AN INVESTIGATION INTO THE SOURCES FOR IDEAS AND RESEARCH OF STUDENTS PARTICIPATING AT THE REGIONAL SCIENCE FAIR LEVEL

JOHN JOSEPH BARRON

An Investigation into the Sources for Ideas and Research of Students Participating at the Regional Science Fair Level

by

John Joseph Barron

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Abstract

The main area of study in this thesis deals with relating student sources of ideas and research to the outcomes of the science fair. There was no literature available that dealt with an experimental approach to studying these questions. This thesis uses a questionnaire administered at the Eastern Newfoundland Regional Science Fair to supply the information on where students get their ideas, and where they do their research.

The most prevalent source for ideas was self-generation. Surprisingly a large number of students, including a large number of medal winners, obtain their ideas from texts, defined as a low-level source within the literature. Few of the students used any research beyond what they found in their school and public library, and in all but a few cases, ease of access was the most quoted reason. The Internet as a research source increased in popularity over the past year, mirroring an increase in the access to this resource within the school system.

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Chapter 1

Introduction

This thesis will discuss the goals and potential outcomes of science fairs and present qualitative critiques of these goals. As well, a brief history of fair structures in various locales and a detailed treatment of the current structure in Canada will be presented. Structures and usages of science fairs can vary according to educational outcomes desired, while the central idea, a meeting of people interested in science for the purposes of display and perhaps competition, remains the same. Whether the end product is an exposition, a showcase night, a noncompetitive fair or the classic science fair, the central focus is the student and the student's work. This theme along with a quantitative treatment dealing with students will be explored as the discussion continues.

The Nature of Science Fairs

The first step in examining the nature of science fairs is to establish a viable definition. One common idea through most of the literature is that a science fair is a place where students come to display their wares of scientific thought, problem solving and innovation. Galen agrees with this definition, stating that a science fair "may be defined as a group of exhibits made by students below college age "(Galen, 1993). Other definitions broaden this common theme, such as McBurney's (1978) which states that a science fair is "an opportunity for a student to receive professional assessment and recognition for some personal *scientific* endeavour of interest to that student." Asimov and Fredericks (1990) concur stating that a science fair offers " . . . students a showcase for their scientific investigations and discoveries"(p. viii). The Ohio Academy of Science sees the science fair as "an occasion for the display and evaluation of student research projects" (Why? Student Research, p. 3, 1987). Then one can say that a science fair is a showcase or exhibition of student science investigations that will be judged by professionals in each particular scientific field. This will suffice as a broad definition that addresses many of the ideas presented in the literature.

Goals of Science and the Science Fair

This section will attempt to establish a comparison between the goals of science, the goals of the science fair, and how each may be attained. In this discussion possible learning outcomes, and direct goals of the fair itself, will be examined. Many critics of the science fair movement, stipulate that many of the learning outcomes a fair produces can be addressed in other, simpler ways. This idea will be examined along with contrary arguments. Slisz (1989) did extensive research in the area of goals for the science fairs. She based her research on those studies that she thought employed sound research methods and ended up with the following goals: 1) inquiry as a goal, based on promoting positive attitudes toward science and promoting sharing and communication, 2) learning process skills, 3) cooperation, 4) motivation (extrinsic and intrinsic), and 5) practice working outside the classroom or developing independent work habits. Slisz's goals provide the framework to continue the discussion.

Goals: attitudes/communication/inquiry

There are many goals that are not exclusively goals of science but are general goals of education. The ability to work in a group, to express oneself clearly, to speak in public, and to organize and present thoughts logically can improve the possibility of the student's being hired and retaining a job in the future (Lankard, 1987) as well as being more effective scientists in the present. Asimov and Fredericks (1990) see the science fair as not only improving the students' skills, but their attitudes and interests as well. They continue to explicitly state what they see the point of science fairs actually is, "to encourage them to understand science and possibly become a scientist or engineer" (Asimov and Fredericks, vii, 1990). In the discussion of inquiry, the ever popular realm of critical thinking skills must also be considered. Critical thinking is an important part of inquiry but is not limited to the attainment of science related goals,

> The fundamental purpose of children's science fair projects is to develop critical thinking that can be applied not only to science but also to other subject areas including, ultimately, reality (Blume, p. 19, 1985).

Woolnough (1994) talked of what industrialists wanted in a student and they essentially agree with Blume's purpose, helping to develop "the autonomy, creativity, problem-solving, teamwork, communication and entrepreneurial skills that are so important in the world of work" (p.49). From a societal point of view, science projects are important. As science fairs form part of the motivation for doing the project, then they too are important.

Goals: Learning process skills

An important goal of any science curriculum includes acquisition of science process skills. There are many classroom and lab activities specifically designed for this acquisition. A science fair project is another one. Rivard sees the science fair project as "a great way of showing students how scientists work" (Rivard, 1989). Asimov and Fredericks within their broad definition, state the science fair offers students the chance to "learn about the processes of science themselves" and see "how scientists investigate and learn about the world in which we live" (Asimov and Fredericks, viii, 1990). Knapp (1975) discusses the importance of the fair in promoting process skills within the elementary grades. Frequently in these grades process skills are given less than optimal emphasis. Generally process skills would include observation, inference, measurement, and classification. Clearly a science fair project, no matter what type, should be an effective way to gain proficiency with these skills. Other skills that can be distinctly addressed in a science fair project would include controlling variables and reporting, which are also addressed through laboratory and classroom activities.

Goals: Cooperation

Many who argue against the science fair movement state that the competitive aspect of the fair removes any chance of cooperation being practised. Within the science classroom cooperation is taught by utilizing group work in labs and class projects. Cooperation can take on many forms, such as the cooperation between a group entering a science fair, the cooperation between science fair participants from the same school, and the sharing that takes place when these students have a chance to sit and talk together. Within the Eastern Newfoundland Regional Fair, a Science Olympics is held as part of the festivities. This should inspire cooperation amongst the 'teams' of participants that compete against one another in the science 'games'. The way it accomplishes this is to arbitrarily assign teams, so that inter-school and geographical rivalries are not in evidence. At the elementary level sharing is a big part of the curriculum and is one of the goals of any elementary science fair (Knapp, 1975). Thus the science fair can be an effective way to engender cooperation amongst participants, contrary to the views of Wolfe (1994) and Smith (1981) who criticize the high competitive nature of the event.

Goals - Motivation (extrinsic and intrinsic)

Motivating students in the classroom may prove to be one of the most difficult tasks for a science teacher. Unless a student has a true interest in all aspects of the course material, this motivation may fluctuate. The science fair, because of it's nature and the nature of the students' participating in it, has a built in motivator. Fairs which depend upon voluntary participation will attract students addressing a research area they are interested in, and this motivates these students to do the work. In the case of a mandatory fair, generally students will still choose topics that they are interested in. This interest motivates students to do the work. This is not true in all cases, but student interest in the topic may play an important factor in the quality of the end products. The benefits to both groups are the same, by holding a science fair we help stimulate interest in the area of science. Olsen (1985) stipulates that competitions of this type may build self-confidence and increase motivation to work in science. Edelman (1988) states directly that there is some evidence that students who do science fair projects will continue on in the science field. Rao specifies that "The greatest value of the science fair is the recognition and encouragement that it gives to the student participants" (p.85, 1985). This is outside the normal goals for science activities, but the fair offers this and much more.

> "...a large part of their motivation is the hope of achieving recognition from entry of their projects in the various science competitions. The feeling of accomplishment derived from carefully planned and executed experiments is another important source of motivation" (Liebermann, p.1067), 1988)

These forms of extrinsic and intrinsic motivations serve a set of purposes which contribute to the importance of the science fair and are frequently lacking within the regular classroom.

Goals - Science work and interest outside the classroom

This goal is one area where the classroom aspect of science learning is not equal to the science fair. Homework may in some cases promote learning, but rarely promotes interest. Science teachers have few resources that would allow them to affect a student's interest outside the regular class time. A science fair, though, by its nature is intended to be separate from and outside the classroom. Promotion of this work and interest is then inherent in a science fair structure. Many authors offer their opinions, such as Jones (1991) who states "science competitions are one mechanism for students to develop their science interests outside the traditional classroom setting." Asimov and Fredericks concur as they see a science fair offering, " . . . students [the chance] to see how science works outside the classroom" (viii, 1990). In fact one of the reasons for science fairs' organizational start was the US government increasing their support to spark students' interest in science outside the classroom (Science Fair Guide, 1990). To promote independent student research is the ultimate goal of any science fair project.

Goals - other

Knapp (1975) identifies some of the goals for the science fair in the elementary grades, including stimulation of creativity and imagination and expression of individual differences. Streng (1966) also saw science fairs in the elementary school as a way to capitalize on the natural curiosity of students in the upper elementary grades. These are goals that should be strived for and which are attainable in the junior and senior high grades as well. In the regular science classroom, these goals are possible, but must be specifically sought after and may be difficult to attain. Other interesting hidden educational outcomes for science fairs are identified by Mann (1984) and include development of reading skills, language, logical and formal thought, writing skills, scientific literacy, self-confidence, and creativity.

Although many of the goals listed are as possible within the science classroom as they are within the science fair, some are not. As well, within a classroom context, science fairs can give purpose to practical work and support the importance of practical work in the curriculum. The British Association on the Advancement of Science (Science and Technology Fairs, 1983) concur with this point. Science fairs take many of the goals of science teaching and encapsulate them into one event. In summary then, the science fair is an extrinsic motivator for students to do science and pursue careers in science, a method of building confidence and creating scientists, a way of taking science out of the classroom but also promoting non-science skills, and a way of creating well-rounded employable graduates. In conclusion, the science fair is not in competition with the science classroom, since they share many goals. The fair is an important extension of the science classroom and a vibrant fair structure is important to the current educational system and the future scientific one.

History of the Science Fair Movement

The USA and UK

The Youth Science Foundation (YSF) Science Fair Program handbook (1990) claims that science fairs originated in the United States, essentially a culmination of the science club movement from the school level. Asimov and Fredericks (1990) put the starting date as the "late 1920's" (p.viii) although the movement did not receive national recognition and support until the advent of the space race against the Soviet Union. During that time, school sciences curricula were revamped, steps were taken to recognize scientific talent early on, and extracurricular activities in science were encouraged. The Chicago Public School's Science and Mathematics conference began in 1950 (Danilov, 1975). This time frame helps us to zero in on an exact date for the birth of the science fair movement. Within the literature this is one of the few start up dates that are mentioned. Other mention of the science fair history was found within articles dealing with the North Carolina Fair. The North Carolina State Fair came into being in the 1950's, the culmination of work starting at the local level. Within that structure, students competed locally, moving up through Regionals and then onto the State Fair (North Carolina, 1988). Both of these references make direct mention of the local school fair, and the local school science club. Although in the case of North Carolina's fair there are no allusions made, the YSF history seems to credit the start of science fairs to a group of individuals who were running a national fair. The fact is that there is no specific date as to when the first teacher held the first science competition in his/her classroom. The only data to be found on dates were those concerned with major events, such as Chicago's City Fair, North Carolina's State Fair and the International Science and Engineering Fair (ISEF). A summary of the history in the US shows that a system started in the late 1920's, evolved nationally in small ways, slowly over the next few years, and finally culminated in a decent size National Science Fair in the middle to late 1950's.

The United Kingdom (UK) also lays claim to developing the science fair idea. The British Association for the Advancement of Science (1983) claims that science fairs were originally intended to spark interest in practical work within schools. They inevitably evolved to a forum for display and presentation for those involved. No specific date is mentioned, although references to "twenty years ago" places the start in the 1960's, some forty years after the American.

Canada

Unlike other countries, the history of the National Science Fair in Canada is quite well documented. This was caused in part by the use of a single continuous organization on a national scale administering science fairs since near their inception here. The first cities to see the science fair, namely Winnipeg, Edmonton, Toronto, Montreal, Hamilton, and Vancouver did so in 1959 (YSF, 1990). Within two years partnerships among "national, professional, scientific and technical societies" (YSF, p. 2-1, 1990) created the Canadian Science Fairs' Council, which held the first Canada-Wide Science Fair (CWSF) in Ottawa in 1962. The Youth Science Foundation evolved from the Canada Science Fairs' Council in 1966. This evolution lead to more programs being added to the YSF's purview, but they still remained the chief organization for science fair activity in Canada (YSF, 1990). At its inception, the YSF supported 30 Regional Science Fairs, but they were not representative of all provinces of Canada. Now thirty years later there are 109 Regional Science Fairs, representing every province and territory which send representatives to the CWSF. There are some notable exceptions to the Regional Science Fair structure such as Quebec which operates its own provincial fair sending students to the Canada Wide as a body rather than through regions. The Quebec-Wide Science Fair (Pan-Quebecois), as it is called, has a structure that's based on philosophy rather than geography. The group which oversees the fair, Conseil de developpement du loisir scientifique (CDLS), is actually seen on a par with the YSF for funding purposes although affiliated with it during the Canada Wide Science Fair. It's importance to the science fair movement cannot be understated although it has little meaning for this study. The structure of the YSF makes the board of directors the overseers of all programs, with some power of decisions being left in the hands of the regions. Although many important decisions must be passed by the board, the Canada Wide Science Fair Committee, elected by regional delegates is the primary organizing body of the fair itself. The regional fair councils, which are made up of local fair organizers, elect the delegates which elect the CWSF committee.

As was the case with the United States, it is easy to see that fairs existed at the local, school-based level before the national body. This history then encompasses the organization that lead to science fairs being a "Canada-Wide" affair.

Newfoundland and Labrador

Staying within the large organizational genre, the topic of how the regional fairs came into being in Newfoundland will now be discussed. These were not the first fairs, just the first that were provincially-based. The first regional science fair in Newfoundland was held on April 11, 1981 (Smith, 1981), organized by a group of secondary and post-secondary educators as well as interested members of the scientific community. They began holding regional fairs that encompassed the entire province. In 1984, Labrador became a separate region under the YSF guidelines (Science Fair Guide, 1990), and within the next four years the island split to the three regions, Eastern, Central and Western. Each region runs it fair organization in a different way. The eastern council relies on a pure volunteer structure, which is also partially the case with the western council. The central council consists of subject coordinators from the various school boards in that region. Western council also has this support. Labrador because of its isolation and large geographical area, runs their council on a school board basis, switching between boards every few years. Throughout these years Newfoundland participated in the Canada Wide Science Fair at various centres around the country. In 1989, the CWSF was held in Newfoundland, hosted by the Eastern Regional Science Fair Committee (ENSFC). It still holds the record for number of participants, and continues to elicit positive comments from the rest of the Canadian Fair Councils.

As one can plainly see, the use of fairs in Canada has a strong continuity, and a healthy base on which to build. Still with signs of declining senior high school participation (Wells, 1995,1996), a reduction in funding at all levels, a reduction in the number of science coordinators, and an increase in the number of different science and engineering events in direct competition with the fair, Newfoundland's place as one of the leaders in science fair organization and participation is in jeopardy. Sustaining a quality program and excellent participation is becoming more difficult each year.

Present Structure

The structure of science fairs is quite well established in Newfoundland. Currently fairs at the school level all around the province feed into the regional fairs, of which there are four in Newfoundland; Eastern, Central, Western, and Labrador. These are run by their own individual councils acting as separate bodies. Although autonomous in many ways, each of these councils follow guidelines established by the National Science Fair Committee and the Youth Science Foundation. The Project categories, including Life Science, Physical Science, Computer Science and Engineering, as well as age groupings, namely Junior, Intermediate, and Senior are just some of the commonalities. Another is the timing of the fairs with all the Regionals being held near the end of March each year, so that entry deadlines for the Canada Wide Science Fair may be met. The winners from these regional fairs then are eligible to attend the Canada Wide Science Fair, which is held in different Canadian centres each year. Nominally under the control of the regional fair delegates as well as the Youth Sciences Foundation (YSF) and its board of directors, this fair is always held the week before the May 24 weekend. The outstanding participants at this level are chosen to attend the International Science and Engineering Fair (ISEF), usually held in the continental US supporting some 416 affiliated fairs and some 831 participants worldwide (Galen 1993). This fair is held in May as well, with Canadian students chosen to attend the following year's fair. Over the period of the year the students work on their projects with help from a mentoring scientist, refining their work to the highest degree possible. The students are immersed in their project for upwards of two years, making it a refined piece of high school science research. This shows a dedication to their science, whether motivated by the extrinsic accolades, prizes and awards or the intrinsic "worth and enjoyment of the science activity itself" (Woolnough, p.109, 1994)

Reason for the Study

The science fair structure in Newfoundland was one of the most vibrant in the country. This fact was most probably a direct result of the time and effort of many of this province's science teachers. At present this time and effort seem to be decreasing. The evidence is found by examining recent years' participation information. This data shows an increasing number of senior-high schools have stopped having annual science fairs. During informal discussions with school personnel, teachers broached a number of issues. Some of them claim that the time and effort required in holding a local fair take too much away from the prescribed curriculum, and inevitably most put completing the course "requirements" ahead of what is seen as an extracurricular activity. Others say that they are finding it too difficult to come up with new ideas for their students, and that there is a lack of student interest overall. Thus a decrease in the number of senior high students participating in science fairs at the regional level has been observed. Once again, the evidence is found in the registration records. In the late 1980's and early 1990's the ratio of senior high participants to junior high was somewhere around 2:1, with approximately 200 senior participants present at the fair. This past year saw that ratio at 1:1 with less than 150 senior participants and a trend towards more participation by the junior grades (Wells, 1996a). This decrease in senior participation, and increase in junior participation is also evident in other years. In 1995, for instance, the Eastern Regional Fair sent more junior high students than senior to the Canada Wide Science Fair (Barron, 1995) while just two years before only senior high students were sent. Other supporting facts include the size of the relative judging groups. Junior Physical Science is the largest group of any at the fair. Constituting close to one third of the participants, this group only includes grades seven and eight. That this increase may be a result of the fact that the Junior High Science Curriculum lends itself more to the practical science than Senior High, is in many ways true. The Junior High course is an activity-based offering, less content driven than its senior high counterparts. Along with a heavy practical component it requires a science fair project as part of its assessment (Grade 8 Science Curriculum Guide, 1995). The problem is that this requirement is not present in the Senior High course descriptions.

