecture series involving researchers from the Genomic Center visiting each of the two high schools in both the first and second semesters.

B) Specialized biology program aimed at all students enrolled in the Biology 40S program. This program would provide students with information regarding current advances, research results and technology.

In collaboration with both VMC and FRC the project coordinator would facilitate the development of a curriculum document which would support the current Biology 40S Transitional Curriculum Document. This written document would also be designed around the stated Curriculum outcomes, both General and Specific as stated in the Pan Canadian Frameworks Document for Biology 40S. This particular section of the model would include the following components:

a) Review of the basics
b) Study of the most common cancers (breast, colon, lung, prostate, skin):
   ---> initiation, progression, diagnosis, treatment
   ---> cell cycle control, tumor suppresser genes, susceptibility genes, the inheritance of "cancer genes".
c) Chromosomes and cancer
d) The future of diagnosis and therapies
e) A one day visit to the hospital (class or specific group)
f) Design of papers and grants

This particular section of the model would include the following components developed between VMC and FRC with the support of the project coordinator:

- prepared student notes with an accompanying teacher guide
- power point presentation covering the listed subtopics
- slide presentation to support written materials
- photographs, diagrams and charts to support written documents

- appropriate student lab activities to support the subtopics
- establishing an Internet activity site to support the stated outcomes per the Pan Canadian Frameworks document
- coordinate a visiting lecture series involving researchers from the Genomic Center visiting each of the two high schools in both the first and second semesters.
- identification of appropriate research topics which students from both high schools may use for grant purposes.

C) Projects for outstanding students would be available to all students with an appropriate background. These small group/individual experiences would be a tremendous enrichment and educational opportunity for students who qualify.

---> critical analysis of published literature

a) Clinical and research experience
b) Exposure to new and innovative technology
c) Scientific projects that may include:
   ---> laboratory work together with a teacher
   ---> data base and image analysis
   ---> animal work
   ---> follow up of patients from work
   ---> write up of the project in the form of a mini-paper

This particular aspect of the program will be open to a limited number of students in year one of the project. Once a coordinator has been hired, the science department heads from both VMC and FRC in collaboration with the coordinator will establish protocol process for student application and selection.

D) Exchange programs with Forum 21 and the German School Board for Cologne, Germany.

Forum 21 is presently a component of a sister project currently offered in German schools. Once a coordinator has been hired, they will begin to inquire into what has to be put into place such that in the future, students from both Canada and Germany may be involved in a collaborative global educational project and for the arranging of future student and teacher exchanges.

APPENDIX F

Eutrophication and Its Affects on The Genesis Pond Project

Prepared for:

Prepared by:

January 9, 1998

Summary

"Eutrophication, the effects of nitrogen and phosphorous, is perhaps the most important issue affecting water quality in the [Canadian praries]," (Wood, 1997). It is a complicated process but it is a treatable problem. Eutrophication can be caused by both natural means and by human pollution. There are several ways to treat the results of eutrophication but it is preferable to treat the cause. The effects of eutrophication can be studied at the Genesis Ponds. Fort Richmond Collegiate began the Genesis Pond Project to study the life cycle of a pond. It has been affected by eutrophication. Although it is possible to treat the problem of eutrophication in the Genesis Ponds, it would be wise to leave the ponds alone and study their development.

Contents

Appendices

Introduction

Eutrophication is a common problem in the Canadian prairies which was first noticed during the 1900's (McGowan, 1996). "Eutrophication in the prairies results primarily from excessive inputs of phosphorus [and nitrogen] to water bodies," (Wood, 1997). As nutrient concentrations increase, algal growth increases and thick algal blooms grow on the water surface. When algal biomass increases, oxygen can not be re-dissolved into the water and animals begin to die. This provides an ample source of nutrients for the bacteria of decay, and oxygen levels are further decreased. Eventually, oxygen levels become too low for the bacteria of decay to function, and a thick layer of mud collects at the bottom of the lake or pond causing the water body to fill up. Eutrophication is a treatable problem; however, it is preferable to treat the cause of eutrophication rather than the result. The Genesis Pond project has been greatly affected by eutrophication and our results will be discussed further in the paper.

