Science and Mathematics Education Centre

INTERNET USAGE IN SCIENCE CLASSROOMS IN HAWAII CATHOLIC HIGH SCHOOLS

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ABSTRACT

The major purpose of this study was to determine what associations exist between student Internet usage in secondary science classrooms and the way students perceive their classroom environment. A second purpose was to study how the Internet was used in each classroom involved and to see what effects these various approaches had on classroom environments. The study included a sample of 431 students in five Hawaii Catholic high schools and data were collected using site observations, student-teacher interviews, and a questionnaire using the Constructivist Learning Environment Survey, a student attitude towards science scale, and Internet usage questions. Site observations were carried out periodically over an academic year, with a high degree of communication between the sample teachers and the author. Some three dozen students representing all five high schools were interviewed in depth in an attempt to qualitatively clarify the quantitative findings of the total sample. The results of the study indicate that there is an association between greater student Internet usage and a positive perception of classroom environment. Additionally, the students in this sample express an almost total acceptance of the Internet as an educational resource. Student interview data suggest that this new technology has moved past the innovative stage and into the mainstream of daily educational routine. It seems that student attitudes, as well as individual feelings of self-control and personal relevance seem to be enhanced by the use of the Internet, allowing students to construct unique meaning on a personal level. Finally, there is a high association between student Internet usage and teacher Internet usage, that is, the attitude and behaviour of individual teachers concerning their Internet usage has an influence on the extent to which their students use the Internet for academic purposes.

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CHAPTER 1

INTRODUCTION

> *The Internet is the first thing that humanity has ever built that we didn't understand.*
>
> (Eric Schmidt, Sun Microsystem's chief technologist in the closing address at EDUCOM'96 in Philadelphia, Pennsylvania, October 11, 1996a)

Given that in America a large amount of educational resources is being allocated to the use of the Internet in schools, it is desirable to conduct the present research into how this technology is utilised in science classrooms and to what extent this usage impacts on classroom environments. This study focuses on the use of the Internet in a sample of high school science classes in five Hawaii Catholic schools and investigates associations between Internet usage and classroom environment. A variety of different science classes, science curricula, and teaching methodologies are included in the study, but in every case, the Internet is used as a supplemental tool and was not taught as a separate class. This research extends previous work concerning classroom learning environments and draws new associations between these environments and student Internet usage.

1.1 Background to the Study

Considering the constructivist perspective of teaching and learning, the "learner" constructs personal meanings dependent upon the individual's existing knowledge, purposes, and motivations. This idea is not at all new. The famous American educator, Malcolm Knowles, expounded upon his idea of student-directed education (androgogy) as opposed to teacher-directed education (pedagogy) a generation ago:

> …at its best…a learning experience should be a process of self-directed inquiry, with resources of the teacher, fellow students, and

> materials being available to the learner, but not imposed on him. The learner should be the active participant, discovering for himself those things he is ready to discover at a particular phase of his personal development. But people don't typically read books in this spirit. They read books as they listen to lectures -- to get answers to questions the author thinks are important rather than to explore questions and answers in the spirit of mutual inquiry. This is the problem: Most people have been trained to read books rather than to dialogue with them. (Knowles, 1970, p. 15)

Of course the problem faced by students in many nations today is that they MUST read the assigned books *to get answers to questions the author thinks are important,* simply because the author is a national testing board holding broad power over the individual student's future. Thus the secondary science teacher faces the classical dilemma: to teach to a standardised exam at the expense of student interest and exploration or to allow for individual discovery and creativity knowing full well that university entrance exam scores may suffer in the interim (Churach & Fisher, 1997). This "science for all" movement results in conflicting demands that are not easily resolved (Woolnough, 1991).

Having spent several decades trying to walk the tight line between the centralised requisites and individual interests, the author, along with many of his contemporaries, has managed to juggle a mixture of the two demands. Of course, the real test of the true educator becomes finding a way to manoeuvre the majority of science students through the maze of standardised requirements without crushing the last vestiges of any innate interest in personal discovery these novice scientists may possess. Surprisingly, the task is not impossible and is aided by an eclectic collection of student-initiated investigations, science fairs, group projects, and the like. It is the author's contention that the rapid growth of the Internet and the growth of on-line connections in the science classroom could prove to have enormous impact on the classroom learning environment.

Initially, the author requested several Internet-capable computers for use in his chemistry-physics laboratory at what was to become one of the sample schools in this study. Because of budget restrictions, only one unit (a P-75 IBM compatible computer with a 56.6k direct line connection to the Internet) was acquired. A less than satisfactory outcome was anticipated because of a lack of terminals, but the author was surprised at what happened, almost immediately noticing that the node in that particular science classroom became a kind of modern day pot-bellied stove around which students and faculty tended to gather. Besides the obvious academic promise of unlimited resources and instantaneous communication, the availability of an Internet site in the classroom allowed the teacher the unexpected bonus of establishing more personal contact with students. The educational applications of this new technology permitted students to go beyond the bounds of their textbooks and to construct individual meaning in the designated field of study. Excitement level built in these young people as they made new friends and developed new relationships with their classmates on campus and (via e-mail) with their counterparts at other schools throughout the Hawaii Catholic Schools. At every step of the way, all seem to display a strong urge to share the latest discoveries they make "on the net."