The high school Physics curriculum guides (Physics 2204 Curriculum Guide, 1992 and Physics 3204 Curriculum Guide, 1992), for both senior high courses, stipulate that a science fair project may be done, but can be replaced by a written research report. The Chemistry guides (Chemistry 2202 Curriculum Guide, 1988 and Chemistry 3202 Curriculum Guide, 1988) perfunctorily mention science projects as a form of evaluation, but do not make the project a requirement. "Students may" do a science fair project (p.48 and p.62). The Biology Guides (Biology 2201 Curriculum Guide, 1994 and Biology 3201 Curriculum Guide, 1994) suggest the science fair project as a way to provide certain types of learning experiences, namely inquiry learning and independent study. They also do not make them a requirement, nor do they mention them in the evaluation section. Clearly these curriculum guides are not making a science fair project mandatory although generally they are promoting the science fair movement in a small way.

Within each of the junior high curriculum guides, (Grade 7, Grade 8, and Grade 9

Science Curriculum Guide, 1995) there is direct support and a requirement for the science project. A section found in the grade eight guide (1995), states the following:

> During each year of the program, students are required to do an independent science project of the type that would be suitable for entry into a science fair. At the grade seven level, students are given extensive instruction in the various aspects involved in preparing the project. Three weeks has been allocated for this in the curriculum. At the grade eight and nine levels, need for instructional time should be lessened. Approximately two weeks have been allocated at these grade levels. (Grade Eight Science Curriculum Guide, p.12, 1995)

Not only is the project a part of the prescribed curriculum, but it is recommended that time actually be given in the class for the development of the project itself. Clearly the junior high program has a true commitment to the science fair process.

This lack of a required science fair project in the senior grades could be part of the cause of the declining participation of that age group. Of course if the science fair project were required there probably would not be a participation problem. King and Peart (1992), in their studies dealing with teachers from across Canada, showed that in the science classrooms in the junior high there was a higher incidence of small group work (53% vs 48%) and less seat work (46% vs 52%) than was observed in the senior high grades. Although not specifically dealing with the area of science fair projects, the propensity of seat work and a higher incidence of teacher lectures in the high school grades (60% vs 58%), may show less opportunity for the undertaking of science fair projects. In the area of evaluation, this same study found many stark differences between the senior and junior high grades. Effort in the junior high science classroom plays a much larger role than that of achievement on tests and exams. Sixty one percent of teachers surveyed stipulated effort being more important than achievement. The senior high grades were the exact opposite. Sixty five percent of teachers surveyed felt that achievement on exams and tests was the most important factor in evaluation (King and Peart, 1992). This supports many of the claims made in the previous section, including the reasons for schools not holding science fairs. It also supports the claims that the teacher or the school may be largely at fault. The focus will now turn to the common excuses used to justify not having a science fair.

The first arguments gleaned from the informal discussions, stipulated that a science fair would take too much out of regular class time and adversely affect the completion of the prescribed curriculum. The fact is that with proper planning the fair and much of the student's work can be outside school and class time. As well, although the senior high curriculum guides do not assign a science fair project as mandatory they still support the idea of the fair, seeing it as a means to utilize and develop critical skills within the curriculum. Lack of student interest also may not be a valid excuse. Students from three of the schools who did not hold fairs entered the regional fair on their own (Wells, 1996a). These students independently chose, researched, and presented their projects, although parental involvement may have played a factor. As well many of the high schools in the St. John's area have voluntary participation within their fairs and still manage to get enough students to hold them. That leaves the lack of new ideas from teachers as the only remaining excuse offered by individual schools. Daab (1988) found the most important cause of a lack of science fair participation to be a lack of teacher interest and enthusiasm towards the fair idea, while Knapp (1975) published a list of common teacher excuses for not holding a fair. Teachers who have participated in the fair in the past may have lost their enthusiasm and may no longer be interested in devoting much time and effort towards a fair. Several lines of reasoning support this idea.

Number one, these teachers have been helping students with projects and providing ideas for years, so it is easy to see why they may be getting tired. The ranks of the ENSFC, show this trend all too well. A past chairperson of the council is one of the teacher's whose school does not hold a science fair. Number two, Junior high science teachers have students at the beginning of their fair careers, and thus old tried and true ideas will still be fresh to these students. Also, Junior High teaching materials have many interesting and rewarding science projects already prepared. The time set aside in the curriculum for the science fair in the junior high is another definite factor. This explains the advances made in the junior high area. Finally, the average senior science teacher in many schools is very senior, in most cases in the last half of their teaching careers, and thus they have done all of this many times before. Holy Heart High School has 13 science teachers on staff, with all but five able to retire within five years. Although this may be an aberration, personal experience shows that this is close to the norm. A more rigorous proof may not be possible as no specific age data is available for this area, yet some support is found in other areas. King and Peart (1992) found that the junior high grades of teachers, although being subject specialists, were more likely to undertake and be interested in a career move. Thus, with the possibility of high turnover fresh teachers are probably injected into the system. Such is not the case in the senior high grades, where the career move possibility was considerably less (King and Peart, 1992).

Other evidence that supports this hypothesis comes from such places as the Youth Science Foundation and Stem~Net. The Youth Science Foundation annually publishes lists and abstracts of winning projects from the Canada Wide Science Fair. As well, they have published a list of possible project ideas for all grade levels, to aid teachers in their job (Science Fair Project Ideas, 1979, and Regional Science Fair Guidelines, 1995). This was part of their fair handbook, included to give teachers' a head start on giving students ideas. Stem~Net, which is the Internet provider for all of Newfoundland and Labrador's education system, has also responded to such requests from science teachers. The organization itself was put into place to support teachers within Newfoundland and Labrador, with the name Stem~Net, actually standing for Science, Technology Education and Mathematics teachers' Network. In 1993 Harvey Weir, then director of Stem~Net, solicited and supported the creation of a Science Fairs Gopher that would give teachers access to new project ideas and information. It proved to be among the most popular gopher sites (Weir, 1994). Following the change in technology and the advent of the World Wide Web, the Science Fairs Gopher became the Science Fair Home Page. The content remained the same, with idea lists as its focus, while its success became measurable through the use of access counters. Between the months of January and May 1996, more than three thousand accesses were made to this page. From May of 1996 to May of 1997, an additional thirty seven-thousand accesses were made. This marked increase in access may be due to several factors, one being an increase in availability of the Internet to students. In support of this hypothesis, the increase in accesses could mean that more students can seek the help they need for their science fair projects or that there was an increased need for the help itself. Either would support the hypothesis that students need help in obtaining ideas for science fair projects. The evidence is controvertible, but weighs heavily in favour of the point that project ideas are among the most important factors of a Science Fair's success. So then, teachers may be the main reason for the decline in science fairs, just as they were the main reason for their inception. The question to ask now is how to help them? If ideas and research are the stumbling blocks for these teachers, then identifying the ways in which students obtain their ideas and research, and making these pathways easier to access for all involved would seem the solution.

Outline of the Study

This research will be addressing two main questions, where do students get their ideas for science fair projects, and where do students do their research for science fair projects. Within these questions several comparisons are possible. One is to view the differences between where high achievers at the fair, namely those who win a medal, and other students get their ideas and do their research. The literature supports such a difference, so it can be expected to be significant. The second is to view the reasons why such sources are used. This will allow insight into what drives a student towards one source rather than another. This insight will have practical significance within the educational system and will address some of the problems discussed earlier.

The basis of answering these questions and observing these comparisons is the final standing of the student at the fair. A concern would be whether or not the instruments used would be capable of answering these questions. Is the difference between a medal winner and non-medal winner statistically sound? Can it be reproduced with a certain degree of certainty? A check of reliability and validity of this process is needed to insure this.

Other comparisons and questions can be raised from the instruments provided, but the main purpose of this research is to answer these questions first.

Chapter 2

A Review of the Literature

Within any literature review the criteria for selecting the articles must be specified. This review will deal specifically with articles that are within the science fair genre, namely all articles dealing with the fair itself, its structure, its purpose, the projects themselves, and all parts of the fair deemed topical. This discussion will formalize the definition and establish the types of projects, review research on project idea sources and concerns, and research methods and concerns.

Definition and Project Types for Discussion

To begin this discussion, the position that different people hold on the issue of the nature of science fairs will be examined. In the previous chapter a science fair was defined as a science competition, involving judging by scientists, students working as scientists would, undertaking a science project. But this undertaking must also be defined. The high school science courses' curriculum guides in Newfoundland and Labrador include a science-fair-type science project among suggested features but none make it a required element. The physics curriculum guides come the closest (Physics 2204 and Physics 3204 Curriculum Guides, 1992), but allows teachers and students to choose this required project to mean a written research paper passed into the teachers themselves. Although this constitutes part of what a science project is, it misses the crux of the matter. Asimov and Fredericks (p.1, 1990) supply us with a well-rounded definition:

> A science fair project is a presentation of an experiment, a demonstration, a research effort, a collection of scientific items, or a display of scientific apparatus.

They are supported by Pushkin (1987) who stipulates that "research is the process of studying a scientific problem with the intent of solving it and/or learning about it" (p.962). These definitions are quite complete and encompass all possible avenues that a science fair project can follow. However, as some people may object to all that is included in this list, it opens up a controversial issue, which is the debate between experimental and non-experimental types of projects.

The controversy revolves around whether the two main types of science fair projects, experimental and non-experimental, should both be acceptable. The Youth Sciences Foundation (YSF), in their Science Fair Project Ideas publication (1979) originally gave an expansive definition of what a non-experimental type of project entails. According to this guide the non-experimental project, or display as they call it, is one of the two following things:

> A display of scientific information already available in printed and non-printed form: usually copies of diagrams, models assembled from kits, summaries of reports and books.
> A chart, illustration, model, collection, specimen or report based on first hand investigation by the student; the display must show evidence of the students own thought. (P.1)

These guidelines have since changed on the national scene, and the classification of projects becomes more complex (Science Fair Guide, 1995). The original definition presented a clear division between experimental and non-experimental projects. It also classified non-experimental projects as being of lower level educationally and within the judging structure. Now there are three categories of projects, experimental, innovation, and study. The experimental project is, as the name suggests, the undertaking of an experiment to address or solve a problem in science. Innovations, clearly within the realm of the non-experimental project, involve:

> the development and evaluation of innovative devices, models or techniques or approaches in fields such as technology, engineering, or computers (both hardware and software). (Goulding, 1997)

The study type of project, another non-experimental type, involves:

> a collection and analysis of data to reveal evidence of a fact or a situation of scientific interest. It could include a study of cause and effect relationships involving ecological, social, political or economic considerations; in depth studies; theoretical investigations. Variables, if identified, are by their nature not feasible to control. (Goulding, 1997)

Once again, these types of investigations are not experimental in nature, but would fall more into Pushkin's (1987) learning about a scientific problem while clearly existing within the demonstration, collection or displays of Asimov and Fredericks (1990). Some authors feel that the non-experimental type of project is not a true 'science' experience. Stedman (1975) views non-experimental types as "valuable experience, but . . . not the best reflection of science"(p.20), while McBurney (1978) views them as non science, "giving students a misleading view of science"(p.420). These authors are supported by Fredrickson and Mikkelson (1979), who see the non-experimental type of project as having a "legitimate place in the teaching of science, but a clear-cut distinction should be made between these efforts and actual scientific experimentation"(p.499). They clearly see non-experimental type projects as less than their experimental brethren. Knapp (1975), although recognizing that many types of non-experimental projects could be part of the science fair, labels them as projects for young children, while encouraging even sixth graders to undertake the more difficult (in his eyes) experimental project. Daab (1988) found that there was a participation problem with the fifth graders within her district. This problem was in part caused by unreasonable demands made upon the fifth graders, namely not allowing them to do non-experimental type projects. This could be viewed as an example of where holding the idea of non-experimental type projects not being "real" science could very well be hurting the science fair movement. However, the author did not see it that way, but rather chose to devise a method to make this experimentation easier for the fifth grade student (Dabb, 1988). Perhaps expanding, or enhancing the ways students do non-experimental projects, as well as enforcing certain strictures upon what topics may be addressed would solve the problem.

The problem or question extends beyond the realm of classroom fairs to major fairs held nationally and internationally. The Illinois Board of Education sees the experimental project as the higher level of the two, with its advantages including fostering scientific thinking and other educational skills. They specifically state that this type may be more applicable to upper-level and upper-ability students, while the only advantage for the demonstration of non-experimental type work is that is could be more successful for and more applicable to lower-level students (Riggins, 1985a). That the presentation of any topic is useful educationally or that even a non-experimental type of project when done well can display scientific thinking is not present in their reasoning. Further proof of this is found in Riggins (1985b) as they take students through the process of designing experiments within the student's handbook, yet make no mention of discovery/display types of projects. Riggins (1985b) is used as a science fair guide. Other such guides were perused and in them the same narrow definition was discovered.

North Carolina's State Science Fair Guide (1988) defines a "true" science project as an "investigation of a question, involving research, planning and application of the scientific method to seek an answer to the question" (p. 4). Of course if the authors had stopped before the application of the scientific method, it would have included non-experimental type projects. Newfoundland's fair guide, which is the YSF's fair guide (1995), assumes that non-experimental type projects are not of high enough level for the Canada Wide Fair, a view shared by the ISEF. In fact, within the Science Fair Project Ideas Guide (1979) published by the YSF, they suggest that the non-experimental type project is of lower educational level and deserving of fewer points within the judging process.

The North Carolina Guide (1988) also calls an experimental project a "successful project." It appears that the fair guide is attempting to funnel students into a project type that would be more successful at a higher level. This is possible, as the YSF guide (1995) and the rules of the ISEF stipulate that a non-experimental type project's level is not appropriate for the Canada Wide Science Fair or the International Science and Engineering Fair. Who then can blame the teacher for guiding their students away from the legitimate yet quite maligned non-experimental projects when success lies upon another path?

Proponents of the non-experimental types of projects are, for the most part, intent on including as many students as possible, and thus do not want to lose the lower-level students such a type of project would usually draw. Chiapetta and Foots (1984) on the other hand see non-experimental type projects in a different light. They say that not all research is empirical in nature and in fact some of the most noted scientists based their work on the work of others (Chiapetta and Foots, 1984). They give Einstein and his theories as an example (Chiapetta and Foots, 1984). At this point, it is interesting to note, that Einstein's work and thought experiment, would fall within the Innovation type of project at the Eastern Newfoundland Science Fair. Inevitably, any well researched and inquisitive project addressing today's issues can be an informative, problem-solving based, critical thinking enhanced, learning experience without being empirical in nature or based along the lines of the scientific method.

McNay (1985) suggests that science projects "are supposed to be experimental, to demonstrate that the young scientist can formulate and test a hypothesis, gather data, interpret results and draw conclusion" (P.17). This position has left non-experimental types out of the top fair projects' picture. McNay (1985) goes on to stipulate that the norm has been:

> Fair projects that display information or demonstrate a principle or process have often been considered insufficiently scientific and have even been described as not only missing the essence of science but also being inconsistent with the goals of teaching science (Smith, 1980) (McNay, P.17, 1985)

Considering McNay's (1985) view that science "means questioning the world, wondering how it works, and, while delighting in its mysteries, raising hope about the possibility of coming to understanding some of them" (P.18) it is obvious why she feels that non-experimental projects are just as important as experimental projects. Wellington's (1994) topology of investigations would list most non-experimental types of projects as investigations. A graphical representation of this topology is found in the next section. Some non-experimental types of investigations would be closed-ended in their scope, with an answer already decided, but it could reasonably be concluded that a question and answer about how something works is a legitimate undertaking. These views not only support McNay's standpoint of non-experimental type projects being legitimate science, but also blend well with the ideas of science investigations discussed before. Her viewpoint on the non experimental approaches have been encapsulated below:

1. Presenting three-dimensional displays based on literature searches.
2. Building working models or presenting technical demonstrations.
3. Demonstrating a basic scientific principle.
4. Observing the environment.
5. Collecting and Analysing data. (McNay, p.18, 1985)

Another proponent, Kevin Collins (1981), offers a unique perspective on independent non experimental projects, taking us from what he used to do, to a more effective strategy he has developed. Essentially Collins (1981) original strategy of suggesting "reports on various topics related to class work being covered at the time" (p.463), lead to the type of "cookbook" experiments and plagiarized work Woolnough (1994) predicted. His present system of explanation of goals, suggested topics, and significant student-teacher interaction, has lead to "not only written papers (in the students' own words), but also to plant collections, photography projects, and other projects offering something for everyone's interests and talents" (Collins, p.463, 1981). Thus Collins started with the structured and moved on toward the more effective (in his case) unstructured research.

As stated at the beginning of this discussion, this is a controversial issue, one which cannot be resolved within a single literature review. Earlier there was established a series of goals, some based on the presentation of the project, dealing with the judges and public, turning students onto science, teaching them about competition, teaching them about how science works, to challenge the student, etc. Although these are not all of the goals for science fairs, the goals mentioned here seemingly can be addressed by a non-experimental type of project. Bombaugh (1987) doesn't actually comment on the experimental versus the non-experimental, but rather in the need to challenge the student, while Daab (1988) admits that non-experimental project could form the basis of an "entry-level" for students into the science fair. In summary, both the non-experimental type and experimental project are legitimate depending on, (1) the age of participants, (2) the nature of the student work on display, and (3) the proviso that the non-experimental type of project actually meets more of the stated goals of science fairs. Within this discussion consideration will be given to both the non-experimental and experimental type of science fair projects.

<u>Project Idea: Sources and Concerns</u>

Obtaining an idea is consistently mentioned within the literature as the first step of creating a science fair project. A common question heard by teachers from their student is "What will I do my project on?" While Students also ask "What will be the overriding question that will lead to my hypothesis and thus into my research?" Leibermann (1988) sees this as "the biggest obstacle to overcome in doing a project" (p.1067) while Bombaugh (1987) stipulated that 30% of any project time would be spent on determining what the topic would be. To differentiate between the main areas of where student project ideas come from, Wellington's "topology of investigations" will be used. A representation is shown to the right.

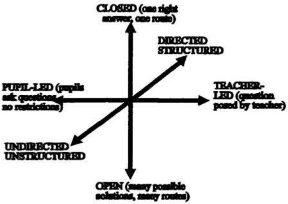


FIGURE I: Wellington, 1994 - Topology of Investigation

Basically, there is a spectrum of investigations leading from directed/structured to undirected/unstructured in research; from closed to open in the questioning; and from teacher-led investigations to student-led investigations. The continuum dealing with who poses the questions, and what type of questions they are will provide the structure for the discussion on ideas. The continuum dealing with the type of research taking place will be used in a later section.