financially feasible alternative to dumping sewage. Wetland creation is widespread but it is estimated that another 120,000 ha of wetland may be created in this way (Wood, 1997). Wetland creation is an extremely beneficial and cost effective way of reducing the number of eutrophic water bodies in the Canadian prairies. (Wood, 1997)

The Eutrophication of the Genesis Ponds

The Genesis Ponds are two small ponds located 5 kilometers south of Winnipeg on provincial road 247 (See Figure 1) which have been affected by eutrophication. The ponds are referred to as the old and new ponds. The old pond is 8 years old and has considerable macrophyte growth. The new pond was dug out in the fall of 1996. Both ponds were covered by the flood of 1997 and have become excellent study grounds for the issue of eutrophication. The Genesis Pond project was originally designed to study the development of a new pond but, because of the flood, the project was changed to study the different results of flooding on the two different ponds. (Genesis, 1997)

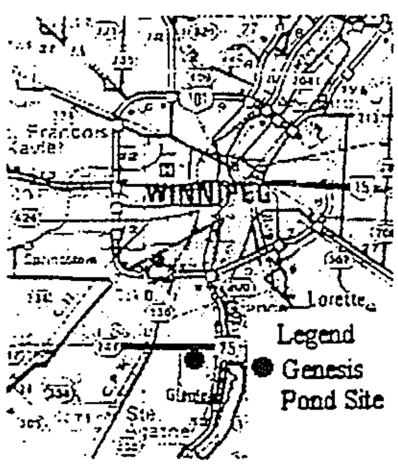


Figure 1: Location of the Genesis Ponds (Manitoba, 1994-1995)

Indications of Eutrophication

Several signs indicate that the Genesis Ponds have become eutrophic. When testing several water samples at the Freshwater Institute, we found that phosphorous and nitrogen loads in both ponds were extremely high. Nutrient loads for the new and old ponds are provided in Appendices A and B respectively. This would provide a source of nutrients for algae and macrophytes and would be an excellent starting point for eutrophication. There are also high levels of suspended chlorophyll A in the ponds. Chlorophyll A is a chemical found in most aquatic plants. The presence of this chemical in such large amounts indicates that there is a large macrophyte and/or algal biomass in both ponds. During the testing of the ponds, we noticed a foul odor and taste in the water at both ponds. At the Freshwater Institute we were told that these were due to the presence of sulfide. Both the odor and taste, and the presence of sulfide indicate that the ponds have reached the eutrophic state. Now that we know that the ponds are in a eutrophic state, determining the source of the problem would help in determining a solution. (Genesis, 1997).

Probable Causes of Eutrophication

There are several probable causes of the eutrophication of the Genesis Ponds. The major cause of the problem was the flooding of the area. Runoff water from farm land and the increasing use of the Red river as a dumping sight for Winnipeg's sewage has caused the phosphorous and nitrogen loads of the Red River to become very high. Although nutrient loads are high the river has not become eutrophic because of the fast water flow. When this water covered the pond site, it filled both ponds flushing out any water which was originally in the ponds. In the ponds the water is not flowing and the nutrient levels remain high. This has allowed algae to flourish causing the ponds to become eutrophic. Because the ponds are not moving, the freshly aerated water on the surface of the ponds is not reaching the bottom. This has caused the oxygen levels at the bottom of the ponds to drop. In these low oxygen conditions, phosphorous can be released from the soil into the water, further increasing the phosphorous load. The river water also introduced several small fish into the Genesis Ponds. These fish prey on the microbes in the water known as zooplankton. As zooplankton levels decreased, algal biomass began to increase due to the lack of predation. The increase in algal biomass accelerated the eutrophication process. (Genesis, 1997).