These anecdotal observations seem to confirm the findings of Maor (1993) who noted that it is not the computer itself which facilitates inquiry learning, but the facilitative role of the teacher that teaches students to utilise the computer as a tool of scientific inquiry. This study was designed to explore whether individual student use of classroom Internet terminals acts to affect classroom environment in a positive way, extending previous research involved with assessing classroom environments.

Quantitatively, the study includes a sample of 431 science students in five Hawaii Catholic high schools, with data collected using a survey questionnaire, site observations, and student and teacher interviews. The questionnaire consists of three parts: part one inventories the student's Internet usage categorising amount of time used, location of usage, and how the student uses the Internet. Part two is constructed primarily from a previously validated classroom environment questionnaire, the *Constructivist Learning Environment Survey* (CLES), developed at Curtin University of Technology (Taylor & Fraser, 1991). This 30-item survey is comprised of five scales denoting the constructivist nature of the learning environment within students' science classrooms. The third section of the questionnaire is a seven-question abbreviation of the *Test of Science-Related Attitudes* (TOSRA) (Fraser, 1981) — used to gain insight into students' general attitudes toward their science classes. Additionally, the ten teachers whose classes were a part of this study completed a 15-question teacher survey concerning the personal Internet habits of each.

Qualitatively, site observations were carried out periodically over an academic year, with a high degree of communication between the sample teachers and the primary investigator. Some three dozen students representing all five high schools were interviewed in depth in an attempt to qualitatively clarify the quantitative findings of the total sample.

Finally, the personal experiences of the teacher-researcher conducting this investigation are reported. These include the experiences, observations, and reflections on student use of the Internet in secondary chemistry and physics classes conducted during the early years of the Internet explosion. It should be noted that the researcher of this study serves on the Catholic Schools of Hawaii Science and Technology Committee along with several of the participating teachers in this study. Additionally, the author is science chair at one of the participating schools, though was on unpaid educational leave during the year research data were collected. Nonetheless, the principal investigator knew personally several dozen students and every teacher who was involved in the study. Though that does not make this work an action research project *per se* (Kyle, 1997), the fact that the researcher was quite familiar with many of the participants (most of the teachers and some of the students) allowed for a more thorough investigation.

1.2 Rationale for the Study

During the past decade, explosive growth of the Internet has left school systems throughout the world torn between the cry of parents and politicians for newer and more extensive connections to the "information superhighway" and tightening resources resulting from government cutbacks. Yet in spite of administrative uncertainty and budgetary constraints on the academic level, the exponential expansion of the Internet has continued unabated. In an 18-month period from September 1995 to March 1997, CommerceNet and Nielson Media Research concluded that the number of over-16 Americans and Canadians using the Internet has more than doubled from 10% to 23% (*The Washington Post,* 13 March, 1997). By February 1997, the Lycos crawler database was keeping track of more than 34 million URLs (Uniform Resource Locators) with over fifty-thousand new sites being added every day (Ciolek, 1997). And though the USA leads the way in Internet usage, it is certainly a worldwide phenomenon, with 155 countries being on-line with as much information passing over the Web in 15 minutes in 1994 as in all of 1992 combined (Langan & Flynn, 1996, p. 4). By 1996, The Netherlands had computers in nearly every classroom, France had pledged to equip all their schools' classrooms with computers, and in South Korea, more than 25% of all PCs sold are going into homes (Gates, 1996 pp. 214-215). By January 1999, the worldwide number of Internet users had reached 153.25 million people and in Australia the number was 4.2 million people, nearly 25% of the total population (Watts, 1999).

The amount of money being poured into Internet applications in elementary and secondary schools was tremendous, with appropriations growing with each new budget. And yet with all the hoopla and publicity concerning Internet usage in schools, a simple ERIC search in late 1997 turned up precious few studies looking specifically at the effects of this new technology on educating children. Specifically, three descriptors with this study were used alone and in combination using the ERIC search engine. Singly, the descriptor Internet was mentioned 2,258 in the database, Classroom Environments turned up 13,613 hits, Secondary Science returned 32,916 positives. In combination, Internet and Secondary Science produced 121 relevant articles, Secondary Science and Classroom Environment returned 659 positive responses, and Internet and Classroom Environment had 35 hits. Finally when all three descriptors were used, Internet and Secondary Science and Classroom Environments, a mere five articles were listed. Of these five articles, none dealt with the evaluation of effects of Internet usage on the classroom environments in secondary science classrooms. In addition to simply using computer databases in an effort to discover similar research, a two-year-plus review of literature shows a total deficit of work relating Internet usage, secondary science education, and classroom environments.