Two of the most prevalent methods of starting an investigation are using lists created by individual science teachers, and using science texts in the acquisition of a fair project idea. These would fall close to the teacher-led side of the spectrum. Hansen (1983), organized his elementary fair around a list using, "suggested topics . . . from the students' science texts"(p.10). Pushkin (1987) concurs, recommending "that the students look through their textbooks for ideas" (p.962). VanDeman and Parfitt (1985) agree that selecting the topic is "perhaps the most difficult part of doing a science project" (p.14) and go on to suggest the use of teacher introduced topics earlier in the year. Two popular Nuffield science texts, used in England during the 1970's, list project suggestions (Tawney, 1975). In fact the basic premise is the same, insuring that the project undertaken is relevant science; relevant to the subject area at hand at least (Hansen, 1983; Pushkin, 1987). It is interesting to note that Asimov and Fredericks (1990) book contains a list of possible experiments. This would lead one to believe that they support not only the student created projects, but the teacher lists as well. The risk is that these questions, already having been answered to some degree, may also fall along the closed-ended side of the spectrum, and their educational worth may be in doubt.

Detractors of this process are not difficult to find. Woolnough (1994) disagrees strongly with this practice stating, "too often practical work has been dominated and distorted by an aim to elucidate or discover some piece of scientific theory" (p.49). He further goes on to say that this "cookery book" type of investigation is unproductive, tightly structured and leads to "unsuccessful comprehension" (Woolnough, 1994, p.49). To lend credence to these statements, Woolnough (1994) relates that many industrialists and educationalists advocate the more student centered "individual . . . research project"(P.49), and their reasons are that this produces the right person for industry, and it fits in with what educators theorise about how children learn. A second contrary view to the list/text practice is found in Foster (1983), who labels such as "cookbook experiments," basically "artificial" approaches (p.20), which do not address the true sense of what a student is interested in. Foster (1983) suggests that the science project be a year-long affair, and that teachers begin by "introducing students . . . to the idea of asking questions about the world around them" (p.20). This then is supported by the introduction of experiments to answer certain questions, and inevitably to the students own question and experiment design (Foster, 1983). From Wellington's point of view, Foster (1983) is attempting to move along the continuum, from the teacher-led end of question posing, and working towards the student side while engendering open-ended questions about "the world around" his students. Essentially the amount of open-endedness of the experiment depends on the student, the teacher's instructions, and the amount of copying of experiments that take place.

Rivard's (1989) work in developing a model of idea development is quite similar to Foster's, and includes, the students listing their interests, teacher involvement by identifying those interests which would lend themselves to scientific investigation and instruction on how to formulate proper research questions, students writing proper research questions from their interest lists, then evaluating and choosing from this their research topic. Rivard starts much closer to the student-led side of the spectrum, and attempts to insure an open-ended questioning. A representation is given below:

> 1. [student] lists his/her interests
> 2. [teacher] studies the interests and seeks to identify those which lend themselves to active research
> 3. [in the classroom] teacher gives examples of how to identify a research problem. General discussion. Instructs students to formulate a number of questions based on the interests listed
> 4. [student] draws up a series of questions based on his/her interests, particularly those identified by the teacher as having research potential
> 5. [student] evaluates each question (or problem) according to its relevance, originality and validity
> 6. [student] selects one problem and gathers information ...
>
> Rivard, p.202, 1989

In all these cases it is the intent that the teacher acts as facilitator, not adjudicator or list maker, and the projects have real relevance for the student involved. Asimov and Fredericks (1990) who also see the act of choosing a topic the most difficult part of the science fair process, suggest that a list of questions that would bring out the student's interests could spark some ideas. They are presuming that students' interests are guiding their research, but in some cases students do projects that they think their teacher wants to see, or that will do well in the competition. Essentially the problems in these cases are time, classroom commitment, teacher quality, ability, and interest. Much of a science class' allocated time would be taken up in the development of these project formulas, and the teacher in question would have to totally agree with the strategy and support it throughout for it to have any chance of succeeding.

There are many reasons why a teacher list should not be used, but here are some variations on that idea which present the argument from a different perspective. One way to insure that the science taking place is relevant, while also decreasing the amount of teacher-led question posing, is the thematic science fair introduced by Winicur (1989). Essentially "all projects within a grade level must conform to the theme, yet the themes are so general as to not really restrict the choices of topics" (p.27). Winicur, though, does not restrict the creativity beyond this proviso, and in fact uses the common theme to engender cooperation among all the students. The lack of restrictions also allows the possibility of more open-ended questions. Keller and Holden (1994) also support the idea of a thematic fair. In their case though the theme is the same year to year, specifically dealing with consumer issues. Their consumer fair still promotes science fairs in general, but channels the students problem-solving skills and creativity into areas that not only make them better scientists, but better consumers as well (Keller and Holden, 1994).

Chinouth (1994) channels her students' ideas in a different direction. She suggests project ideas and supplies a teacher list for projects that are inexpensive. Wishing that all students compete on a level field, and that some not be left out due to sociol-economic status, Chinouth (1994) developed solutions that cost little yet pay off big in the science learning arena. Such things as learning about recyclables around the house and creating projects from everyday household materials are just some of the possibilities.

Liebermann (1988) meanwhile, gets around the problem of cookbook experimentation by pushing his students beyond the norm. He uses a list developed from experiments presented in the pages of the Journal of Chemical Education. His case is special amongst the teacher provided experiments, as seen below:

> It may concern some readers that these experiments, the outcomes of which are more or less known are treated as research projects. However, these experiments are new to my students, and in their hands no outcome is certain . . . They realize they are reproducing previous work, but with the intention of modifying and extending it in some way beyond what was presented in [the Journal of Chemical Education] and in some of the original literature. (Liebermann, P.1067, 1988)

Thus although teacher-led, these investigations move towards being open-ended. There are others who feel the same way and suggest moving in the same directions as Liebermann. Giese and his colleagues (et al, 1992) think that the act of perusing lists of past student experiments will assist students in their search for a topic. Tawney (1975) concurs, suggesting even that texts, "intended for younger pupils, may stimulate ideas for the A level student"(p.78). Field, dealing with younger children, has addressed this problem as well, "of course, students will need guidance at every phase, including the initial one-selecting a problem to be studied" (Field, p.18, 1987). Yet in his case, even though the logical course is presenting the students with a list of project ideas to choose from, Fields uses "a little prompting and a few examples to start," allowing the students to ask their own research questions, questions to which they do not know the answer. Here then is a partially teacher-led investigation with moderate open-endedness. This mirrors Liebermann (1988) to some extent, stressing the need for the student to search out answers to questions they themselves do not know the answer to. One of the ways to get the most out of a science fair is to use more than one method in helping students come up with their project idea. Asimov and Fredericks (1990) suggest that students should peruse various research sources to find a topic. Specifically the school library, a university library, government agencies, local scientific laboratories, newspaper or magazine offices, city or county agencies or even mail order.

Romjue and Clementson (1992) provide a resource list with their science fair set-up guide. This list includes the library, newspapers and magazines, old science textbooks, professional journals and community resources all of which can be used to "inspire science fair projects" (Romjue and Clementson, P.24, 1992). It is interesting to note that all of these resources can be used to help in the research of a project as well.

Galen (1993) tells us that the "choice of a topic for scientific research is very important," and then continues with the ways and means he himself uses in the classroom. Essentially these amount to ISEF abstracts (a form of list), the student's own creativity, the student's previous year's project (giving the student two years to research and build up a project) and his own personal experience, yet he does not comment on their effectiveness beyond commenting on the success of his program, which includes 23 ISEF fair competitors (Galen 1993). There is no mention as to whether his tutelage is the cause of these winning projects, although it is implied. In Galen's case, he allows the students ability to determine where the question falls on the continuum. Goodman (1975) has his senior students narrow their topic choices based on their field of interest, choosing a topic from Biology, Physics or Chemistry. They could then refine their choices into some subset of that particular discipline, such as zoology. He also suggests that good ideas are available from such sources as articles in journals and abstracts. Goodman goes on to counsel the use of teacher directed whole-class projects as an alternative (Goodman, 1975).

Giese, Cothron, and Rezba (1992) suggest "a simple questionnaire asking students to identify their hobbies, part-time jobs, talents, science articles they read, or any science-related interests can help identify topics"(p. 32). As well, books on science tricks, demonstrations, popular magazines, science course-related materials, or lab manuals are other suggestions, once again allowing the student themselves to choose whether to lead or follow in posing a question (Giese et al, 1992). They submit that by "altering the variables" such activities could become unique, meaningful student investigations, essentially opening a closed-ended investigation.

Of course the students own creativity on coming up with a project idea cannot be discounted. This would seem to be the highest form of student-led investigation and creativity. Some would suggest that the student's ultimate motivation for doing the science fair is "an intrinsic interest in finding answers" (Giese, Cothron, and Rezba, p.32, 1992). Not only that but the student in experiencing the world is able to ask such questions themselves:

> Ideas for projects can be found everywhere. I frequently recall Gerd Somerof's story of a boy who, during a school trip to Broadcasting House, found inspiration for a project in the controls of the completely ordinary lift used to reach the studios. (Tawney, P.78, 1975)

Fields (1987) also supports the idea of spontaneous project idea generation. Wondering aloud about anything could be a research topic. As well, presenting a "discrepant event" (p.19) to students could spark the choice of a topic. Pearson (1976) stipulates quite clearly that there need to "be more ways to help teachers turn student ideas into projects" (p.30). Although the onus is on the teacher throughout the research process in this case, the onus is on the student for the topic. Wolfe (1994) also leaves his project idea choice open-ended, only stipulating that the students "explain or describe a scientific or mathematical principle or concept" (p.17). Knapp (1975) while dealing with the issue of fairs in the elementary grades addresses issues of relevance to all science fairs. He suggests that each child must select their own project idea, because "Children resist having to make forced choices from lists" (p.12)

Foster (1983) suggests that students contributing to a classroom resource centre on science may stimulate the idea process. Another approach taken by VanDeman and Parfitt (1985) is allowing students to have practice in asking questions, much as suggested by both Blume (1985) and Foster (1983). Fields (1987) presents an interesting viewpoint on the topic choosing. Within his fair the research taking place is group work, and the students actually share ideas and then choose the topic together. This form could add to the excitement as well as introduce cooperation and de-emphasise the competition issue (Fields, 1987). It could also involve guidance from the teacher involved and serve to stress the importance of teacher intervention. But by far the most innovative strategy involves a mentorship program, involving local scientists, giving students a chance to investigate "a wide variety of topics under the guidance of interested community members" (DeBruin, Boellner, Flaskramp and Sigler, p.20, 1993). In this case the variety is chosen by the researchers, yet the student has the final choice of which project to do from that variety. Alternative methods of project idea generation change depending on the situations at hand, yet these methods seem to be among the most effective.

One thing that is missing from most if not all of these articles is discussion of research on where students believe their ideas come from. This epitomizes the problems with most of the literature dealing with science fairs. The literature mainly consists of hypothetical help manuals dealing with theories of learning yet containing very little in the way of research results. Student comments found on this study's questionnaire show that the idea process is not as easy or clear as was originally thought. Some students were unclear as to exactly how they finally came up with their ideas. In several case more than one source was listed, possibly showing that ideas were discarded and new sources used, or that the original idea was modified by the second source. In Science and Children (Sebeck, Goergen, Loftus, and Larison,1976), students were given a chance to write on their experience. These students also found they changed their project's focus, that difficulty in obtaining information and materials changed topics, and that inevitably their interests, or suggestions from parents decided what they would do. All four of these children attended the district fair (Sebeck, Goergen, Loftus, and Larison,1976). The question of how and where students do their research is the next area of discussion

Research Methods and Concerns

This section involves the discussion of the various research methods used by students. Whether the project is experimental or non-experimental, they all require a substantial amount of research. Research for the purposes of science fair projects can encompass library work (Galen, 1993), textbook searches (Foster, 1993), teacher questioning (Galen 1993; Puskin, 1987), parental involvement (whether intended or not) (Burtch, 1983), magazine, and AV materials (Foster, 1993). Other materials to investigate are: "encyclopaedias, dictionaries, biographical dictionaries, atlases, pamphlets, records, newspaper files, maps, bibliographies, library card catalogues, audio and video recordings, almanacs, textbooks, graphs, brochures, magazines and professional journals, historical stories, photographs and art, charts, magazine indexes, public documents" (Rao, p.35-36, 1985). In fact almost anywhere that could have any information in the student's topic is a potentially useful place. Asimov and Fredericks(1990) concur, making varied suggestions for doing research outside the school library. They also suggest a number of individuals that the student can talk to. This suggests that students use many different sources.

Foster (1993) sees research in several stages, with "few investigations because most answers to simple questions can be found in books" (p.22). Using books or a library as a beginning to any research project is supported by Galen (1993) who finds that "local school libraries and public libraries are the best beginning sources of up-to-date information"(p.465). Some advocate not only that the school libraries be used, but insist on it. Such is the case with Hansen (1983), whose science fair sets up work areas at the school where all the project work must be done. The reason is simple, "to make sure that students (rather than parents) did the projects" (Hansen, 1983, p.10). Gifford and Wiygul (1992) disagree with this method saying that this action would put some students at a disadvantage, and remove their "equal and fair chance of winning in science fair competition" (p.117). They back this statement up with empirical evidence that shows that "access to a college or university and resource dollars appear to be the most important factors" (Gifford and Wiygul, 1992, p.117) for student chances of winning. A conclusion that could reasonably be drawn is that by insisting on local research methods, the chances that the student will be competitive at higher levels are lessened.

The fear of too much parental involvement is a real one. The question which arises is how much of this project is the student's and how much is the parent's. Pryor and Pugh (1987) sidestep this problem by making suggestions as to how parents can be of assistance, and in some instances inviting the parents to help out in the classroom during the project process. All of this serves to humanize not only science education but science itself. In fact one should not discount the importance of the family in helping produce a science fair topic. Sittig (1985) while relating her personal experiences with fair projects tells us as how the family had a meeting to determine the best way to undertake a given project idea while refining the idea itself. "Parental involvement is one of the hallmarks of every exemplary science program" (Pryor and Pugh, p.49, 1987). As to how much is too much, or proving that the child accomplished the project themselves, Henderson (1983) recounts the experience of one student who worked on his project with his grandfather, learning not only science but important family and personal skills. Cramer (1981) actually suggests using the parent as a resource person directly, and using what research and materials that are on hand. Other sources suggested include:

> education journals, basic science texts, experiment idea kits, trade books, TV and radio commercials, food and soft drink labels, cleaning agents, newspaper articles, and -of course- questions and ideas from students (Cramer, p.18, 1981)

These are suggested as starting points for research and ideas, leading to more specific sources of information. Hamrick and Harty (1983) also see the parents playing an integral role in the student's project process, and they wrote a primer to facilitate this.

Fields (1987) sees "seeking information . . . [as an] integral part of the scientific research process" (p.19). He has a set plan for research, one that requires some foresight and planning work on the part of the teacher, but also one which may offer a degree of success:

> Include a review of resources at some time in the planning stage . . . Have the students review the information in the school or local library, contact individuals in the community who have expertise in this area, or write to appropriate organizations for additional materials (Field, p.19, 1987)

In this case Field has encapsulated certain places that information can be obtained, essentially, the library, from knowledgeable people in that field, or appropriate organizations. These would fall within the categories specified on this study's research instrument and although structured to some degree, leave much to the student's own decisions.

Outside of the school there are sources that may be tapped by the student. Researchers and research centres that are near to their homes are one such source. Even within this type of assisted research there are many forms. The state of Iowa initiated the Iowa Junior Academy of Science (Glass, 1984) as a formalization of the process of student use of available researchers. This academy helps young researchers from before project planning right to the state fair level and beyond. Thus a built in support group exists to help students refine ideas, find resources and research sources, and when necessary link to the science community. Another method of involving members of the scientific community as resource persons could be a mentorship program. In Ohio, fifth grade science students are paired with researchers from many institutions in their general area allowing them to investigate in a tandem with the researchers (DeBruin et al, 1992). Essentially the resource person becomes the primary source of the research, with scheduled meetings taking place before the fair, so that all background materials and research can be checked and validated. Although this is an interesting method, and utilizing mentorships is also used by students going from the Canada Wide Science Fair to the ISEF, a mentorship is only possible where large institutions are readily available and where the researchers in question are willing to participate.

Not all locales can have this kind of support available, but each of them has one thing in common, a science teacher. The degree to which that teacher is trained, is interested, or has the time will determine the success of the fair. Within Wolfe's (1994) Science Expo, materials were the students' responsibility, but he set himself up as the resource person. Knapp (1975) in his treatment of the science fair in the junior high grades, presents us with a series of reservations about science fairs. These are common themes of why schools do not have science fairs, and several of them deal specifically with the teacher:

> I don't know enough science to help my children with a wide variety of projects. (p.11)
> I don't have enough time to help each child with a project, collect the materials, check on his progress, etc. (p.11)
> If I conduct a science fair I won't have enough time to cover the rest of the year's work in science. (p.12)

These problems must be worked out in each individual class. These selfsame arguments are probably being used in Newfoundland every year. The importance of teachers as a primary resource in the science fair project development cannot be overstated. The enthusiasm with which a teacher exhibits the plans for a science fair will determine the enthusiasm with which their students participate (Daab, 1988).

<u>The Experiment</u>

The realm of the actual experiment is the next area of inquiry. At this point, the use of the teacher as a resource becomes paramount. Pushkin (1987), Galen (1993), Foster (1983), Stedman (1975), Rivard (1989), Winicur (1989) and Hansen (1983) all expound on the importance of teacher/facilitator involvement in the experimentation process. Pushkin (1987) sees the teacher as a guide, which is much the same as Galen (1993) sees them. Foster (1983) views teacher involvement as helping "children develop ways of finding out what makes things happen, and what will happen if . . . " (P.22). Science as an activity is an important concept that students must understand if they are to be successful in their projects and Stedman (1975) sees teachers as the main focus of understanding. In Hansen's (1983) model the students have only the school as a resource, and in this case teachers become integral to the process. Hudson (1994), sees the teacher active even when students are designing their own investigation:

> Allowing pupils to design their own investigations will offer opportunities for them to develop many cognitive skills. It is important that pupils unfamiliar with this approach are **offered support and guidance** . . . Pupils will draw on previous experience and knowledge to help them carry out investigations . . . (Hudson, p.100, 1994)

Rivard (1989) has his teachers active throughout the entire project process, from idea to question to experiment, while Winicur (1989) needs a facilitator if her thematic approach is to have merit. The amount of this involvement determines where on the spectrum the research will fall. Clearly in Hudson's (1994) and Rivard's (1989) cases there is less structure involved while Hansen (1983) and Foster (1983) have their teachers introducing more structure to the research taking place. This treatment shows that the amount of structure is dependent on the teacher, how, when, where and why a teacher intervenes or contributes to a student's science fair project determines the amount of structure involved.