The old Genesis Pond was developed before the flood. The macrophyte population had slowly increased and the pond was in equilibrium. When the river water introduced high phosphorous and nitrogen levels, the balance of the pond was upset. After the flooding, the developed macrophytes in the pond continued to flourish and the phosphorous and nitrogen in the pond were internally cycled. This accelerated the eutrophication process. (Genesis, 1997).

Conclusions and Recommendations

Due to the flooding of the Genesis Ponds, the ponds have become eutrophic. The flooding of the pond site introduced elements into the ponds which, in conditions of low water flow, caused the Genesis Ponds to eutrophy. Treating the cause of eutrophication, in the case of the ponds, would not improve the situation because the source of nutrients has already been removed. Treating the results of eutrophication is the only option remaining in the Genesis Pond project. The most feasible treatment in the case of the Genesis Ponds is chemical addition. Adding chemicals which reduce the amount of bio-available phosphorous and nitrogen in the pond would return the ponds to the mesotrophic or oligotrophic stages. The chemicals used would need to be biodegradable and non-toxic because the low water flow of the ponds would not neutralize these chemicals after they were introduced. This would not be enough to end the problem on the long term however. Because of the low water flow in the ponds, oxygen levels would stay low and the ponds could become eutrophic again. By dredging the soil in both ponds, the oxygen level in the water would increase and the chances of the ponds becoming eutrophic again would be highly unlikely.

Although there are possible treatments to the eutrophication of the Genesis Ponds, it would be wise to leave the ponds alone. We are using the ponds for educational reasons and our study is to see the natural progression of the ponds. Perhaps in the later stages of the project treatment would be a wise idea but, at the present time, treatment would defeat the purpose of the Genesis Pond Project.

On the larger scale, the Red River must be treated. The levels of phosphorous and nitrogen in the river remain high and the river water carries the potential to cause eutrophication. By improving Winnipeg's sewage treatment facilities to tertiary treatment, and considering alternatives such as effluent irrigation or wetland creation, the Red River's nutrient loads and therefore its potential to cause eutrophication would be dramatically decreased.

Appendix A

Chemical Levels in the New Genesis Pond

Date	Depth (m)	Susp. Nitrogen (µg\l)	T.D. Nitrogen (µg\l)	Susp. Phosphorous (µg\l)	T.D. Phosphorous (µg\l)	Chlorophyll A (µg\l)
04/07/97	0	102	1615	29	305	4.72
04/07/97	2	114	1610	33	327	3.19
10/07/97	0	107	1590	28	256	6.69
10/07/97	2	162	1625	32	282	4.25
10/07/97	3	99	1905	92	440	2.20
25/07/97	0	799	1175	133	172	81.63
25/07/97	2	431	1070	139	485	18.92
25/07/97	3	341	1010	96	167	12.35
31/07/97	0	899	935	160	180	48.72
29/08/97	0	4578	1350	403	52	438.63
29/08/97	2	3180	1415	960	176	232.54

Note: T.D. stands for Total Dissolved and Susp. stands for Suspended (Genesis, 1997)

Appendix B

Chemical Levels in the Old Genesis Pond

Date	Depth (m)	Susp. Nitrogen (µg\l)	T.D. Nitrogen (µg\l)	Susp. Phosphorous (µg\l)	T.D. Phosphorous (µg\l)	Chlorophyll A (µg\l)
04/07/97	0	587	1550	93	199	57.18
04/07/97	2	267	1865	54	255	14.46
04/07/97	3	213	2340	49	300	4.92
10/07/97	0	912	915	149	62	94.22
10/07/97	2	1049	945	163	72	114.12
10/07/97	3	488	1100	204	396	29.76
25/07/97	0	592	970	982	65	43.22
25/07/97	2	536	860	162	195	36.39
25/07/97	3	711	825	281	1053	40.48
31/07/97	0	950	935	165	53	112.42
29/08/97	0	2003	1400	170	42	160.95
29/08/97	2	773	1600	129	140	36.99

Note: T.D. stands for Total Dissolved and Susp. stands for Suspended (Genesis, 1997)