1.3 Research Questions

As indicated earlier, this study extends previous work in the area of classroom environments. Specifically, the Constructivist Learning Environment Survey has been validated earlier on populations of secondary science students in several Perth schools in Western Australia (Taylor, Dawson, & Fraser, 1995) and in Dallas, Texas Public Schools in the United States (Taylor, Fraser, & Fisher, 1997). The broad array of ethnic backgrounds and wide cultural diversity of the population within the Hawaiian Islands represents a very different sample of students compared with the above cases, providing the impetus for the first research question:

> *Is the Constructivist Learning Environment Survey (CLES) a reliable and valid instrument for use in Hawaiian (USA) Catholic Schools?*

Since the explosion of the Internet on the secondary education scene has occurred so rapidly, few if any teachers have been formally trained in its use and integration with existing curriculum. Because of this, it is essential to determine just how this new tool is being used in science classrooms. This forms the focus of the second research question:

> *What are the various approaches and methodologies to student Internet usage employed by individual schools and teachers (e.g., Internet usage integrated into the standard classroom curriculum, World Wide Web used as an adjunct resource tool, e-mail utilised as a communications tool, etc.)?*

A positive, constructivist approach to education is one that allows students the freedom to set learning goals and explore areas of personal interest, to work collaboratively with others, and to test existing ideas and to construct new knowledge which can be tested through open-ended dialog and interaction with other students. Considering the breadth of the World Wide Web as an educational resource and the availability of e-mail to more and more secondary students, the Internet seems to be an ideal tool to promote constructivist principles. Research question three is posed as follows:

> *What relationships or associations can be found between student Internet usage and the individual student's perception of the constructivist classroom environment?*

The final research question deals with gender differences and the variation between the approaches to Internet usage employed by girls and boys:

> *In regard to student Internet usage, are there any apparent differences in individual student's perception of classroom environment based on gender?*

1.4 Overview of the Thesis Paper

The purpose and justification of this research is outlined in this introductory chapter. A review of the literature concerning previous work relating to the subject is discussed in Chapter Two. This literature review is broken down into a look at the constructivist approach to learning, a review of research in classroom environments, and a look at the use of the Internet and World Wide Web (WWW) in secondary schools and evaluation of these projects to date. Though a great deal of work has been done in all of these areas, very little research linking them together exists in the literature. Chapter Three outlines the methodology employed in the research. The quantitative methods include the CLES (Taylor & Fraser, 1991) and the TOSRA (Fraser, 1981) and the development of the third part of the research tool, the survey items dealing with student Internet usage and the teacher Internet usage survey. The qualitative methods involving the classroom observations and student and teacher interviews are also covered. The statistical treatment of the data and validation of the CLES (research question one) are presented in Chapter Four along with a summary of quantitative data concerning associations found between Internet usage and classroom environment. In Chapter Five the results concerning Internet usage, varying methodologies, classroom environments, and gender differences gleaned from student and teacher interviews and classroom visitations are reported in detail (research questions two, three, and four). Conclusions of this study are drawn in Chapter Six.

CHAPTER 2

LITERATURE REVIEW

> *I know of nothing more terrible than poor creatures who have learned too much… What they have acquired is a spider's web of thoughts, too weak to furnish sure supports, but complicated enough to produce confusion* (Ernst Mach, 1895).

Chapter One presented the overview of the study looking into the effects of Internet usage on the environment of secondary science classrooms. This chapter begins with a review of some of the studies involving the constructivistic philosophy of education. Additional studies involving classroom environments are highlighted, with particular attention paid to the secondary science classroom. The use of a variety of classroom questionnaires and the use of each are explored, with particular emphasis placed on constructivist classroom environments. Finally, the use of the Internet in school classrooms is reviewed, again with special concern placed on secondary science classrooms. This review of research accentuates the gap in existing literature relating the effects of Internet usage to secondary science classroom environments.

2.1 Constructivism

Two things can be said about education in the Western world about which there is little debate: it is constantly evolving and it is thoroughly rooted within the social structure in which it develops. That said, it can be noted that some of the very well known early Americans such as inventor Ben Franklin, and first president of the United States, George Washington, were both taught at home. Famous Australian soldier and autobiographer, A.B. Facey, and Prime Minister James Scullin also had no formal schooling. Even former Prime Minister and namesake of Curtin University of Technology, John Curtin, left formal schooling at age twelve and never was a "secondary student" in the sense that we use that term today. Whether Revolution-period American or Eighteenth Century Australian, many Seventeenth and Eighteenth Century colonists used their kitchens for a schoolhouse and their mothers as their teachers. No doubt there were early attempts at centralising education as more and more one-room schoolhouses were built in the USA. And yet as the agriculture and ranching economies expanded, it was the move from an agrarian to an industrial economy that brought on the big brick urban schools that sprang up across America in the late 1800s (Davis & Botkin, 1994). For the most part, a *"traditionalist"* approach to education was employed within these schools and continued to be the primary method used by educators right into the second half of the Twentieth Century.

This *"traditionalist"* approach to secondary education is characterised by the "teacher and textbook as the source of all information" and has been practised in the Western world for well over a century now. If one marks the beginning of the "information age" as the introduction of electronic digital computer ENIAC (*Electronic Numerical Integrator And Computer*) at the University of Pennsylvania in 1946, we are already into the sixth decade of the "information economy" and still using the old traditionalist paradigm in many of our schools. Few would argue that this traditional approach is no longer effective. “Inquiry has become a sacred word in science education. Everyone recognises it as important, accepts it, and proclaims its centrality to science teaching” (Yager, 1997). But why is this the case and exactly how did it come to be?