Essentially, research for background material in any science fair project, be it experimental, innovative or just purely non-experimental, must be done somewhere. It is how the material that is obtained from these sources is used that determines whether a project is non-experimental or not. Library, textbook, AV materials, magazines and mentoring are all aspects of a successful science fair experience, as long as what takes place is like doing science. McBurney (1978), Fredrickson and Mikkelson (1979), and Stedman (1975) all concur on this point. The process taking place for the project must be like doing science; getting background materials, up-to-date information, seeing if other experiments have already been done (Galen, 1993), using resources to help design experiments, and define variables are what science researchers do in the course of their experimenting. In these cases certain aspects of the research end up being quite structured, while the research itself may be entirely student-directed. This leaves us with the fact that all aspects of research, from non-experimental type to the innovation, are important to the student understanding of what it is to do science.

Other Important Issues

Mandatory versus Voluntary Involvement

Another difficult question dealing with the science fair is the question of mandatory versus voluntary involvement. Illinois' State Board of Education teachers' handbook on science fairs goes to some length to present both sides of this argument. Their arguments are encapsulated on the next page.

There is no consensus as to which of the two types are the best within the literature, but Riggins (1985a) does go on to support his favourite. He sees the mandatory fair as the best, with all students involved and with similar expectations, he believes that this will generate more peer interaction and possibly encourage some students to deepen their involvement in science (Riggins, 1985a).

Voluntary Participation

PROS	CONS
• easiest	• overall success of the fair may suffer
• small numbers	• need to promote
• positive student-teacher interactions	• lack of student involvement
• few parental complaints	• lack of other teacher involvement
• positive attitudes during fair	• lack of administration involvement
• no management problems	• possible lack of parental involvement

Mandatory Participation

PROS	CONS

• whole school involvement	• management problems
	  • location
	  • judges

• all cons can be overcome with good planning	• parental complaints
	• too much parental involvement
	• poor student-teacher interaction time

(Riggins, 1985a)

Locally, a number of examples on both sides of this argument have been seen. When the Bell Island Science fair began in 1993, all students from the school were required to participate. This resulted in more than 70 projects and 140 participant and a fair that the whole community became involved in. This mandatory involvement continues to this day and the fair continues to grow. At Holy Heart in St. John's the fair was mandatory for the Advanced Placement Students only, and this resulted in more than one hundred projects. It also resulted in a silver medal at the ISEF in Hamilton, and four CWSF medals (YSF, 1993-1995). This year the fair was changed to voluntary because of heavily committed advanced placement students (some were doing three or more of these college level credits) and a lack of enthusiasm on the part of the teaching staff. None of the students went to the CWSF this year (ENSFC, 1996). It is also difficult to argue with participation numbers such as the Murch Science Fair which included 116 projects and 350 students, and one of the reasons is that the principal required projects from the 50 graduating sixth graders (Fort, 1985). Fort

(1985) goes on to describe the exceptional planning and forethought that went into this successful venture showing the need for a science fair oriented staff. Clearly the resolution of this issue must be accomplished within each school depending on each set of circumstances. The entire matter is dependent on goals and on teacher commitment. Yet to follow the spirit of the curriculum guides rather than the letter, a science project should be undertaken in every science course, and mandatory participation in a science fair is the best choice.

Fairs or no Fairs?

The last area of contention for discussion does not have anything to do with ideas or research, but the question of whether a fair is the proper medium in which to display student work. The competitiveness of the fair may undermine its purpose, that of "developing a deeper appreciation and understanding of science by the participants" (Stedman, 1975, p.22). Cooperation amongst students in a fair setting is almost nonexistent, even though Stedman (1975), Winicur (1989), Paldy (1971), McBurney (1978), and Burtch(1983) stipulate that students working together are an important part of understanding science. More and more noncompetitive showcase nights (Scarnati et al, 1992) and science congresses (Paldy, 1971) are sprouting up to remove the competitiveness of the fair, and the resultant pressure on the student. Whether these are the future replacements of the science fair is not the issue but rather if they meet the needs of the students participating as well as a competitive fair. Liebermann (1988) sees the competition and recognition as a large part of the motivation for students doing science fair projects but Burtch (1983) offers much evidence to support the claim that noncompetitive fairs may be as effective, or more effective, than their contentious counterparts. Streng (1966) sees fairs in the elementary school being quite different from those in the upper grades. Essentially the judging process in the elementary grades should not be used as a grade or prize comparator but rather as a coaching type of experience. Concluding this argument is quite easy, for the versatility of the science fair, or the science expo, or the science showcase will solve most of the problems. Essentially a school science fair can be adapted to permit any student who has done a project to participate, even to the point of arranging it as an exhibition for the school day (Rao, 1985).

Summary

The area of study in this thesis deals with relating student sources of ideas and research to the outcomes of the science fair. There was no literature available that dealt with an experimental approach to studying these questions. Generally the science fair literature is a promotion of the fair, establishing that it can prove to be an excellent educational experience and meet many goals in science education. Using Wellington's Topology, as a student progresses through the school system their science fair experience will change. They should start near the teacher-led part of the spectrum dealing with questions with distinct answers, and a directed structured approach. This would be the non-experimental project years of "cookbook science," where the theme of the fair is as important as the projects themselves. The student over time will move along the various spectrums, until with minimal teacher intervention (expect this to be all at the beginning), they are attempting to answer broad questions about the world around them, following their own interests on their own time in their own way. This concludes the literature review.

Chapter 3

Design of the Study

This study consists of two distinct pieces of research, a survey and a test of reliability. The survey section attempts to delineate where top achievers at the science fair get their ideas and do their research. Top achievers, for the purposes of this thesis, are all those who receive a medal as a sign of their standing. Medals are awarded to students attaining higher than seventy out of a possible one hundred on a judging sheet (Wells, 1996b). The second part of the study consists of a test of reliability of science fair judging. The survey data collected will be compared to the final standings in the fair which in turn are reliant on the judging process. The test of judging reliability is to insure that this aspect of the data was reliable. The survey pilot study insured that the other aspect of the data, namely the survey and the results from it, were also reliable. A further discussion of the methods used for the test of judging reliability is found in the next section. The remainder of this section is devoted to the survey section of the study.

Survey Sites and Scheduling

The survey was administered on three occasions. The first was a full pilot study conducted at a local school fair to fine tune the instruments and insure the possibility of valid results in the main study. The pilot study site was chosen for expediency. Holy Heart of Mary High School is the largest school in Newfoundland, providing the possibility of ample test subjects at the fair. Also this researcher has been employed at that school for two years and is familiar with the structure of that local fair as well as most of the participants. Any large school holding a fair would have been sufficient. The second administering took place at the Eastern Newfoundland Regional Science Fair. This fair, held in St. John's each year, brings close to three hundred students together from various schools on and around the Avalon Peninsula. This was done for practical reasons. Since all the student participants were present during the judging process this proved the best time to administer. In some cases there was a long wait before judging, giving the students ample time to complete the questionnaires. A third administering of the survey was undertaken at the following year's science fair. Any regional fair in Newfoundland and Labrador would have been sufficient for the administering of the questionnaire.

Survey Design

A questionnaire was used to obtain as much information as possible within the time frame available. All of the items found on the student questionnaires were either chosen from the literature or obtained through informal conversations with teachers and students. The survey was also reviewed by an educator with extensive experience in the science fair area. The identities of the students remained anonymous with their project numbers being used as the only identifier. These numbers were compared with placement results from the ENSFC to determine each participant's final standing.

The Survey Pilot

The pilot of the survey was undertaken at Holy Heart of Mary High School at the time of their annual fair. Some sixty participants were present, along with twenty judges. The purpose of the pilot was to fine tune the instruments and to present a test of reliability for the surveys. The fine tuning was accomplished through informal consultation with students who had completed the survey and in some cases as they were completing the survey. Their suggestions, such as increasing the number of choices and leaving a space for other sources that were not present, were incorporated into the final design of the survey. A test of reliability of this survey instrument was possible through those students attending the regional fair from Holy Heart. Annually this school sends ten projects to the regional fair and these ten projects' participants have served as a test-retest form of reliability. Comparisons were made between major answers given from the first administration to the second. The survey had changed between administrations as a result of the feedback discussed above, and thus aspects which were dissimilar were ignored in these comparisons. In this particular case test-retest seemed the logical choice. Test-retests of this type are an excellent form of stability testing (McMillan, 1992), and help insure that the reliability of the instrument is sufficient. As reliability is "the degree to which a measure is consistent in producing the same readings when measuring the same things" (Slavin, 1984), it seems logical that all other things being equal, test-retest are the best measures to use. It was cost-efficient, as access was available to the students at their local fair as well as at the regional fair. The information gathered was useful and reasonably valid considering that there was a two-week time lag between testing, the same people were used in both cases, and only those questions that were present on both forms were compared.

The Survey - At the Fair

The survey was handed out to each student project area. Only one student in each project area was asked to participate. This resulted in some two hundred questionnaires, a large number of which were completed. The information on the questionnaires (see Appendix A) allowed a variety of questions to be addressed which is summarized below.

- Why do certain students do well at science fairs? - Central Question
  - Is the final standing of students a result of
    - where students get their ideas?
    - where students do their research?
    - the student's age level?
    - the student's category?
    - the student's project type?
    - the amount of teacher intervention?
    - the student's accessibility to the Internet?
    - a rural/urban living environment?

The major question to be investigated is why do certain students do well at science fairs. With the other data collected from the surveys, all of the available factors will be used to help in the determination of a possible answer to the central question.

Judging Validity and Reliability

The basis of the research question discussed in the previous section are the standings from the Eastern Newfoundland Science Fair. These standings of course depend on the reliability and validity of the judging process to be accurate and useful in a research sense. Thus a study is included into these questions to ensure that the main conclusions will be valid. In order to get a clearer picture of judging reliability, a description of what the judging process entails is necessary. The judging process in schools on the Avalon and at the Eastern Newfoundland Regional Fair are similar, differing mostly in scope. Therefore the discussion of one process will apply to both contexts. Judges are chosen on the basis of their scientific knowledge, although in smaller areas they are sometimes chosen for their prominence in the community. A case in point of this is the use of mayors in many small towns. In most of those cases the mayor has no scientific background. Most school fairs will have no more than two judges in a judging group. The Bell Island Fair, The Holy Heart Fair, and several junior high fairs are examples of this from the first hand knowledge of the researcher. Most local fairs in fact have trouble acquiring judges, and sometimes resort to using internal examiners. This is not the case at the regional fair, where judges are taken from all walks of life. There are still only three judges to a group at this level.

Once chosen, judges attend a judge's meeting which is held before the fair. At the school level this meeting usually takes place on the day of the fair and involves a cursory overview of the forms and what entails a good project. The Eastern Newfoundland Regional Fair has a more in depth process. The judging meeting takes place several days before the fair. At this meeting judges are assigned their respective duties and given student-written abstracts, called summaries, describing each project they will judge. An in-depth overview of the form and what entails a good project is also included. This prepares each judging team for the projects they are going to view in the next few days.

There are three types of judging forms used at the Eastern Newfoundland Regional Science Fair, one for experimental type projects, one for innovations and one for studies. The same is true for some of the local fairs. In the local case, the teacher is responsible for determining what "type" the project will fall into. At the Eastern Regional, students usually are responsible for determining their own project type, but that determination is evaluated by members of the governing council before the fair, to ensure it is correct. No matter which type of form is used, a judging form includes five parts, each dealing with different aspects of the evaluation. The first part is the only part that changes with the type of project. It is always worth forty-five marks out of the total one hundred, and deals with scientific thought. Four levels of this thought are identified and explained on the form. These explanations are different for each type of project available, defining each level in terms of experimental, innovative or study types of projects. Within each level there are ten extra discretionary marks to be awarded to projects that fall closer to one level than the next. The second part of the form, worth twenty-five marks, deals with originality and creativity. This evaluation consists of five statements with a five-point Likert scale after each. As is the case with all parts of this form, how much the judge thinks the project adheres to each statement determines the mark awarded on the likert scale. The next two parts, worth ten marks each, deal with skill and dramatic value. Each consists of four statements with two or three point likert scales. The final part, also worth ten marks, deals with the project summary. The project summary is that section of the project passed in with the registration form that allows the judges a chance to preview each of the projects they are going to judge. This section consists of five statements with one, two, and three point likert scales.

On the day of the fair, judges begin their judging by viewing the projects in the absence of students. This usually takes one to two hours. At local fairs this is very cursory, and quite brief. Once this is completed, the students are permitted back into the fair site and the judging interview takes place. Most judging teams will judge no more than seven to eight projects. This allows approximately fifteen minutes per project site. A large proportion of this time is used by the judges in asking questions of the science fair participant. Through this questioning, the preexamination, and the abstract the judges can ascertain what marks they think the student deserves in each of the five categories of judging. The remainder of the time at each site is utilized completing judging forms and tabulating marks. After all the judges' assigned projects are completed, they move to the judge's conference room to compare marks and general standings. At the local fair this process is usually undertaken by the fair conveners. At the regional fair the judge's discuss the projects they have rated and by the end of the judging process have reached a consensus about the best projects in each category.

This describes the process as it now exists and because of this, the test of reliability of science fair judging is the most difficult treatment mathematically because of the small number of raters within a particular group of judges. Any reliability test depending on large numbers of participants will not be possible.

> When evaluating reliability coefficients, it is necessary to examine the description of the manner in which they are obtained. We will obviously have more confidence in a reliability coefficient obtained from 200 students that we will from one computed on 30 students. (McDaniel, p.55, 1994)

As well, not all the projects are judged a second time, and those that are, are usually among the highest achievers within the first judging. Finally, in an effort for consistency, all the forms used by judges must be the same. An example of the judging form is found in appendix B. It should be noted that this form is nearly identical to the form used at the Canada Wide Science Fair and that the Eastern Newfoundland Science Fair Council has adopted this form as their official one. This was done for several reasons. Firstly there is some effort for consistency between the National Fair and the Regionals. Secondly a standardized form ensures that all judging results will be comparable. Thirdly the original design of this form was felt to be sound and preferred by judges to more detailed forms. Finally, and perhaps most important, the form reflects what people think is valuable in science fairs. With all judging forms the same, small numbers of participants to test, and the lack of a formal second judging, such common estimates of reliability as the Kuder-Richardson Method, the Split Half Method, the Test-Retest Method and the Alternate-Form Method (Oosterhof, 1994) cannot be used to estimate the reliability in this case. The only possible estimate is the inter-rater method.

Oosterhof (1994) stipulates that "when students' responses must be subjectively scored, [a useful practice], is to involve more than one rater" (p.80). This is the standing practice of the judging for the Eastern Newfoundland Science Fair. But this use of more than one rater brings internal inconsistencies to light that might not have been seen with only one. Such sources of error are encapsulated below from Mehrens (p.190, 1991).

1. The halo effect
2. Generosity error
3. Severity effect
4. Central tendency error
5. Bias
6. Logical error
7. The rater's attitude

Oosterhof (1994) describes the inter-rater method as a way to detect the inconsistency between more than one rater:

> Basically, two or more teachers independently score each student's performance and obtain two scores for each student. The correlation coefficient is then computed between the teachers' scores. (P.85)

Within this inter-rater comparison, a Pearson coefficient is calculated by using the scores from each of the judges, in each of the sections. Judging groups will be selected at random, and will be followed through all the projects that they rate. To be able to estimate a high reliability for the judging process, a high correlation between the individual judges in each group is necessary.

The intention is not to prove that this form of judging is unreliable, but to ensure that it is the most reliable system available and in turn, that the results of the fair are also reliable. The population base of this area may make it unreasonable to change the process. An example of a judging process that would be easier to prove as reliable from available literature such as Oosterhof (1994), (McMillan, 1992), and (Slavin, 1984), would involve multiple ratings of the same projects by different judging groups. It would also involve a more rigorous statistical analysis to downplay any inter-rater unreliability. A scenario for this process would involve, judging groups of five judges, numerous enough groups to judge every project twice, the use of statistics for results within a judging group to determine the standard deviation and then dismiss any score either one deviation higher or one lower, and the use different judging forms for reliability testing. Although this solution does not guarantee reliability, it would allow more rigorous reliability testing, but introduces another problem. For a fair of two hundred projects within the time frame currently worked under, the number of judges required would be in excess of two hundred and fifty. The only other option available would be to extend the fair length, but at the current number of judges (approximately forty-five) this new option would take approximately 675 minutes or eleven hours of judging. Neither of these two options is realistic nor implementable.

Along with the inter-rater calculation of correlation and estimate of reliability there is also a need for some estimate of validity if this reliability is to have any meaning. There are at least two kinds of validity involved here. One is validity in the construct sense. The key question with this type of validity involves the intellectual coherence of the judging form. The form used by the Eastern Newfoundland Science Fair is strongly based on the form used at the Canada Wide Science Fair. It has the same categories, the same mark weighting, and the same basic structure. It is in fact the form used at the Canada Wide Science Fair in 1989. That judging form was constructed by the judging committee of the Canada Wide Science Fair. It has been modified over the years of its use by various experts in the science fair area, namely the chief judges at the annual Canada Wide Fair. In this sense the form is well validated.

The second form of validity to be discussed, is validity in the predictive sense. An estimate of this type of validity can be obtained by comparing the regional judging to that of the national fair. This would include a comparison of the regional judging with respect to the judging of the other regions in Canada and the national fair itself. In all cases those who attend the Canada Wide Science Fair are the top projects in each of the regions. Thus when this region's projects compete against other regions', a comparison between their judging is automatically obtained. As well, in terms of validity, how much the national judges agree with Eastern Newfoundland's is a test of the predictive validity. The conclusion from this is that if Eastern Newfoundland's projects do as well as or better than other regions, then this region's judging should be valid in the predictive sense. It must be noted that formal predictive validity assumes reliability and cannot be numerically larger than the reliability measure.

Data Analysis and Reporting

Within this context, the process of data analysis and reporting is quite simple. The most difficult and therefore the most controversial part of the process is the generalizing of answers. When an open-ended question such as this is used on a questionnaire, students have the freedom to use a wide range of language to essentially describe the same things. To aid in the study of these answers, general categories for each of the student's answers are needed. This is predetermined in the idea source and research source categories, but is not necessarily the case within why each source was chosen. The following generalizations were used for those answers:

In the why certain idea source's category -

1) easily accessible;
2) modified existing idea source (whether it is a previous project, a teacher list etc.);
3) wanted projects to be original;
4) most available sources;
5) personal interest;

were the most often used generalizations. These generalizations were used to describe student responses that were quite similar. For instance, the generalization of "wanted projects to be original" was used for "I wanted my own idea for a project" and "I wanted to use my imagination for my project and be creative." In my opinion these are clearly the same answers to some degree, just expressed in different terms. In some cases where no generalization would fit, the actual student answer was listed. Examples of these answers are:

1) taken from a science project book in a library;
2) on the job experience;
3) parental career.

Of course because they were mostly single student answers, they all tended to be statistically insignificant. They were used as examples for special circumstances.

Data Analysis was undertaken through the use of a database program. After data entry was completed and all generalizations accounted for, a series of data charts was created to examine and observe certain statistical tendencies. Comparisons were made between the major factors such as age, category, project type, rural/urban, project idea source, and research sources and the final medal standing of each group. Other comparisons that were made, included the reasons for the use of certain ideas, and research sources themselves. All of these comparisons were done in graphical form with the percentage included in all cases. The purpose of the former comparisons was to see if any of those factors had an effect on the overall standing of the student. The purpose of the latter comparisons was to see why certain students used certain sources. The intent is to contrast the two sets of comparisons and from this determine the most useful pathway for improving student achievement and learning at the science fair.

The correlational coefficients compare the results from judges that have judged the same project. Copies of the official judging form are found in appendix B. As can be seen from this form, there are several areas that can be used for comparison. A total of eight judging groups were selected for this treatment constituting close to 20% of the judges as a whole. They were selected randomly on the basis of project number with that number being obtained from a random number generator. Once selected, each judging group was tracked through all the projects that they had judged. This allowed for average correlational coefficients to be calculated for each particular judging group. Within the form all the categories of judging would be compared for each project number. Currently there are five parts to the judging form, with two of those parts having five subsections and two of them having four subsections. It was decided that the inter-rater calculation would be based on the marks for each judging subsection. This should allow a fair estimation of the correlational coefficient and insure that the calculations are reasonably correct. The correlation raw data is found in appendix D.

Chapter 4

Data Analysis

The previous chapter set down the process that was undertaken to acquire the data for this study. Within this chapter we will look at the results of the surveys, the calculation of reliability for the judging process, and the establishment of validity for the judging process.

Results of the Surveys

Of the two hundred surveys handed out at the 1996 Eastern Newfoundland Science Fair, one hundred thirty three were returned with their permissions completed. In 1997, an additional two hundred surveys were distributed, of which only fifty-six were returned. All of the information was entered into a database and a series of summary charts were created. Those charts and the information they represent are found on the following pages. The data collected from the two different years was subjected to a t-test, to insure that no statistical difference between the two data sets existed. There was no statistical difference found, at the $p=0.10$ level, either in the idea sources or the research sources. This allowed the data to be combined in one set.

There are a number of issues that were raised in the literature that can be dealt with from this study. Those include lists and texts as idea sources, parental involvement, and non-experimental projects versus experimental projects. Other questions were raised in the previous chapter as aims of this research. A reproduction of those aims is found on the page below:

- Why do certain students do well at science fairs? - Central Question
  - Is the final standing of students a result of
    - where students get their ideas?
    - where students do their research?
    - the student's age level?
    - the student's category?
    - the student's project type?
    - the amount of teacher intervention?
    - the student's accessibility to the Internet?
    - a rural/urban living environment?

All of these questions will be addressed in the following pages.

The first set of charts to be examined deals with idea sources. The question of where students get their ideas is important to the central question of the thesis. The first chart deals with the breakdown of the entire fair group, while the second chart deals with only the idea sources of the medal winners. A key to the individual abbreviations is found after the charts themselves.

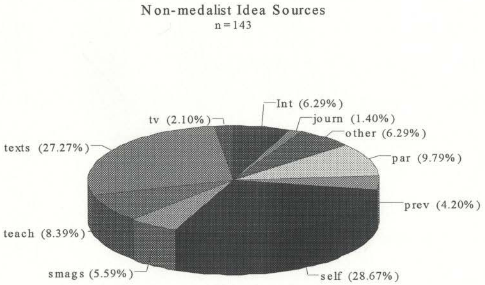


Figure 2

Medal Winner Idea Sources
n =46

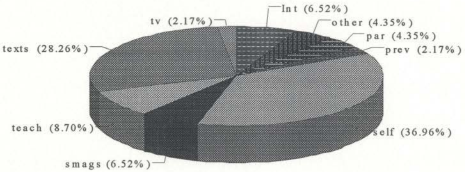


Figure 3

Abbreviations:
texts = textbooks; **tv** = television; **Int** = Internet; **journ** = scientific journals; **par** = parents; **prev** = previous project; **self** = self creation; **smags** = science magazines; **teach** = teacher sources

These graphs show the relative differences between the medal winners and the fair group as a whole. The size of the general fair group was 189, with the non-medalists at 143, while the size of the medal winner's group was 46. These of course were the students who answered the questionnaire. The two main areas of usage here are self creation (self) and textbooks (texts). Taking the percentage value of self generation and textbooks directly a χ^2 comparison of these areas show no significant difference to p=0.7967. Self-creation and textbooks then do not play a statistically significant larger part in the idea generation of the medal winners than of the regular fair group. That does not make these results less educationally significant, but does make any differences seem to be caused by chance. Increases in the percentages of self creation and textbook use are the only visible signs of differences. Most of the other percentages including the Internet, television, teacher sources, science magazines, and previous projects sections were almost identical. Some differences were noted within the other section and the parental sources section but because of the small percentages involved they were deemed insignificant from a practical as well as statistical point of view.

The next charts examine the reasons why students use these two sources of textbooks and self creation most often. This was examined from the group of students who named self-creation and textbooks as their most used source for idea generation and once again separated along the lines of medal winners and non-medal winners. This differs from the previous chart as being an examination of differences of students within a particular area of idea generation. The self-creation group consisted of 58 participants total, 17 medal winners and 41 non-medal winners. The textbook group consisted of 52 participants total, 13 medal winners and 39 non-medal winners. Similar answers were grouped when possible.

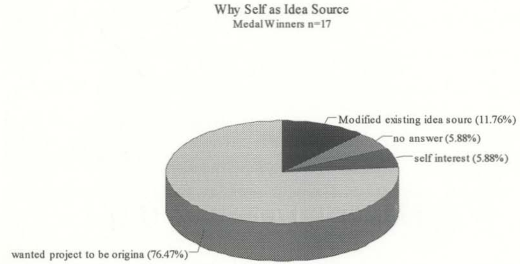


Figure 4

Within the self generation area amongst medal winners, wanting their project to be original is the most prevalent reason for coming up with their own ideas. As could be expected, ease was not an important factor for these students. Most would consider self-generation of project ideas to be quite difficult. Within the non-medalist group wanting the

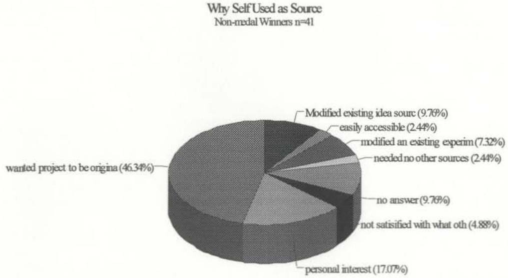


Figure 5

project to be original was also the most prevalent, but not to the degree that it was in the previous chart. In fact the difference in this prevalence was significant to the p=0.001 level.

Within the area of texts as source much the same results manifest themselves. As seen below, ease of access is the most prevalent on first inspection, but modification of either experiments or the source itself when taken together actually are the higher percentage. These two categories were quite close in intention and meaning, leading to approximately 46 percent of medal winning students choosing modification while only 30 percent opted for ease of access.

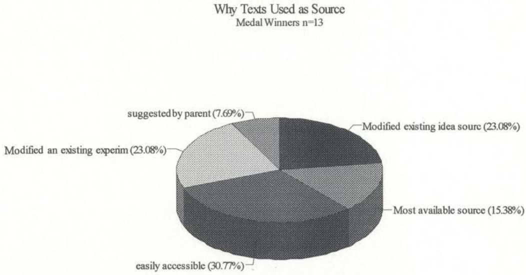


Figure 6

The chart dealing with why texts were used as the main source for the non-medal winner group show some differences. The ease of access is clearly the most prevalent even when combining other categories is considered. A statistical analysis shows that this difference is significant to the p=0.014 level.

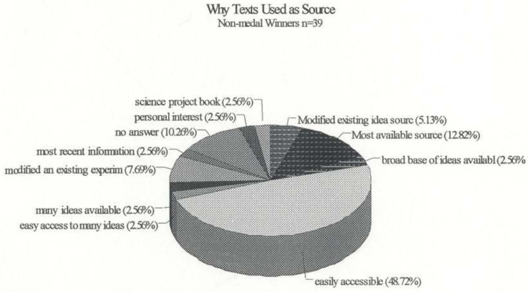


Figure 7

The next charts deal specifically with the area of research. The first chart concerns the non-medalists with 143 surveyed, the second the medal winners of the fair with 46.

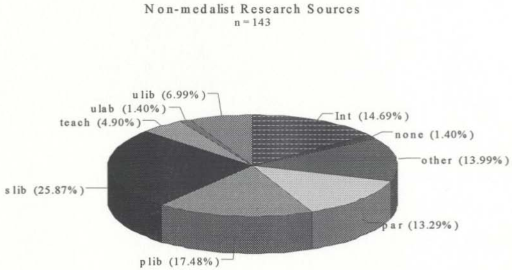


Figure 8

Abbreviations:
slab = school laboratory; **slib** = school library; **teach** = teacher sources; **plib** = public library
ulab = university laboratory; **ulib** = university library; **Int** = Internet; **par** = parental sources

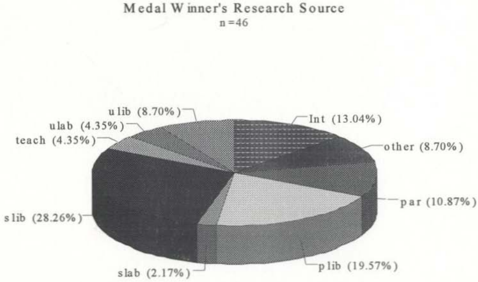


Figure 9

The school library and public library were clearly the most predominant in the first chart. Other important areas to note include the use of the Internet at 14.29%, parental sources at 12.70%, and the university library at 7.41%. These would form the most important sources of research given the numbers of students involved in this study.

Within the medal winners chart, school and public libraries are predominant once again and in fact are of higher percentage value than the previous chart. A direct comparison of these four values using χ^2 yielded a p=0.8660, clearly statistically insignificant. Even without statistical significance, and taking each section separately the libraries, both school (slib) and public (plib) play a large role in the research undertaken by these students. To study these large roles, analyses of the reasons behind student use of these sources are necessary. The next charts deal specifically with this area. The charts are broken down along medal winner and non-medal winner lines with the number surveyed for school libraries at 50 and for public libraries 34.

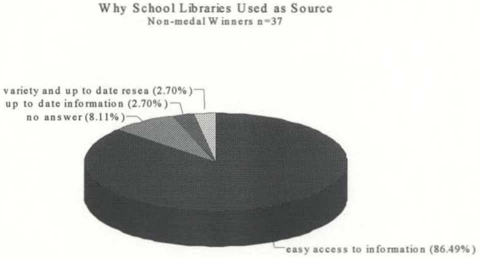


Figure 10

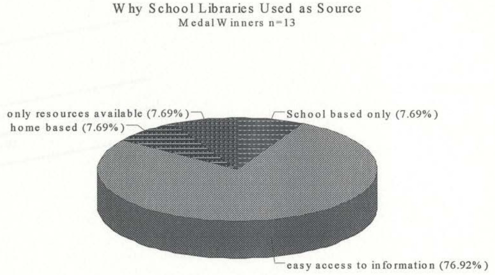


Figure 11

The predominant factor in both these cases is clearly the ease of access for their research sources rather than any other reason. Although a lower percentage was present in the previous chart, it was not found statistically significant to the p=0.10 level using a χ^2.

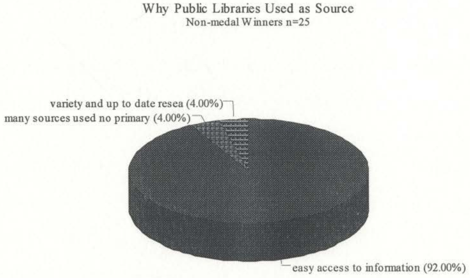


Figure 12

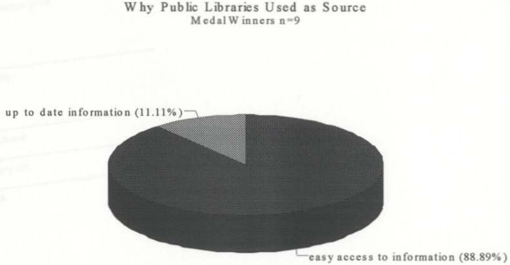


Figure 13

Ease of access to information was the majority answer in the public library chart as well. Once again, all remaining answers consisted of a single answer in each category. A summary of both these charts show that students are looking for the easiest route to doing their research. There was no statistical significance present in their differences.

Our next area of study involves the student's age level. Two charts shown on the next page were developed to deal with this area the first for non-medalists at 143 participants and the second for medal winners at 46. In this particular case student age level is determined by their judging level. Junior (jun) is defined as students in grades seven and eight, roughly between the ages of twelve and fourteen. Intermediate (inter) is defined as students in grades nine and ten, roughly between the ages of fourteen and sixteen. Senior (sen) is defined as students in grades eleven and twelve, roughly between the ages of sixteen and eighteen. There was no statistical significance to these results as χ^2 was less than 1 with a p value greater than 0.3. An interesting result of this part of the study shows that a higher percentage of seniors and intermediates win medals than the juniors. This result lends credence to the fear that the quality and high standing of the Eastern Newfoundland Science Fair may be falling because of a decrease in the number of senior participants.

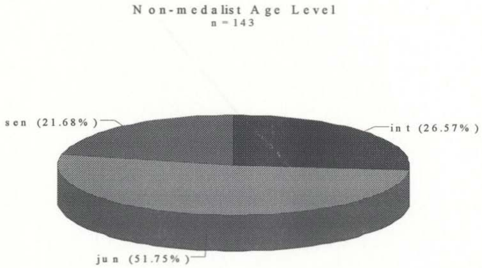


Figure 14

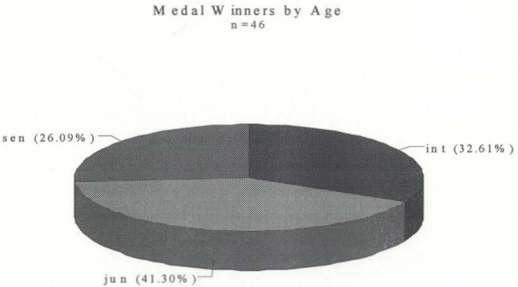


Figure 15

Next on our list of issues to explore is the category of the individual projects. Once again the first chart deals with non-medalists at 143 and the second with medal winners at 46. The categories are Physical Science (ps), Life Science (ls), Engineering (e), and Computer Science (c).

Non-medalist Category
n = 143

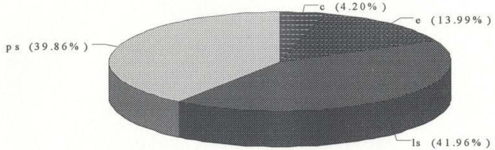


Figure 16

Medal Winners by Category
n = 46

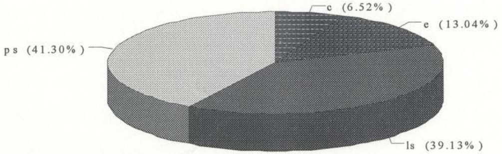


Figure 17

The values are almost identical yielding a χ^2 result of less than 0.1 with a p value close to 1. There is no statistical significance in their differences.

The next charts deal with the issue of project type. It is in this area that non-experimental versus experimental project types will be examined. The three types of projects are experimental (e), innovation (i), and study (s). The latter two are by definition non-experimental types of projects. The first chart deals with the non-medalists at 143 and the second with medal winners at 46.

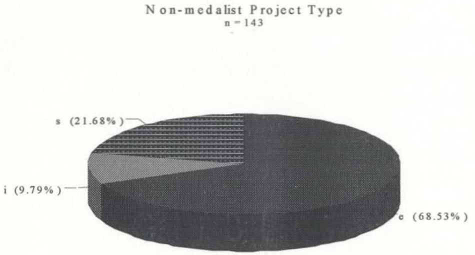


Figure 18

The charts show quite clearly that the predominate type of project is experimental. The study did not focus on this area so no reason is available but a speculation is that the normal science teacher would be looking for something dealing specifically with the scientific method. As well many students seem to lean in this direction. A χ^2 yielded no significant difference between the two groups with a value less than 1 and p greater than 0.6. No obvious discrimination towards non-experimental projects is present.

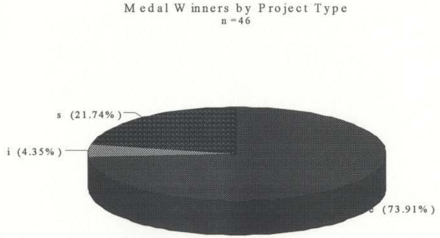
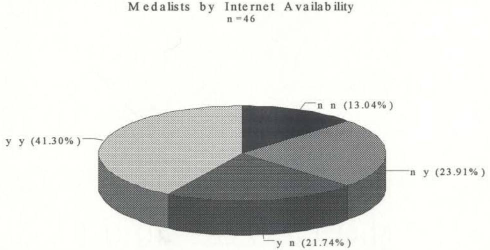


Figure 19

The next set of charts examines whether students' accessibility to the Internet plays a role in their final standing at the science fair. There are several areas being looked at in this section. The first is the comparison between non-medalists and medal winners with regards to accessibility.



Abbreviations:

Figure 20

yy= Internet available at school and home, **yn**=Internet available at school not home
ny=Internet available at home not school; **nn**=Internet not available at school or home

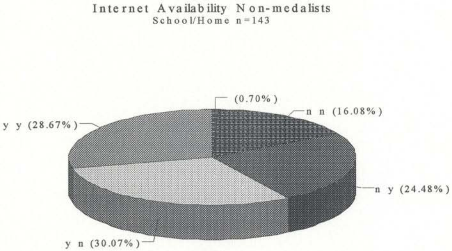


Figure 21

A χ^2 comparison of the categories yielded a p value of greater than 0.20 showing that the differences shown were statistically insignificant. The small amount of difference shown, especially amongst those who had no access to the Internet is also practically insignificant. The next chart is a comparison of idea sources between the two years of the study.