After the Soviet Union threw its *“Sputnik scare”* at the Western World in 1957, the USA in particular underwent a great deal of soul searching which led to reforms in science education. These reforms in the 1950s and early 1960s were aimed at producing “little scientists” as quickly as possible and any thought of learning the history, philosophy, or social context of science was of minor importance (Matthews, 1989, p. 4). The faulty assumption here was that the student comes into a science classroom as *“tabula rasa,”* a blank slate just waiting to be written upon with the teacher holding the pencil. And yet there is a dire need to understand just how the student inquires. Matthews continues, “Students often have deeply ingrained intuitive beliefs and conceptions regarding natural processes and these affect how the world is seen, how new concepts are understood, and how the student ‘inquires.’” But just how do children "inquire"?

Child psychologist Jean Piaget (1973) is often seen as the “great pioneer” of the constructivist philosophy. In his landmark work, *To understand is to invent: The future of education* the psychologist relates the learning of one student to the process of the growth of mankind's knowledge.

> The basic principle of active methods will have to draw its inspiration from the history of science and may be expressed as follows: to understand is to discover, or reconstruct by rediscovery, and such conditions must be complied with if in the future individuals are to be formed who are capable of production and creativity and not simply repetition (p. 20).

In that respect, constructivism is an epistemology, or theory of knowledge, that views knowledge as being ‘constructed’ (or generated) within the learners’ minds as they draw on their existing knowledge to make sense of perplexing new experiences (Hardy & Taylor, in press; von Glasersfeld, 1993; 1995).

Mathematician and educator Seymour Papert worked with Piaget for five years in the early 1960s and then went on to do research on artificial intelligence at Massachusetts Institute of Technology. Papert endorses Jean Piaget's model of children as builders of their own intellectual structures. Children are innately gifted learners and long before they ever go to school acquire vast quantities of knowledge by what Papert calls "Piagetian learning" or learning without being taught (Papert, 1980). It is this very informal way that children learn to speak, learn a form of intuitive geometry that allows them to get around in three-dimensional space, and learn enough logic and rhetoric needed to deal with parents and siblings. In each case, children “learn” without ever being "taught."

Two major themes have shaped Papert's research agenda on computers and education: that children can learn to use computers in a masterful way; and that learning to use computers can change the way they learn everything else. Borrowing from Papert, it is asserted here that science students can learn to use the Internet effectively and that using the Internet as a tool has a positive impact on learning outcomes, particularly classroom environments. Papert sees learning as a constructive process and in fact is the one credited with first using the term *"contructivist"* in reference to that broader school of thought (MacKnight, 1997). Papert believes that Piaget's most important contribution was <u>not</u> his work concerning stages of intellectual development, but his recognition that people possess different theories about the world. Children's theories contrast sharply with adult theories. Piaget showed that even babies have theories about how things work. For Papert, the way these theories are transformed is a constructivist one as children build their own intellectual structures (Solomon, 1986, p. 104).

Maybe, in the truest sense of the word, *"constructivism"* can be summed up in a look at an educational situation in which no other methodology can really be employed — the one room school house mentioned earlier. A well-known commentator on the Internet and co-founder of the Electronic Frontier Foundation John Perry Barlow (1997) related his school experience in rural Wyoming where the entire student body consisted of seven children aged 5 to 13. Education could not be "informational," but had to be "experiential and creative." Barlow speaks of the one-room school house as the ultimate in constructivist education: because all the kids were different ages, the classroom had to be highly interactive — the kids taught each other as much as they learned from the teacher.

The Internet could yet prove to be the new one-room school house or even the "one-child school house" and the ultimate constructivist teaching tool. Davis and Botkin (1994) tell the story of five-year-old Megan worried about the monster that lived under her bed. She was afraid of the monster and finally solved the problem, coaxing the monster into her brother's room where it now lives under his bed. The two educators point out that children have been seeing monsters for a long, long time, but what makes Megan so different is the <u>way</u> she told her story. The little girl drew pictures on her computer, wrote and recorded her words into the presentation, and using a modem hookup, posted her story to an electronic bulletin board where other kids her age could watch and hear it. Though the presentation lasted only one minute, the feat was amazing considering the fact that this little preschooler accomplished all the major tasks of moviemaking from writing the screenplay and creating the visuals to editing, producing, directing, and distributing. Her learning was integrated into the reality of her life and for Megan, it was all just play (Davis & Botkin, 1994). This little story demonstrates the concept of "Piagetian learning" or *constructivism* at its best.

But does this approach work at the secondary level? Is there any empirical evidence to support a more constructivist approach to teaching the sciences? In recent years, there have been several trends away from the more traditional approach of "teacher as information giver." Plomp and Voogt (1995) identified three innovative approaches to secondary science education that have occurred over the past few decades:

1. *Inquiry Approach* - In the late 60s and into the 70s, programs were developed to explore the nature and process of science. In this approach, students acted as scientists and the scientific method was the most important part of the curriculum. Here science content acted as a means to learn science process skills. From meta-analysis we know that these programs generally had a positive effect on student achievement and motivation (Shymansky, Kyle, & Alport, 1983).

2. *Societal Approach* - During the 1970s into the 1980s, a new movement emphasised science as part of our technological society. Teaching learning skills involved with decision making and problem solving in relationship to society became the central concern of this movement. Students were expected to become responsible citizens and the science content of any curriculum was derived from societal issues.

3. *Conceptual Change Approach* - From about the mid-1980s, a number of programs developed that stressed conceptual change in learning science. The starting point here is that the learner constructs a worldview based on personal observation and experience, and curriculum content was derived from key science concepts.

These views contrast with objectivist views of knowledge as an independent commodity of unquestionable truth status that can be conveyed through language from mind to mind. To these transmissionists, scientific knowledge exists totally independent of one's mind and is forever static and unchanging. It follows that from this point of view, there is a scientific truth that, given enough time and the proper tools, all reasonable humans will find independent of cultural or social restraints (Taylor, Fraser, & White, 1994). Here the teacher embraces the role of the authority whose sole purpose is the transmission of these truths to their students. However, much of this objectivist view of knowledge has been rejected during the past several decades (Kuhn, 1962; Feynman, 1986; Feynman, 1989) as constructivism replaced the metaphor of knowledge as product with knowledge as meaning, and the metaphor of learning as reproduction with learning as meaning-making.

From a constructivist perspective, learners construct knowledge from perplexing experiences in two ways. First, as they attempt to make good sense of their new learning experiences they construct their ideas or understandings from, and in relation to, their existing network of concepts. This process of conceptual assimilation involves incremental knowledge growth and only a small degree of perplexity for the alert and motivated learner with appropriate background knowledge. One of the challenges facing a good teacher is, therefore, to provide learning experiences that enable students to appraise critically the quality of their background knowledge. Without this foundation, the connection with and between new ideas and understandings is likely to remain tenuous or shallow. Second, this critical self-reflection results in a restructuring of relationships between major concepts in the student's background knowledge. The challenge for a good teacher is to find ways of engaging students in the emotionally uncertain experience of sustained critical self-reflection, evaluation, and reconstruction. It is quite possible that the usage of the Internet can enhance this constructivist approach to learning.

Why have these more innovative approaches not been used? For one they are all very time consuming and presuppose a great deal of individual instruction. Second, teachers need to undergo a drastic role shift from fact providers to facilitators. More directly to the point of this thesis, though nearly everyone agrees on the usefulness of the "hands-on approach" in the science, it has also proved difficult to provide the rich learning environment that goes beyond a mere "cook book" approach to science laboratories. This study proposes that the Internet may be just the device needed to offer this rich, powerful learning tool needed in any constructivist classroom.

2.1.1 The Construction of Knowledge

Consider for a moment two divergent approaches to education. One, the *pedagogical* (teaching of children) model of learning is teacher-directed and the teacher has full responsibility to decide what is learned, how it is learned, and when it is accomplished (Pellone, 1995). The assumption here is that each child needs to satisfy her or his teacher in order to be promoted. The *androgogical* (teaching of adults) model expounded by Malcolm Knowles (1970) is student-centred and considers the self-directive nature of adults based on their previous life experiences. Knowles did not use the term constructivism, but that is exactly the same concept he called *androgogy*. In this model, the assumption is that people learn what they need to learn when they need to learn it. Knowles is an adult educator and it may be argued that a young child simply does not have the independence or past experiences to learn in the same manner as an adult. Even their motivations are quite different.

Youngsters are driven more by external pressures from parents and teachers. Though adults may have some external forces pressing them on with their education such as job promotions and salary increases, they are more driven by the internal factors of curiosity and personal satisfaction. However, by the time most children reach the secondary level of education, it is contended that their primary method of learning becomes more and more *adult-like*. The line between "adult" and "child" education is quit blurred and in many ways the distinction becomes moot. Whether the term *androgogy* or *constructivism* is used, the outcomes are the same. Even highly technical university chemistry, physics, and biology courses are having positive results with constructivist, "lectureless" classrooms as they employ more and more discovery techniques that elementary and secondary educators have talked about for decades (Brennan, 1997).

So it seems that Knowles' *androgical* approach can be viewed as simply the adult version of the whole *"constructivist"* philosophy of learning popularised in the education ranks over recent decades. "Constructivism… whatever else it may be [is] a 'powerful folktale' about the origins of human knowledge" (Phillips 1995, p. 5). These days educators simply no longer believe that individuals come "pre-stocked" with knowledge or that knowledge can be "absorbed" directly from the teacher. By and large, both knowledge and the methods and criteria we use in human inquiry are all uniquely "constructed" (in the purest sense of that word) from the individual's previous experiences. Furthermore, each individual student has self constructed all of those past experiences.

The epistemological alternative is the *social constructivist* view of the nature of scientific knowledge (Solomon, 1987; Tobin, 1990), which views knowledge as culturally bound and based on the individual's past experiences and encounters with the environment. In that sense, each student must *"discover"* knowledge based on pre-existing ideas and shape this knowledge through interaction with others. From this perspective, the teacher becomes a mediator for her or his students as they interact with their physical environment in the context of the student's past experiences. In this respect, knowledge is relative to the individual.