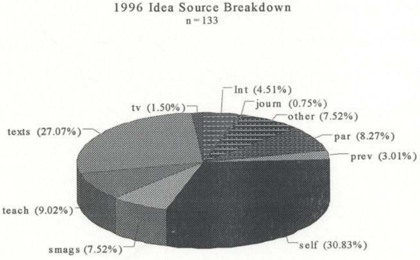


Figure 22

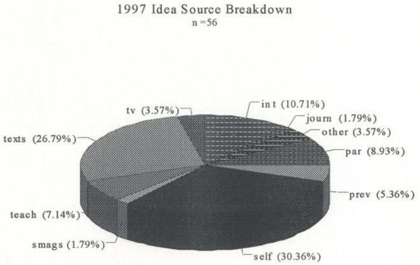


Figure 23

Abbreviations:

ulib = university library; **Int** = Internet; **par** = parental sources; **plib** = public library; **slab** = school laboratory; **slib** = school library; **teach** = teacher sources; **ulab** = university laboratory

Within this breakdown, there is little change between years. A χ^2 calculated for these two groups yielded a p value greater than 0.60 showing no significant difference found. Without statistical significance there can still be practical significance. The point of interest within the first chart is the Internet value which stands at 4.51%. The next year's chart, shown below the 1996 chart, reveals a marked increase in percentage of Internet usage. That increase was to 10.71% in 1997. A χ^2 test of this difference showed that this was not significant to a p value of 0.25, but considering other evidence, such as the increase in access of the Science Fair Homepage and the increase in availability of Internet for students at the school level in Newfoundland the difference may have an educational significance.

The final charts in this section compare Internet availability between 1996 and 1997.

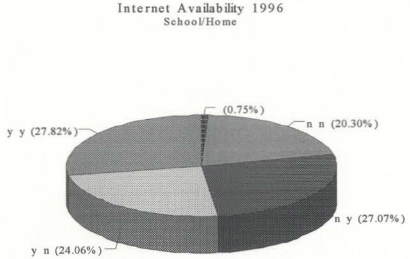


Figure 25

Abbreviations:

yy= Internet available at school and home, **yn**=Internet available at school not home
ny=Internet available at home not school; **nn**=Internet not available at school or home

The lack of access at either the school or home is almost nonexistent in the second year when compared to the first. Using χ^2 the difference is significant at the p=0.004 level. This may serve to explain some of the differences observed above.

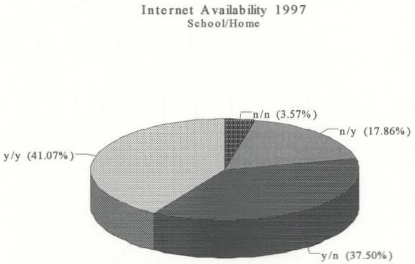


Figure 24

The next charts deal specifically with the rural and urban questions within the literature. Gifford and Wiygul (1992) stipulate that access to resources affect the final standing of students. Within this study rural and urban differences are one measure of this access difference. A comparison of proportions of urban and rural medal winners to the proportions of rural and urban participants in the survey is found below.

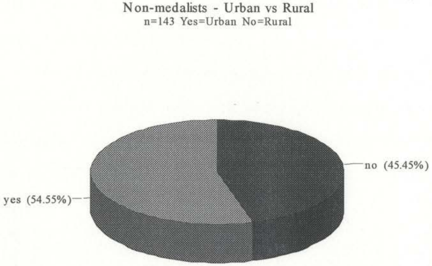


Figure 26

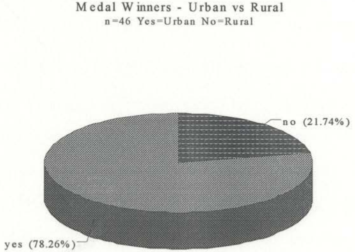


Figure 27

The graphs show the distinct difference in the final standings of rural and urban students. Clearly the urban students are winning medals more than three times as often as the rural students. These results become problematic when compared to the statistics for non-medalists. A χ^2 of these results show significant difference between these two instances at the p=0.05 level. We cannot dismiss this difference as being an aberration nor can we simply attribute it to a lack of resources. It was expected that the other centres remained close enough to the city to utilize its facilities.

The final information to be garnered from the survey portion of this study involves the time students spend on their science fair project and where they spend it. The survey allowed students to write the time they spent at school, at home, at the library, and in other locations. A comparison of these times broken down by rural/urban living environment is found in the chart below.

	Count	Hours School	Hours Home	Hours Library	Other	Total	per stud
Urban	114	294	4055.5	367.5	221.5	4938.5	43.32018
		5.95%	82.12%	7.44%	4.49%		
Rural	75	277.1	1624	141.1	96.5	2138.7	28.516
		12.96%	75.93%	6.60%	4.51%		

Table 1

Time spent at school constitutes less than thirteen percent of the total time spent on projects. The home is clearly the most prevalent location for student's doing their projects. The per student values for urban and rural are statistically significant. As well the difference in the percentage of time spent in the schools was also statistically significant. The amount of teacher intervention into a project could be directly related to this figure and this figure will be used as a measure of that intervention. Several of these factors may offer some explanation of why rural students did significantly poorer than their urban counterparts.

Establishment of Reliability

The reliability of the judging was measured by the correlation between the judges in each judging group. If the marks of the two judges correlate highly over a series of projects, then considering the aspects of inter-rater reliability which we are studying, the process should be highly reliable.

The judging groups were selected at random and followed through all of their project judgings. All of these groups were correlated on the basis of the scores they awarded on the five main sections. Below is found the entire results table.

Pearson Results Table

Project #	1	2	3	4	5	6	7	8	9	10	Averages
Judging Group 1	0.6147	0.976	0.902	0.95	0.949	0.92	0.98				0.8988
Judging Group 2	0.9557	0.989	0.988	0.997	0.983	0.969	0.98	0.992	0.981	0.983	0.9819
Judging Group 3	0.9891	0.878	0.948	0.99	0.852	0.688	0.955				0.8998
Judging Group 4	0.8511	0.388	0.876	0.878	0.915	0.915					0.8040
Judging Group 5	0.9772	0.987	0.994	0.991	0.999	0.995					0.9905
Judging Group 6	0.9444	0.799	0.92	0.758							0.8554
Judging Group 7	0.9703	0.999	0.991	0.992	0.909	0.991	0.983	0.88	0.978	0.983	0.9675
Judging Group 8	0.9936	0.997	0.974	0.999	0.994						0.9914

Table 2

The data shows a high correlation between judges in most cases. Several of the judging groups had greater than 90% correlation present at all times. A closer look at the table shows that some of the groups had high correlation overall yet still had one or two instances of low correlation. Although not significant overall these aberrations show that the judging system needs constant monitoring to insure good results. The correlations as a whole were of high enough quality to establish that the judging is very stable within a judging group. One factor not dealt with in the correlation is error introduced through the judging form itself. The judging form introduces some problems from a correlation point of view. Part A is marked on a scale of four, which in turn translates in a mark from five to forty-five. Large mark discrepancies are realized from this design even though the correlation would still be high. The alternative of awarding the entire forty-five marks based on some other criteria introduces even further problems in the process, and will lead to lack of correlation between judges.

Another factor not dealt with in the correlation involves evidence that was discovered during the tabulation of the judging scores. Although there was a high correlation between judges in a judging group, in some instances there were significant differences in their marks and their decisions for final standing. Inspection of the forms showed that within some judging teams the rating varied from a silver from one judge to no medal from the other. The average mark is then taken and the project receives a bronze. What aspect of the process, what inherent error factor caused this discrepancy? This has significance from the regional level, but becomes paramount at the local level where only one judge per group is the norm. If an average is taken to determine final standing at the end of the process, then a more efficient method may involve a consensus approach on certain parts of the form. Considering the value of the first section and how it is determined, a simple way to reduce variance introduced by the form, and by individual differences, is to obtain a consensus mark on part A. This should produce an even more stable result on the judging form. The validity of this stability will be set in the next section.

Establishment of Validity

Predictive validity in this case is begun by looking at the results of the Eastern Newfoundland contingents to the Canada Wide Science Fair. These results must be studied, bearing in mind one factor, that at all levels the top achievers move onto the next level. Each High School sends its best to the regional, each regional has as its top award the trip to the Canada Wide, and the Youth Science Foundation sends only the best to the International Science and Engineering Fair. Thus, being chosen to represent Canada at the ISEF is the highest award possible at the Canada Wide Science Fair. Below is a breakdown of the Eastern Newfoundland Regions standing for the last three Canada Wide Science Fairs.

1994 -	1995 -	1996 -
eight participants	eight participants	six participants
1 gold	1 gold	1 gold
1 silver	1 silver	1 team Canada selection
1 bronze	1 honourable mention	
1 team Canada selection	1 Manning Award	

The results speak for themselves. There was an average of at least 600 participants in the Canada Wide Science Fair every year mentioned here (YSF, 1996). On a participant basis, Eastern Newfoundland captured one of twenty positions on Team Canada or the equivalent for the last three years. The region constituted less than 1.35% of the participants in 1994, and captured 5% of the available top awards. 1995 saw much the same results, even though there was no Team Canada selection awarded. Eastern Newfoundland's top participant won the first Manning Award ever won by a Newfoundlander. Members of the selection committee intimated that this same student would have been selected as a Team Canada particpant had he not been too old. Hence it is logical to assume that the ability to attend the ISEF except for age would still constitute capturing a five percent of the available top awards. 1996 saw a constituency of less than 1% and again a capturing of 5% of the available top awards.

Looking at Eastern Newfoundland as a region it only constitutes less than 1% of the whole, there being between 100 and 108 regions. Once again Eastern Newfoundland winners have captured more than their expected percentage in top awards even under this comparison.

Clearly these results show that Eastern Newfoundland Science Fair winners obtain per participant, a higher percentage of the top awards at the Canada Wide Science Fair. Taking this one step further these results should show that the process that sent these students to the Canada Wide Fair must be valid, not only when compared against the Canada Wide Fair results, but also when compared indirectly with the results of other regional fairs across Canada. At this point it is interesting to note that Eastern Newfoundland's participant in the International Science and Engineering Fair of 1995 won a Silver medal as part of a Team Canada that took proportionally more awards home than any other country including the United States.

Chapter 5

Conclusions and Implications

The fourth chapter of this study presented the data in its raw and summary form. This chapter will look at what that data actually means, and what ramifications this has for science fairs, science curricula, and science teachers.

Summary of Data

The data as a whole allowed a glimpse into the motivations and sources students use in their science fair experience. Addressing the central question of the research of 'Why do some students do well at science fairs?' involved many aspects and a large amount of data. Although some of the results were expected and generally accepted as true prior to this research, other results may serve to change the way science fair projects are looked at and how preparation of students is undertaken. Not unexpectedly medal winners at the fair used self-generation of ideas predominately. In fact the whole fair group used this source most often. The unexpected result was the next most popular source for ideas, textbooks. Textbooks as idea sources are discussed in the literature as "non-science," similar to a teacher generated list, "cookery-book science" or rote science. That a practically significant number of medal winners would utilize this source was not predicted.

Research sources held few surprises nor did a look at the effects of variables that should not have determined student standing, such as category and age. In all these cases the results supported the prevailing viewpoint. Surprisingly, and contrary to the literature, non-experimental projects did not seem to be duly prejudiced within the judging process. Other findings involving the use of the Internet and the availability of the Internet showed that they had little effect on the fair standings although according to the literature some of these factors should have played a role.

The study of rural/urban relationships at the fair revealed possible inequities and drawbacks to coming from a rural area. Although this is somewhat unexpected given the general proximity of the rural schools to a major center, the literature does support such a difference. Some explanation can be found when looking at project hours and their location. There were some interesting results showing some difference between the amount of time spent on projects on a per student basis between the rural and urban groups. Although it was expected that less time would be spent in libraries and more at home by the rural students due to transportation factors, this was not the case to a statistically significant level. What was the case was that less time was spent on projects at school for urban students possibly signifying less teacher intervention for that group or perhaps more help at home.

The Pearson Correlation study of judging groups yielded interesting results as well. Some of the judging groups maintained a high correlation throughout, while others seemed more arbitrary. Marks fluctuated wildly in some cases, with more than 20 points in the difference. This was true even within groups with high correlation results. More consensus is required on certain aspects of the judging form to insure that the correlation between judges is high.

and the use of the scientific method, it could sometimes be about thinking, reasoning, and working beyond the work of others. Along with teaching students how to design experiments that are original, there seems to be a need to teach students how to adapt existing work, to change rote experiments, and to go beyond the expected results. Lieberman (1988) suggests a way to incorporate these findings into every day teaching. We use lists, textbooks, previous experiments, and journals for sources but we cannot allow the students to replicate the work. They must expand, go beyond, generally increase the body of knowledge in the area they have chosen. This could allow for the use of relatively easy methods for project idea generation without reducing the quality of the work being produced, rather in some cases possibly improving it. That is not to say that we limit students to these sources, for in the end they must undertake the project.

From a self-generation point of view the problem that seems inherent in our system is the lack of experiments to which the answer is not commonly known. In my experience, teachers will frequently tell students what it is they are expected to see. It seems to be rare for students to be asked to modify an experiment or suggest how it could be done differently. It could be argued that some students are not capable of this exercise. On perusal of course materials most of the experiments in the schools appear to this author to involve little more than filling in the blanks. Even when a student is asked for a formal lab report the form of the report seems to be dictated and straying from that form is penalized. How then can a student be asked to be creative on a science fair project that may be marked by the same teacher? Is our allegiance to the set pieces of the scientific method misplaced? Are we stifling the creativity of our students by asking them to conform to this in their projects? The answer to these two questions cannot be directly addressed through this research but inspection suggests that experimental projects still dominate the medal standings and the judging form is weighed heavily in favour of the scientific method.

What this means for teaching is simple in thought but not in practice. Teachers should try to incorporate more questions into students' learning. VanDeman and Parfitt (1985), Blume (1985) and Foster (1983) all suggest that students need practice in asking questions. Rivard (1989), set down a process for teacher's to bring out their student's natural questioning ability. Foster (1983) had a process that also helped his student's to ask "questions about the world around them." Strategies such as these could be useful in supporting the creative student. The next logical step would seem to be to have them design methods to answer the questions. As mentioned before very little student design of experiments appears to be incorporated into the existing course offerings. The first steps need not be complicated just simple methods to answer simple questions. Over time the development of the students' skills may allow for development of experiments in support of taught theories. The junior high grades with their time allocation for science fairs could be the logical place to start this process, but it must be continued and reinforced throughout the students' high school education as well.

Research Sources

The lack of statistically significant differences between the research sources of medalists and non-medalists is significant in itself. The literature had supported to some degree the existence of those differences. Within this study it can safely be concluded that research sources have no effect on the final standing of the fair. Hence suggesting to students that they seek out their research in such areas as they can find would be the safest course. It would appear that teachers need not search out new sources to give their students a reasonable chance at the science fair. Of course it is what the students do with the research that is important. Some students will require assistance in the finding, gathering and disseminating their background research. In the author's opinion science teachers must start pooling their resources with teachers in other disciplines who are themselves developing such skills in students. If a school were to take a unified approach to the science fair the work load requirement of the science teacher would probably be of acceptable levels, and allow a whole curriculum approach to a specific project.

The one area of research that had statistical difference involved the availability of the Internet. Medal winners had statistically significant more access to the Internet than did the non-medal winners. Although this did not manifest itself within the research sources themselves several reasons present themselves as to why this may be the case. One is that students may not recognize the Internet as where they got the initial 'idea' for their projects. A second is that students may have used the Internet to point them to sources that they could then find elsewhere. The third could have been a survey design problem involving the use of the Internet at the public library or the school library. That the Internet could be used as a science fair research tool is quite clearly illustrated in the number of accesses to the Science Fair Homepage.

Little or no research has been undertaken to discuss the use of the Internet as a science fair research tool. The results showing the increase in availability from 1996 to 1997 lead to a conclusion that there is a need for a closer look. To a certain extent, the web may be compared to a text-type, or list-type of idea procurement. The literature is not kind toward these types of resources labelling them as "cookbook experiments," and "nonscience" (Wollnough, 1994). The Internet may go beyond these limited resources within the area of mentorship. The author received some one hundred and fifty instances of email from students across North America. This email asked for guidance, ideas, procedures, and opinions. Where possible students asking for this information were prompted to devise procedures for themselves, ask questions about what they wanted to do, and were induced beyond the idea they had obtained. This is likened to Liebermann (1988) who used the Chemical Journal of Education for his projects, and pushed his students to change the project from its origins. The difference is that the students on the Internet have access to many more resource people than just their teachers and with proper guidance can probably take their ideas farther than with just their teacher's intervention. It is here that the Internet will possibly prove it's value to the science fair movement.

To support this idea and work toward using the World Wide Web more effectively in education, a group of scientists at Memorial University has agreed to start fielding such questions from students on the Internet. A new homepage will be attached to the Science Fair Homepage that will allow students to ask a question by email directly to a scientist in the field of study. It is hoped that this new form of limited mentorship will not only increase the educational value of the Internet for science fairs, but also benefit the science fair movement itself.

Non-determining Factors

The students choice of project type and project category did not affect their standings to any significant level. Among the most interesting findings within this section were the general project type results compared to the medal winners' project types. There was no significant difference between the two and no significant differences in the non-experimental types of projects in this area as well. This alludes to the fact that there may have been no prejudice evident at the Eastern Newfoundland Science Fair where non-experimental projects are concerned.

Another interesting finding within this section was the large percentage of experimental projects that are entered into the fair. Experimental projects constituted close to three quarters of all the projects entered. Other types such as studies and innovation were significantly less in evidence. As a byproduct of this study an in depth examination of the current mainstream curriculum guides took place. Within these guides and the accompanying textbooks there seems to be extensive scientific method support. The courses (Physics, Chemistry, Biology) and the design of the science curriculum as a whole seems to support the use of experiments. Thus results such as those found of page 71, showing a high proportion of experimental projects should not be surprising. As mentioned previously this does not serve to give an accurate nor rewarding view of the scientific process. More support for other types of scientific research should be incorporated into all levels of the curriculum. As well more support for these types should be incorporated within the teachers' education program and the science fair movement itself.