But does this necessitate that the world is void of any recognisable order, is in fact incomprehensible? On the contrary, most scientists would argue there is a realist position. In *Science for all Americans* (AAAS, 1989) it is simply stated that, "The world is understandable." (p. 25) The treatise goes on,

> Scientists assume that even if there is no way to secure a complete and absolute truth, increasingly accurate approximations can be made to account for the world and how it works… The modification of ideas, rather than their outright rejection is the norm of science, as powerful constructs tend to survive and grow more precise and to become widely accepted (AAAS 1989, p. 26).

It is important to point out that under the broad canopy labelled *"constructivism,"* a wide range of beliefs can be found. The extreme position held by the *radical constructivists* who argue that no external reality of the universe can ever be known. The belief here is that we only have our own sensations upon which to reflect and so we are never able to judge any correspondence between our ideas and the world (Good, Wandersee, & St. Julien, 1993). The *progressive constructivist* takes the middle ground, maintaining that knowledge is partially constructed from the learner's social interactions, but that there is a "real world" that somehow leaks in at the end. And the *reactionary constructivist* holds that though knowledge may begin as an image within an individual's mind, it only really becomes "scientific" when all traces of social constructivism have been shed (Phillips, 1995).

So which will it be — the radicals, the progressives, the reactionaries? Maybe the whole idea of one school being the "true" path to educational nirvana is a useless construct. There is certainly room for a combination of views, for if one truly believes in the constructivist philosophy of learning, one would also need to allow for an unlimited number of conceptualisations of constructivism — one for each individual educator who contemplates the notion. Indeed one can subscribe to the constructivist philosophy without totally negating the realist approach to knowledge. Latour (1987) points out that scientists tend to be realists when doing the mundane day-to-day tasks of science, but quickly become relativists when confronted with unresolved questions. In many ways this paradox explains the attraction science educators have to both realism and constructivism (Good, Wandersee, & St. Julien, 1993). However nearly all constructivists (including this researcher) agree on the necessity for the active participation of the individual student and social nature of the learning process.

> Knowledge consists of past constructions — we come to know the world through our logical framework, which transforms, organises, and interprets our perceptions. Learning is an organic process of invention, rather than a mechanical process of accumulation. A constructivist takes the position that the learner must have experiences with hypothesising and producing, manipulating objects, posing questions, reaching answers, imagining, investigating and inventing, in order for new constructions to be developed. Learners must construct knowledge. Teachers may serve as mediators in this process (Fosnot, 1987, p. 87).

Certainly, many others echo the sentiment warning us not to confuse learning and training. Problem solving in and of itself is not learning (Hewitt, 1990). Real learning necessitates a second loop in which there is reflection on one's own activities and mistakes and one's conduct may be modified accordingly (Fallshaw, 1993). Even for university-bound secondary science students, rote learning of specific facts and terms is not a positive use of time. The really valuable skill is to know where to find these facts and how to apply basic scientific principles (Jackson, 1993).

Could it really be any other way? To assume that all children could somehow all learn the exact same material is certainly an erroneous delusion at best. At worst it is a prescription for mediocrity and underachievement. "What someone knows is as idiosyncratic as a fingerprint; there are no two people on earth who know the exact same stuff. Why pretend otherwise?" (Gehl, 1996, p. 5).

One of the fallacies often expressed by the anti-constructivists concerns the diminished need for competent teachers. Nothing could be farther from the truth. Within a constructivist classroom environment the students transform themselves from passive receptacles to active learners responsible for constructing their own meaning. And yet teachers are challenged with discovering just what their students bring with them to the classroom in the form of past experiences, world concepts, and personal questions. In this framework, the teacher chooses what experiences may best allow students to explore a variety of scientific concepts (Ward, Dubos, Gatlin, Schulte, D'Amico, & Beisenherz, 1996).

Consequently it could be argued that the constructivist approach places a <u>greater</u> emphasis on the teacher, calling for a more personalised approach with every individual in the class. As pointed out earlier in this paper, the "hands-on" approach called for in the constructivist classroom places incredible demands on the teacher to provide a rich learning environment broad enough to involve every student (Plomp & Voogt, 1995). This area of learning environment is discussed in the following section.

2.2 Classroom Environments

> A learning environment is a construction of the individuals in a given social setting, an individual's socially mediated beliefs about the opportunities each has to learn and the extent to which the social and physical milieu constrains learning. Although learning environments are necessarily personal, each individual's constructions are mediated by the actions of others in the social setting and characteristics of the culture in which learning is situated. What actually happens over a period of time constrains the construction of what an environment is like for learning (Lorsbach & Tobin, 1995, p. 19).

The idea that social and psychological environments have significant impact on individual performance is not new. Kurt Lewin (1935, 1936) first suggested the idea that the interaction of an individual's unique characteristics with her or his environment is among the basic determinants of human behaviour. In Lewin's early works (1935 and 1936), he suggested the idea that the interaction of an individual's unique characteristics with her or his environment is the basic determinants of human behaviour. He went so far as to formulate a function for human behaviour (B) in the form B = f(P, E), where P represented personal characteristics and E denoted the environment. Many psychologists tackled the problem of determinants of human behaviour resulting in a variety of opinions. One end of the spectrum could be represented in the controversial behaviourist works of Skinner (1948 and 1971) whose view looked at environments as things to be manipulated in order to affect outcomes. At the other end of the gamut were more humanistic ideas expressed by Carl Rogers (1961) with his *"non-directive*" approach to teaching summed up in the question "How can I provide a relationship which this person may use for his own personal growth?" (p. 32). The one commonality running through all these divergent theories is that the human environment — physical, physiological, and interpersonal all-inclusive — does indeed have a profound effect on personal behaviour.

But more specifically, in what way do environments affect student behaviour and achievement in school settings? In recent years, science educators have led the way in investigating the effect of learning environments on student behaviour and achievement in school settings (Fraser & Walberg, 1991). Studies of junior high and high school students show that supportive relationships with teachers and classmates and an emphasis on student participation in well-organised classrooms promote student morale, interest in subject matter, and a sense of academic self-efficacy. Gains on standard achievement tests are most likely to occur in task-oriented classes that set specific academic goals in context of supportive relationships and clear structure (Moos, 1991).

The association between learning environment variables and student outcomes has provided a particular rationale and focus for the application of learning environment. In a meta-analysis which encompassed 823 classes in eight subject areas and representing the perceptions of 17,805 students in four nations, Haertel, Walberg, and Haertel (1981) found enhanced student achievement in classes which students felt had greater cohesiveness, satisfaction and goal direction and less disorganisation and friction. Other literature reviews since then have supported the existence of associations between classroom environment variables and student outcomes (Fraser, 1994; Henderson, 1995).

Theo Wubbels (1993) used the *Questionnaire on Teacher Interaction* (QTI) on samples in both The Netherlands and in Australia and found a positive correlation between student attitudes and positive interpersonal teacher behaviour (strong in student responsibility and freedom behaviour, understanding behaviour, helping/friendly behaviour, and leadership behaviour). The opposition scales were negatively related to student attitude. Concerning educational outcomes, Wubbels found that three dominance scales (strict behaviour, leadership behaviour, and helping/friendly behaviour) were positively related to student achievement, whereas their submissive counterparts were negatively related to achievement. His research showed that interpersonal teacher behaviour was strongly related to student outcomes, but that no strong relationship between curriculum materials and outcomes existed. The only area of conflicting demands found was that of teacher strictness — higher achievement was promoted by more strict behaviour whereas better student attitudes were encouraged by less strict behaviour. He suggests that the introduction of new curriculum materials must be accompanied by appropriate changes in teacher behaviour in order to be effective.

One Australian study showed that where secondary biology students perceived strong leadership, greater understanding, and helpful and friendly behaviour in their teachers, students consistently had more positive science classroom attitudes. On the other hand, when students perceived greater uncertainty, dissatisfaction, admonishment and strictness in their teacher's interpersonal behaviours, their attitude scores were significantly lower (Fisher, Henderson, & Fraser, 1995). There is further evidence indicating that a constructivist classroom environment of the model characterised in the National Science Education Standards (NRC, 1995) is associated with a variety of desirable student outcomes (Huffman, Lawrenz, & Minger, 1997; Fraser, 1994; Tobin & Fraser, 1990; Fraser & Tobin, 1989).

Though earlier work dealt strictly with individual classrooms, more recent efforts have carried this study forward to look at both a broader and a narrower view. For example, studies have now looked at the *entire school* as a whole, finding that along with curriculum, resources and leadership dimensions, *school environment* (or climate) makes major contributions to just how effective a school is (Fisher & Fraser, 1990b). Additionally, more qualitative techniques have been used to explore the realm of sub-environments, recognising the fact that one individual student in any classroom may function in a variety of secondary environments within the greater group such as that with a laboratory partner, within a small discussion group, and within the class as a whole (Ritchie, Tobin, & Hook, 1995).

A wide range of literature reports on the importance of environments to the learning process. "Overall, the evidence gleaned from a variety of settings… and using a variety of approaches supports the assertion that environment does exert considerable influence on human behaviour." (Fisher, 1992b) The question of just how one may evaluate these environments within individual classrooms has led to a wide array of assessment tools and these are dealt with in greater detail in Chapter Three.

In the review of literature so far, a case has been made for the importance of classroom learning environments to positive educational outcomes. From the first half of the twentieth century, researchers such as Lewin and Skinner laid the groundwork for later studies conducted by the latter day giants of Fraser, Fisher, Wubbels, Moos, Walberg, and others. In some ways, merely having a constructivist environment within the classroom was seen as a positive end in itself as Fraser and Walberg point out in the introductory notes of their book, *Educational Environments*:

> It is assumed in this book that having a positive educational environment is an educationally desirable end in its own right. Moreover, comprehensive evidence presented here also clearly establishes that the nature of the classroom environment also has a potent influence on how well students achieve a range of desired educational outcomes. Consequently, educators need not feel that they must choose between striving to achieve constructive classroom environments and attempting to enhance classroom achievement of cognitive and affective aims. Rather constructive educational climates can be viewed as both means to valuable ends and as worthy ends in their own right (1991, p. *x*)

And yet just how does one go about determining the state of the environment within a given classroom? Certainly over the years researchers have combined a variety of qualitative and quantitative assessment tools to help explore the interpersonal workings within a classroom that contribute to the broad milieu we call "environment." This study was designed to employ both approaches as will be outlined in Chapter Three which details the methodology used in the research. However a significant body of data collected in this study was accomplished using a classroom environment questionnaire (the CLES) and it is essential to note the historical development of this type of survey instrument.