Urban/Rural Differences

The statistical difference found between the rural and urban groups was another important finding from this study. Inspection of the results show that students who came from defined rural areas had statistically less chance of winning a medal at the fair. A number of factors may have contributed to this result. First and foremost was the time factor. It could be expected that rural students would have less time to spend on projects within libraries and within school because of their need to travel longer distance to and from school. This was not supported by the results from the study which show that rural students actually spent double the percentage of time at school than did urban students and a comparable percentage of time in the library. What was significant in the results were the figures showing that rural students spent 50% less time on their projects on a per student basis. A more in depth survey would have to be conducted to find out why this was the case, but in any event this may be a factor for why they did not perform as well at the fair. It is also expected that this result may be misleading. This year's fair consisted of a high number of projects from rural schools, yet at most only five rural schools were included. This means that those schools sent many of their available projects to the fair when in many cases within urban schools only the very top projects are sent. The experience of participating at a regional fair, the tours of the university, the trip to St. John's, and the meeting of other science minded students may have been just as important to these rural students and their teachers than winning a medal.

Judging Reliability

The portion of the study that dealt with judging reliability contained some interesting results that should be looked into further. Correlation, reliability and validity were, for the most part, quite high. The correlational averages over several projects were high, but in some instances, correlations taken from single projects would have been quite low. These could be labelled as aberrations in that they were not repeated within the judging groups. Such aberrations within the judging process could cause significant differences in results. The whole process as it exists then could be called into question. What is at stake is the final standing of the students and in some cases the reputation of the region on a national scale. Clearly a consensus between the judges as to the level of the project in Part A is necessary if correlation is to be high and marks are to be consistent. The cases of low correlation discussed above did not have such a consensus. Technically if the judges are properly briefed this should be a given, but individual differences, inherent variance possibilities within the form and error factors play a large role. The consensus issue should be raised to judges in their briefings before the fair takes place and adopted as an accepted practice. As well examples of various levels of projects should be made available for judges to peruse at the briefing sessions.

The 1997 Eastern Newfoundland Science Fair implemented the changes listed above. Mark discrepancies decreased significantly, with very few problems being seen. Results from the 1997 Canada Wide Science Fair show that the judging process in the past year may have been of higher quality than previous years. In 1997 Eastern Newfoundland won twenty percent of the available top awards, one of the only five participants invited to attend the

ISEF for the coming year. As well, the five projects sent to Canada Wide won two golds, a silver, an honourable mention, and three special awards. The judging process, on the surface, seems to be improved by the changes with less confusion, consistent ratings within a judging group, and a high predictive validity for the Canada Wide Science Fair.

Summary

Essentially there seems to be a need for a fundamental shift in the education of science students and teachers in Newfoundland. Below a series of concrete recommendations for changes in the science curriculum, science education, and the training of science teachers is encapsulated. These recommendations could form the framework for a more vibrant, open, and real science curriculum that would not only incorporate the essentials of science but of critical thinking, experiment building and scientific reasoning through the use of a science fair project.

1) A new direction for science curriculum that mirrors more of what true science is about;

2) More training for teachers in these areas;

3) Development of lessons and activities to spur on student questioning;

4) More support for science fairs through inclusion as mandatory activities within all curriculum guides;

5) More unknown experiments and original experimental activities;

6) Development of more research oriented science sites on the Internet;

7) Research should be undertaken to examine the Internet as a research tool in science;

8) More emphasis on non-experimental science.

These recommendations only scratch the surface of what is needed to be done, but they would seem to be a first step in the correct direction. The importance of science education is stated often and in many ways but the future of excellence in science education and the science fair movement are inextricably linked.

Suggestions for Further Research

In many ways this study created more questions than it addressed. Among those questions are many important areas that should be studied further. These are listed below.

- The Internet as a school science research tool.
- Urban/Rural differences and school science research.
- Resource availability and the effect on student achievement.
- Science Fair Participation and the effect on student career choice.
- Teacher age by grade level teaching assignment.
- Teacher experience and the effect on student science fair participation rates.

In the author's opinion these would be among the most important issues to study further.

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Appendix A -Example Survey and Cover Letter

Student Science Fair Questionnaire

The purpsoe of this questionnaire is to help determine the source and importance of various sources for student ideas and research in developing science fair projects. Names of the participants will remain confidential and your project numbers will be asked for only to determine your final standing in the fair. I thank you for your participation.

1. What is your project number?________________

2. What area does your project fall under?
   experiment innovation study

3. What category/subject area does your project fall under?

   Physical Science Life Science

   Engineering Computer

4. What grade are you in? (circle one) 7 8 9 10 11 12

5. Is your school located in a **city/large town** , or a **smaller town of community** ? (In Newfoundland examples of cities and large towns are: St. John's, Mount Pearl, Corner Brook, Grand Falls, Gander. If you do not live in one of these, please check the smaller town of community section.)

6. Generally where did you get your **idea** for the fair project? Please check the most frequently used source and put x's next to any other sources used.

   Textbooks
   Teacher supplied lists
   Science Magazines
   Scientific Journals
   The Internet
   Parental Guidance
   Television/Radio
   Your Previous Projects
   Self-creation
   Other (you may list as many as you like): ____________________
   ____

7. Why do you feel your most used source for ideas, chosen above, is the most used source? ______________________________

____

____

8. Generally where did you do or acquire your **research**? Please check the most frequently used source and put x's next to any other sources you used.

School Library
Public Library
University/College Library
School Lab Facilities
University/College Labs
The Internet
Parental Sources
Teacher Sources
Other (you may list as many as you like): ______________________________

____

9. Why do you feel your most used source for research, chosen above, is the most used source?

____

____

____

10. Do you have access to the Internet within you school? YES NO

Do you hace access to the Internet from home? YES NO

11. How many hours were spent on you project:

In school

At home

At the library

Other

I understand that my participation in this study is totally voluntary, and I give my permission for my data to be used for research purposes only.

Signature:______________________________

Holy Heart of Mary High School
55 Bonaventure Ave.
St. John's, NF
A1C 3Z3
(709) 726-2667

Hello:

My name is John Barron, and I am undertaking research towards my Masters in Education at Memorial university under the supervision of Glen Clark.

The purpose of my research is to discover where science fair participants get their ideas and do their research, and see how this affects their general standing in the fair as a whole. This research is important if the fair movement is to survive in Newfoundland and Labrador. The procedure involves using the results of the Eastern Newfoundland Science fair and the results of a questionnaire that students complete at the fair. There will be no follow-up questions, no long-term undertaking in this project and from the students nothing is required beyond the five (5) to ten (10) minutes to complete the survey questions. The purpose of the questionnaires is to discover from the students where they did their research and where they go their ideas. The purpose of the results is to compare them to the answers on the questionnaires.

At this point it should be noted that no mention of any student's name or even specific project title will be made in the research. The only identifier is the project number which will be used to establish standing in the fair as a whole and then will be disregarded. All student questionnaires will be destroyed on completion of the data-taking, or before if that is your wish.

All this research and the conclusions drawn from it are available to you at any time, just by requesting it from the address or telephone number above.

This research is purely voluntary, and you have the right to withdraw at any time without prejudice. As well this study meets the ethical guidelines of the University and the Faculty of Education. Any questions or inquiries can be directed to the undersigned or to Dr. Frank Riggs, Associate Dean of Graduate Studies who is separate and outside the research group. I thank you for you help in this matter.

John Barron

I have read the preceding information, and do hereby give my consent for the use of this questionnaire and the results of my placement in the fair, in this research project.

Signature:____ Date:__________
If under the age of sixteen, parental consent is required:
Signature of Parent/Guardian:___________________________ Date:_________

EASTERN NEWFOUNDLAND
REGIONAL SCIENCE FAIR
Judging Form for Experimental Projects

TOTAL MARK [ ]

Project #   Language:
Entrant :
Partner :
Category: Division: Type:
Project Title:
Judge:

"Experimental Project" - An investigation undertaken to test a specific hypothesis using experiments. Experimental variables, if identified, are controlled.

Part A: SCIENTIFIC THOUGHT (Maximum 45 marks)
Level 1- Duplication of a known experiment to confirm the hypothesis. The hypothesis is totally predictable. 5 MARKS MANDATORY (Maximum 15/45) + 0 1 2 3 4 5 6 7 8 9 10
Level 2- Extend a known experiment through modification of procedures, data gathering and application. 15 MARKS MANDATORY (Maximum 25/45) + 0 1 2 3 4 5 6 7 8 9 10
Level 3- Devise and carry out an original experiment with controls. Variables are identified. Some significant variables are controlled. Data analysis includes graphic representation with simple statistics. 25 MARKS MANDATORY (Maximum 35/45) + 0 1 2 3 4 5 6 7 8 9 10
Level 4- Devise and carry out original experimental research which attempts to control or investigate most significant variables. Data analysis includes statistical analysis. 35 MARKS MANDATORY (Maximum 45/45) + 0 1 2 3 4 5 6 7 8 9 10

PART B: ORIGINAL CREATIVITY (Maximum 25 marks)						
1. Topic originality	5	4	3	2	1	0
2. Originality in approach	5	4	3	2	1	0
3. Resourceful use of equipment and information services	5	4	3	2	1	0
4. Creativity in interpretation of data	5	4	3	2	1	0
5. Judge's discretion	5	4	3	2	1	0

PART C: SKILL (Maximum 10 marks)				
1. Necessary scientific skill shown	3	2	1	0
2. Exhibit well constructed	3	2	1	0
3. Material prepared independently		2	1	0
4. Judge's discretion		2	1	0

PART D: DRAMATIC VALUE (Maximum 10 marks)				
1. Layout logical and self-explanatory	3	2	1	0
2. Exhibit Attractive	3	2	1	0
3. Presentation by student clear, logical and enthusiastic	3	2	1	0
4. Judge's discretion			1	0

PART E: PROJECT SUMMARY (Maximum 10 marks)				
1. Has all the required information been provided?	3	2	1	0
2. Is the information in the specified format?			1	0
3. Is the information presented clearly with continuity?		2	1	0
4. Does the summary accurately reflect the actual project?		2	1	0
5. Presentation (Neatness, grammar, spelling in report)		2	1	0

Appendix C - Board Permission Request Letter

March 15, 1996
Box 424, RR #1
Paradise, NF
A1L 1C1

Mr. Brian Shortall
Superintendent
RC School Board for St. John's
Belvedere, Bonaventure Ave.
St. John's, NF
A1C 3Z3

Dear Mr. Shortall:

My name is John Barron, and I am undertaking research as part of my Masters in Education thesis at Memorial University under the supervision of Glen Clark. I am requesting permission to run a pilot study for an upcoming research project at a single school within your board, and a full study within several schools within your board.

This research study will be attempting to delineate areas where science fair participants acquire their ideas and their research. It also involves a study of the reliability of judging within a fair. The main site for this research will be the Eastern Newfoundland Science Fair Council's Regional Fair, but in an effort to fine tune the instruments to be used, I wish to test it at Holy Heart of Mary High School. Although it will be a full running of the instruments, none of the data collected is expected to be used in the study, although the data collected is available to you at any time, just by requesting it at the phone number below.

The second part of the study requires the students and teachers who are attending the regional fair to complete questionnaires, which will take five (5) to ten (10) minutes of the their time at the fair. These students come from a variety of schools within your board, and permission from their parents will be requested when required.

The instruments include a student questionnaire, a teacher questionnaire, and the acquiring of judging sheets used in the fair proper. Participation is voluntary for participants, and the students and teachers have the right to withdraw at any time without prejudice and will be informed of this right. Copies of these questionnaires are attached to this letter. The identity of the all participants will remain confidential, and the names of students will not be recorded.

The research as a whole could be an important link to why science fairs have been declining in the near past, and I believe, help in revitalizing the process. This study meets the ethical guidelines of the University and the Faculty of Education. If you have any further questions please do not hesitate to call me at 895-6697 (H) or 726-2667 (W).

A recap of my request: I am requesting permission from your board to undertake a pilot study at Holy Heart of Mary involving questionnaires, and a general study involving students and teachers attending the regional fair, on where students get their ideas and where they do their research for science fair. I will make the participants aware that their participation is purely voluntary and they can withdraw at any time. All the information gathered is strictly confidential and no individual will be identified.

I thank you for your time and look forward to hearing from you.

Yours sincerely,

John Barron

Appendix D - Table of Data

Type	Category	Level	Urban (Y/N)	Medal (Y/N)	Idea	Why Idea	Research Source	Why Research	Internet (S/H)	Hours school	Hours Home	Hours Library	Other
e	ls	jun	yes	y	texts	Modified existing idea sources	ulib	easy to access necessary information	y n		20	3	10
e	e	int	no	n	smags	Modified existing idea sources	other	easy to access necessary information	y n	2	6		24
e	ps	jun	yes	n	texts	easily accessible	other	home based	n n	7.5	188		
i	c	sen	yes	y	self	Modified existing idea sources	slab	easy to access necessary information	n n	10	300	73	
s	ps	sen	no	n	texts	easily accessible	Int	easy to access necessary information	y n	5	36		2
e	ls	jun	yes	n	texts	broad base of ideas available	slib	wide variety of up to date research	n y	2	10	2	
i	ps	int	no	n	smags	personal interest	plib	wide variety of up to date research	y y	5	45	5	
i	e	jun	yes	n	Int	broad base of ideas available	Int	wide variety of up to date research	y y		9		
e	ls	jun	yes	y	texts	Modified existing idea sources	slib	easy to access necessary information	n y	2	30	3	
e	c	int	yes	y	self	wanted project to be original	slib	easy to access necessary information	y y	2	40		
s	ps	jun	no	y	encyc	easily accessible	slib	home based	y n	1	6	1	
e	e	jun	yes	n	Int	broad base of ideas available	Int	wide variety of up to date research	n y		12		
s	ps	int	no	n	texts	easily accessible	slib	easy to access necessary information	y y	1	12	4	
s	ps	jun	no	n	self	wanted project to be original	slib	easy to access necessary information	n n	4	8	2	
i	c	sen	yes	n	self	personal interest	teach	wide variety of up to date research	n y	1	500		
e	ps	jun	no	n	self	wanted project to be original	slib	easy to access necessary information	y n	4	12	4	
e	e	sen	yes	y	self	wanted project to be original	par	parental career	y y	5	40	5	
e	ls	int	yes	y	texts	Modified existing idea sources	ulib	easy to access necessary information	n y	10	200	3	0.5
s	c	sen	yes	n	Int	wanted project to be original	Int	wide variety of up to date research	n y	1	400	2	
e	ls	jun	yes	n	self	wanted project to be original	Int	wide variety of up to date research	y y		50		
s	ps	int	no	n	texts	Modified existing idea sources	slib	easy to access necessary information	y n	2	8	1	
i	e	jun	yes	n	self	wanted project to be original	ulib	easy to access necessary information	n y	4	15	3	
	e	jun	no	n	par	parental career	par	easy to access necessary information	n n		20		

Type	Category	Level	Urban (Y/N)	Medal (Y/N)	Idea	Why Idea	Research Source	Why Research	Internet (S/H)	Hours school	Hours Home	Hours Library	Other
	e	int	yes	n	other	Modified existing idea sources	plib	easy to access necessary information	y y		60	3	
e	e	int	yes	y	other	Modified existing idea sources	plib	easy to access necessary information	y n	2	20	2	
e	ps	int	no	n	self	personal interest	Int	wide variety of up to date research	y n				
e	ls	sen	yes	y	teach	Modified existing idea sources	teach	teacher sources	y n	15	10	3	
e	ls	jun	yes	y	smags	Modified existing idea sources	Int	wide variety of up to date research	y y	5	20		
e	ls	jun	yes	n	par	Research scientist or facility	ulib	easy to access necessary information	y y		6		50
e	ps	int	no	n	teach	Modified existing idea sources	teach	teacher sources	y y		60		
s	ls	int	yes	n	self	personal interest	slib	easy to access necessary information	y n	16	90	5	6
e	ps	jun	no	n	self	Modified existing idea sources	slib	easy to access necessary information	n n	2	7	1	
e	ls	sen	no	n	teach	easily accessible	plib	easy to access necessary information	n y	5	5	5	
e	ps	jun	yes	y	self	wanted project to be original	other	home based	y y	1	30		
e	e	jun	no	n	texts	Modified existing idea sources	slib		n n	2	15	2	
e	ls	jun	yes	n	texts	easily accessible	ulib	easy to access necessary information	n n		12	2	
e	ls	int	yes	y	self	wanted project to be original	slib	only resources available	n n	2	40	2	2
e	ps	jun	yes	n	par	Research scientist or facility	ulab	parental sources	y y	1.5	12		3
e	ls	jun	no	n	self	not satisified with what other sources offered	ulib	easy to access necessary information	y y	1	12	3	
s	ls	jun	yes	y	texts	easily accessible	plib	easy to access necessary information	n n	2	8	2	
s	e	jun	yes	n	smags	easily accessible	slib	easy to access necessary information	n y		28		
e	ps	jun	yes	n	texts	easily accessible	other	easy to access necessary information	n y	1	7	1	
e	ls	int	no	y	self	wanted project to be original	slib	easy to access necessary information	n y	3	20	4	4
s	ls	sen	yes	n	self	wanted project to be original	slib	easy to access necessary information	n y		20		
e	ps	jun	no	n	texts	easily accessible	other	home based	y n	1.5	2		

Type	Category	Level	Urban (Y/N)	Medal (Y/N)	Idea	Why Idea	Research Source	Why Research	Internet (S/H)	Hours school	Hours Home	Hours Library	Other
	ps	jun	yes	n	teach	easily accessible	Int	wide variety of up to date research	y y		5	6	
s	ls	jun	no	n	self	wanted project to be original	plib	easy to access necessary information	n y	5	12	2	
s	ls	int	yes	n	par	Modified existing idea sources	par	easy to access necessary information	n y		60		
s	ls	jun	no	n	teach	easily accessible	plib	easy to access necessary information	n y		6		0.5
e	ls	jun	yes	n	self	Modified existing idea sources	plib	easy to access necessary information	n y		1.5	2	
e	ps	jun	yes	n	self	not satisified with what other sources offered	Int	wide variety of up to date research	n y	1	20		
s	ls	jun	no	n	smags	Modified existing idea sources	par	parental sources	n n		5		
e	ls	jun	yes	n	self		par		n y		6		
e	ps	jun	no	n	teach	Most available source	slib	easy to access necessary information	y n	2	8	1	5
e	ps	jun	no	n	prev	Modified existing idea sources	plib	easy to access necessary information	y n		2	0.5	
s	ls	int	no	n	par	suggested by parent	par	parental sources	y y		24		
e	e	sen	yes	n	texts	Most available source	par	parental sources	n y		100		
e	ls	jun	yes	n	par	suggested by parent	none		n y	1.5	20	0.5	
e	e	jun	no	n	texts	easily accessible	other	home based	n y	2	31		
e	ps	jun	yes	n	texts	easily accessible	other	home based	n y	0.5	6	0.5	0.5
e	ps	sen	no	n	self	easily accessible	par	easy to access necessary information	y n	3	35	1	1
e	ps	jun	yes	n	texts	easily accessible	plib	easy to access necessary information	n n	1.5	12	2.5	
s	ls	jun	yes	n	prev	Modified existing idea sources	ulib	easy to access necessary information	y y	11	14	6	
s	ls	int	no	n	self	personal interest	none						
e	ls	jun	yes	n	texts		other	home based	n n		14		
e	ps	int	yes	y	self	wanted project to be original	ulib	easy to access necessary information	y y	2.5	9	4	
e	ls	jun	yes	n	smags	personal interest	ulib	easy to access necessary information	n n		20		

Type	Category	Level	Urban (Y/N)	Medal (Y/N)	Idea	Why Idea	Research Source	Why Research	Internet (S/H)	Hours school	Hours Home	Hours Library	Other
e	ps	jun	yes	y	texts	suggested by parent	ulab	parental sources	n y	1.5	13.5	1	
e	ls	jun	no	n	texts	personal interest	slib	easy to access necessary information	y n	12	24	1	
i	ps	jun	no	n	texts		plib	easy to access necessary information	y n		20		
e	ls	jun	yes	y	self	wanted project to be original	plib	easy to access necessary information	n y	2	7	1.5	7
e	ps	int	yes	n	prev	Modified existing idea sources	plib	easy to access necessary information	y y		30	5	
e	ps	jun	no	y	tv	Modified existing idea sources	plib	easy to access necessary information	y n	8	15	7	
e	ps	sen	yes	y	teach	easily accessible	slib	easy to access necessary information	y y	4	20		
i	e	int	yes	n	self		par		n n		10		
e	ls	jun	no	n	journ	most recent information	plib	easy to access necessary information	n n		47	3	
e	ps	jun	yes	n	texts	easily accessible	plib	easy to access necessary information	n n		20	10	
s	ps	jun	yes	y	self	wanted project to be original	plib	easy to access necessary information	y y	0.5	13	2	
e	ls	jun	yes	n	par	easily accessible	other	specific to project	y y		5		2
s	ls	jun	no	n	texts	easily accessible	slib	easy to access necessary information	y n	7	8	3	1
i	e	int	yes	n	self		other	many sources used no primary	y y				
e	ps	int	no	n	par	easily accessible	other	specific to project	n y	1	35		1
e	ps	jun	yes	n	texts	easily accessible	slib	easy to access necessary information	y n		10	1	
e	ls	sen	yes	n	self		slib		y n	10	8	3	
s	ls	jun	no	n	smags		teach		y n	5	4	2	2
e	ls	int	no	y	self		slib	easy to access necessary information	n n	4	24	8	
e	ps	jun	no	n	teach	easily accessible	teach	easy to access necessary information	y n	15	20		5
e	ls	int	no	n	texts	most recent information	slib	easy to access necessary information	n n	3	1		
s	ls	jun	yes	n	other		other	purchased books	n y	0	0	0	
e	ps	sen	no	n	texts	easily accessible	plib	easy to access necessary information	y y	10	30	10	

Type	Category	Level	Urban (Y/N)	Medal (Y/N)	Idea	Why Idea	Research Source	Why Research	Internet (S/H)	Hours school	Hours Home	Hours Library	Other
e	ls	jun	yes	n	other	easily accessible	slib	easy to access necessary information	y n	1	4	1	1
e	ps	sen	yes	n	Int	most recent information	slib	easy to access necessary information	y y	2	12	2	
e	ps	sen	yes	y	Int	most recent information	slib	easy to access necessary information	y y	2	12	2	
e	ps	jun	no	n	self	wanted project to be original	par	home based	y n	6	24		
e	ps	jun	no	n	self	Modified existing idea sources	slib	easy to access necessary information	n n	15	40	5	10
e	ls	jun	yes	n	other	easily accessible	plib	easy to access necessary information	y n		10		
e	ls	jun	yes	n	teach	easily accessible	plib	easy to access necessary information	y n		10	2	
s	ls	jun	yes	n	texts	Most available source	plib	many sources used no primary	n y	2	10	2	2
e	ps	jun	no	n	tv	Modified existing idea sources	other	specific to project	y n	1.5	5	1	
e	ls	jun	no	n	texts	science project book	slib		y y	1	15	2	
s	ps	sen	yes	y	self	wanted project to be original	slib	easy to access necessary information	n y		30	2	
e	ps	jun	no	n	self	personal interest	other	easy to access necessary information	n n		100		
e	ls	jun	no	n	par	suggested by parent	slib	easy to access necessary information	n n	4	15	5	
i	c	sen	yes	n	self	personal interest	teach	School based only	y y		30		
s	e	jun	yes	y	texts	Most available source	par	easy to access necessary information	n n	2	21	8	
i	e	jun	no	n	self	wanted project to be original	other	used general knowledge, no other research	y y		12		1
e	e	jun	yes	y	teach	easily accessible	plib	easy to access necessary information	y y		10	2	2
s	ls	sen	yes	n	self	personal interest	Int	easy to access necessary information	y y	1	20		
e	ls	sen	yes	n	prev	Modifed existing idea sources	slib	easy to access necessary information	y n	10	40	50	5
e	ls	sen	no	n	par	Research scientist or facility	ulib	easy to access necessary information	y y	40	18	4	2
e	ls	sen	no	n	other	on the job experience	slib	easy to access necessary information	y y	5	12		
i	e	jun	no	n	texts		par	home based	y y		4		

Type	Category	Level	Urban (Y/N)	Medal (Y/N)	Idea	Why Idea	Research Source	Why Research	Internet (S/H)	Hours school	Hours Home	Hours Library	Other
e	ls	sen	yes	y	texts	easily accessible	slib	easy to access necessary information	y y				
e	ls	jun	yes	n	teach	easily accessible	plib	easy to access necessary information	y n		14	1	
e	ps	sen	yes	n	other	on the job experience	slib	easy to access necessary information	n n	3	11	2	
e	ls	sen	yes	n	smags	Modified existing idea sources	ulib	easy to access necessary information	n n	40		7	
e	ls	jun	no	n	par		par	parental career	y y				
i	ls	jun	no	n	texts	Most available source	other	purchased books	n y	0	6	0	0
s	ps	int	yes	n	self	needed no other sources	other	specific to project	y y	0	27	0	2
s	ps	jun	no	y	smags	Most available source	slib	easy to access necessary information	n y	2.5	48	1	
s	ps	jun	no	n	texts	many ideas available	par	home based	n n	3	6	0.5	
s	ls	int	no	y	self	wanted project to be original	other	used students visiting school as test subjects	y n	2	56		3
e	ls	int	no	n	texts	easily accessible	ulab		y n	1	20		
e	ps	jun	yes	n	other	easily accessible	plib	easy to access necessary information	n n	0	12	2	
e	ls	int	yes	y	texts	Most available source	plib	easy to access necessary information	n y	0	30	0.5	
e	ps	int	yes	n	texts	Most available source	par	parental career	n y	3	10	2	8
e	e	int	no	y	self	Modified existing idea sources	par	professional engineer	n n	0	25	0	5
e	ps	jun	yes	y	smags	Most available source	slib	School based only	n y	4.5	20	1	
e	e	int	yes	n	self	wanted project to be original	plib	easy to access necessary information	n y	0	48	2	1.5
e	ps	sen	no	n	Int	Vast amount of information	Int	wide variety of up to date research	n y	10	25	2	
e	e	int	yes	n	texts	Most available source	plib	easy to access necessary information	n y	0	20	2	
e	ps	jun	yes	n	teach	Most available source	teach	School based only	y n	4	3	0.5	
s	e	jun	yes	n	self	Modified existing idea sources	par	parental career	y y	0	4	0	6
e	ps	int	no	y	texts	modified an existing experiment	Int	easy to access up to date information	y/n	2	75	1	0

Type	Category	Level	Urban (Y/N)	Medal (Y/N)	Idea	Why Idea	Research Source	Why Research	Internet (S/H)	Hours school	Hours Home	Hours Library	Other
I	c	sen	yes	y	texts	easily accessible	plib	easily accessible	y/n	2	10	2	0
e	ls	jun	no	y	teach	direct teacher intervention	other	easy to access up to date information	y/n	2	20	2	0
s	ps	jun	no	n	self	wanted project to be original	slib	easily accessible	y/n	2	20	2	0
i	c	sen	yes	n	self	wanted project to be original	Int	easy to access up to date information	y/y	4	120	3	0
e	ps	int	yes	n	teach	easily accessible	par	easily accessible	y/y	0	14	2	0
s	ls	int	yes	y	par	direct parental involvement	Int	easy to access up to date information	y/y	1	15	0	3
s	ls	int	yes	n	Int	easy access to many ideas	plib	easily accessible	y/n	0	10	5	5
e	ps	sen	yes	y	self	self interest	other	yacht club	y/y	2	100	10	0
e	ps	int	yes	n	self	wanted project to be original	plib	access to necessary information	y/y	3	3	4	2
e	ps	sen	yes	y	Int	easy access to many ideas	Int	access to necessary information	y/y	10	18	6	0
e	ps	jun	no	n	self	modified an existing experiment	slib	access to necessary information	y/n	20	36	5	0
e	ps	jun	yes	y	texts	modified an existing experiment	teach	easily accessible	n/y	20	0	0	0
e	ls	sen	yes	y	prev	modified an existing experiment	Int	easy to access up to date information	n/y	3	20	0	40
e	ls	int	yes	y	self	wanted project to be original	par	access to parental workplace	y/y	2	30	10	0
e	ls	int	no	n	texts	modified an existing experiment	slib	easily accessible	y/n	4	30	0	3
e	ls	int	yes	n	self	wanted project to be original	par	parental access to information	y/n	0	26	0	0
i	c	int	no	n	self	wanted project to be original	slib	easily accessible	y/y	3	6	1	0
s	ls	int	yes	n	smags	easy access to many ideas	Int	easy to access up to date information	y/n	0	20	10	10
s	ls	jun	yes	n	prev	modified an existing experiment	slib	easy to access up to date information	y/y	4	12	0	3
e	ps	sen	yes	n	self	modified an existing experiment	slib	easily accessible	y/n	0	60	8	0
e	ps	jun	yes	n	par	direct parental involvement	par	parental access to information	y/n	2	25	2	0
e	ls	int	no	n	texts	modified an existing experiment	slib	easily accessible	y/n	20	7	2	2
e	ps	sen	yes	n	self	wanted project to be original	par	parental access to information	n/y	0	35	4	0

Type	Category	Level	Urban (Y/N)	Medal (Y/N)	Idea	Why Idea	Research Source	Why Research	Internet (S/H)	Hours school	Hours Home	Hours Library	Other
e	ls	sen	yes	n	par	direct parental involvement	plib	easily accessible	n/y	0	10	10	25
e	e	int	yes	n	self	wanted project to be original	Int	easy to access up to date information	n/y	0	45	0	0
s	ls	jun	no	y	self	wanted project to be original	Int	easy to access up to date information	y/y	1	25	0	0
e	ps	sen	yes	n	self	wanted project to be original	slib	easily accessible	n/n	0	15	0	0
e	ps	sen	yes	y	self	wanted project to be original	ulib	access to necessary information	y/y	4	40	10	0
e	ps	jun	yes	y	texts	modified an existing experiment	slib	access to necessary information	y/y	4	30	5	0
e	e	jun	yes	y	Int	easy access to many ideas	ulab	access to necessary information	y/y	1	72	0	4
s	c	sen	no	n	Int	easy access to many ideas	Int	easy to access up to date information	y/y	0	100	0	0
e	ps	sen	yes	n	self	wanted project to be original	Int	easy to access up to date information	n/y	0.5	45	0	2
e	ps	sen	yes	n	texts	easy access to many ideas	ulib	easy to access up to date information	y/y	0	7	3	0
e	ls	int	no	n	prev	modifed an existing experiment	plib	access to necessary information	y/n	0	20	3	2
e	e	int	no	n	texts	easily accessible	ulib	easily accessible	y/y	0	100	15	10
e	ps	int	yes	n	other	science experiment book	other	science experiment book	y/n	1	12	1	0
e	ls	jun	yes	n	texts	easily accessible	slib	easily accessible	y/n	5	10	5	0
e	ps	int	yes	n	self	modifed an existing experiment	slib	easily accessible	y/n	3	61.5	2	0
e	ls	int	no	n	teach	modifed an existing experiment	teach	direct teacher intervention	y/y	1	5	1	3
e	ls	sen	yes	n	teach	first place looked	other	access to necessary information	y/y	0	12	2	2
e	ps	sen	yes	n	tv	easily accessible	Int	access to necessary information	y/y	4	42	1.5	0
e	ps	jun	no	n	par	direct parental involvement	par	direct parental involvement	y/n	0	10	0	0
e	ls	sen	yes	n	texts	modifed an existing experiment	other	used subjects for exp	y/y	0	12	0	0
e	ps	jun	no	n	texts	easily accessible	slib	easily accessible	n/y	0.1	5	0.1	0
e	ls	sen	yes	n	texts	no answer	Int	easy to access up to date information	y/n	5	20	5	0
e	e	int	no	n	texts	easily accessible	plib	access to necessary information	y/y	0	25	10	1

Type	Category	Level	Urban (Y/N)	Medal (Y/N)	Idea	Why Idea	Research Source	Why Research	Internet (S/H)	Hours school	Hours Home	Hours Library	Other
	ls	int	no	n	Int	easy access to many ideas	Int	easy to access up to date information	n/y	0	6	0	0
e	ps	int	yes	y	texts	easily accessible	plib	easy to access up to date information	y/y	3	25	4	1
s	ps	jun	no	n	other	idea came from scout program	Int	easy to access up to date information	y/n	4	5	0	0
e	ls	int	no	n	self	wanted project to be original	Int	no answer	n/y	1.5	53	0	0
e	ps	jun	yes	n	tv	easy access to many ideas	other	easy to access up to date information, used cdrom	n/y	2	30	3	6
e	ls	sen	yes	n	Int	easy access to many ideas	Int	easy to access up to date information	y/y	5	20	0	10
e	ls	jun	no	n	texts	easily accessible	slib	easy to access necessary information	n/n	4	10	5	5
s	ps	jun	no	n	journ	easily accessible	slib	access to necessary information	y/n	6	10	3	4
s	ps	int	yes	y	par	parental career	par	access to parental workplace	y/n	3	20	0	0

Appendix E Pearson Results Table

Group 1	Judge 1						Judge 2					
	Part A	Part B	Part C	Part D	Part E	Total	Part A	Part B	Part C	Part D	Part E	Total
Project"1"	17	18	6	8	8	57	13	8	8	7	7	43
Project "2"	23	16	9	8	9	65	14	12	5	7	9	42
Project "3"	23	20	9	7	7	66	15	9	7	8	5	39
Project "4"	34	24	9	8	10	85	23	12	4	7	8	54
Project "5"	26	11	6	5	5	53	21	17	6	7	8	61
Project "6"	24	15	6	6	9	60	23	17	8	8	4	60
Project "7"	23	18	7	8	9	65	17	13	7	6	9	52
Group 2												
Project"1"	17	7	7	6	7	44	18	10	6	6	7	47
Project "2"	19	14	7	6	7	53	20	14	7	8	8	57
Project "3"	21	17	7	6	10	61	18	16	6	7	10	57
Project "4"	35	24	9	10	10	88	31	20	9	10	10	80
Project "5"	31	21	7	9	10	78	29	17	9	9	9	73
Project "6"	25	13	7	7	6	58	16	12	6	7	6	47
Project "7"	23	18	7	8	9	65	17	13	7	6	9	52
Project "8"	27	16	7	7	8	65	27	14	8	7	8	64
Project "9"	25	19	8	10	7	69	24	16	9	8	5	62
Project "10"	30	19	7	9	10	75	21	16	7	7	10	61
Group 3												
Project"1"	28	10	7	9	10	64	35	13	8	8	9	73
Project "2"	15	8	4	4	9	40	15	5	8	7	9	39
Project "3"	17	11	5	4	9	45	20	11	7	6	7	51
Project "4"	25	16	8	9	9	67	24	14	9	9	8	64
Project "5"	10	5	6	5	9	35	20	7	7	7	10	51
Project "6"	15	16	6	7	9	52	15	8	7	5	9	44
Project "7"	19	17	9	8	9	62	20	14	5	7	8	54
Group 4												
Project"1"	10	9	6	7	6	38	14	13	4	5	9	45
Project "2"	11	16	7	8	7	49	21	12	9	9	10	61
Project "3"	21	16	7	7	5	56	18	12	5	3	9	47
Project "4"	11	11	7	7	8	44	20	13	8	6	7	54
Project "5"	19	17	5	5	0	46	31	15	8	6	0	60
Project "6"	11	15	6	8	0	40	22	20	10	8	0	60
Group 5												
Project"1"	25	15	7	8	8	63	25	12	7	6	9	59
Project "2"	30	15	7	7	6	65	25	12	5	8	7	57
Project "3"	30	17	8	7	8	70	30	17	8	4	6	65
Project "4"	34	18	10	10	6	78	35	17	8	7	7	74
Project "5"	27	15	6	7	8	63	27	15	6	6	7	61
Project "6"	25	13	6	5	5	54	24	12	5	4	6	51

Group 6												
Project"1"	15	14	6	9	4	48	23	21	9	9	8	70
Project "2"	16	14	7	5	1	43	19	13	6	5	9	52
Project "3"	15	14	9	9	9	56	14	9	6	5	6	40
Project "4"	15	10	5	6	5	41	12	11	8	6	0	37
Group 7												
Project"1"	23	19	9	8	3	62	28	21	9	10	8	76
Project "2"	16	13	7	8	9	53	21	16	7	9	10	63
Project "3"	30	16	9	8	8	71	34	21	10	8	8	81
Project "4"	23	14	4	6	6	53	28	16	7	7	9	67
Project "5"	15	15	6	7	3	46	20	14	6	6	6	52
Project "6"	23	12	5	5	0	45	27	14	4	5	2	52
Project "7"	30	17	8	9	8	72	33	23	10	9	9	84
Project "8"	15	18	6	7	7	53	24	19	10	8	6	67
Project "9"	17	14	6	6	6	49	20	15	7	6	9	57
Project "10"	30	19	7	9	10	75	21	16	7	7	10	61
Group 8												
Project"1"	16	18	8	8	9	59	16	17	7	8	9	57
Project "2"	22	19	9	8	10	68	20	18	8	8	10	64
Project "3"	24	23	9	8	10	74	24	19	8	9	10	70
Project "4"	29	22	10	9	9	79	26	20	10	10	10	76
Project "5"	24	20	9	7	9	69	23	19	9	9	9	69