2.3 Instruments for Assessing Classroom Environments

How does one know whether or not a school is doing well in meeting its educational objectives? Certainly one basis could be an assessment of student outcomes as measured by grade point averages, standardised exams, or job placement. Some may try to associate resources with achievement, assuming that the more books, computers, software, and modern facilities a school has, the better the level of education. Though the evaluation of all of these areas may be a worthwhile endeavour, one can not have a complete picture of the learning process without consideration being given to classroom environments (Waldrip, 1994). “Measures of environments are more often like measures of motivation than measures of ability or achievement. They do not require demonstrations of performance but involve judgements of psychological or social-psychological states of classes or schools” (Fraser & Walberg, 1991, p. *x*).

Learning climate, atmosphere, surroundings, environment — no matter what term one applies to the concept, the fact is that a person’s environs may have an extreme effect on behaviour. Similarly in the educational sense, the idea of somehow assessing classroom environments certainly is not new. As pointed out earlier in this paper, works by Lewin (1935, 1936) in the 1930s and Skinner (1948) in the 1940s looked at the effects of environment on human behaviour and learning. Various approaches to collecting data concerning specifically classroom environments have been developed and can be grouped into *low-inference* and *high inference* measures (Rosenshine, 1970). Low inference measures are easily gathered with classroom observations and tally specific actions (e.g., number of student questions, which student the teacher calls on). On the other hand, high inference measures require judgements about intentions and the meaning of classroom events (e.g., how friendly is the teacher, are students free to voice opinions). These high inference measures are more involved with the psychological significance of classroom events and are more easily accessed using perceptual measures. Of course the question remains of exactly how to best assess these perceptual dimensions — who is best able to make these subjective judgements?

> Students have a good vantage point to make judgements about classrooms because they have encountered many different learning environments and have enough time in class to form accurate impressions. Also, even if teachers are inconsistent in their day-to-day behaviour, they usually project a consistent image of the long-standing attributes of a classroom environment (Fraser, 1994, p. 494).

Using the students’ perceptual measures has advantages over observation, namely they are more cost effective, they are based on student perceptions over many lessons, and they pool the perceptions of many different students. Additionally, student perceptions determine student behaviour more than observed behaviour and these measures have been found to account for variance in student outcomes to a greater degree than variables directly recorded by observation (Fraser & Walberg, 1991).

Some of the first attempts at measuring social climates were carried out in the late 1960s and early 1970s in settings other than secondary schools. One of the giants in the field, Rudolf Moos, developed his first social climate scale for use in psychiatric hospitals (Moos & Houts, 1968) and correctional institutions (Moos, 1968). Looking across a broad spectrum of institutions in which humans interact, Moos identified three psychosocial dimensions of these environments (Fisher & Fraser, 1990a):

- *Relationship Dimensions* – How individuals interact and relate with each other, including how they participate with and support one another.
- *Personal Development Dimensions* – How individual needs for personal growth and self-enhancement are fulfilled.
- *System Maintenance and System Change Dimensions* – How well order and control are maintained within the environment and how responsive and adaptive it is to change.

These dimensions are still accepted as relevant to any study of school environments and all classroom and school environment instruments assess one or more of them.

Historically there have been several approaches to analysing classroom environment in secondary science classrooms. The *Learning Environment Inventory* (LEI) was one of the first attempts to use a systematic approach to looking at learning environments in secondary science classrooms (Walberg, 1968). The LEI questionnaire grew out of the Harvard Physics Project implemented at that time, and asked individual students to look at the overall environment within the whole classroom. The instrument consisted of 15 scales with seven items in each scale for a total of 105 statements answered on a four-point scale (*Strongly Disagree, Disagree, Agree, Strongly Agree*).

The *Classroom Environment Scale* (CES) was developed within the same timeframe and also used a classroom survey to poll individual students concerning their views on overall classroom environment (Moos & Trickett, 1974). The CES questionnaire incorporated nine different scales with ten items in each answered by a simple True-False response. The *Individualised Classroom Environment Questionnaire* (ICEQ) used five scales each with ten items (Rentoul & Fraser, 1979). The ICEQ differed from the earlier instruments in that it attempted to measure individualised and open classroom dimensions that set them apart from conventional ones (Fraser, 1991).

The assumption in the LEI, the CES, and the ICEQ is that there was one unique classroom experience that all student participants perceived more or less in the same way. However this assumption was challenged in the 1980s (Fraser, McRobbie, & Fisher, 1996) with research indicating there were certain "target" students more involved in classroom discussions and activities who generally had a more favourable view of that particular learning environment (Tobin, 1987; Tobin & Gallagher, 1987a; Tobin & Malone, 1989). Out of these findings was developed a new approach to measuring classroom environment in which both a *Personal Form* and a *Class Form* of an inventory were given (Fraser, Giddings, & McRobbie, 1992). The two questionnaires differed in that one asked individual students how she or he perceived the class *personally* as opposed to the other asking the individual student how she or he thought the rest of the *class* viewed the environment.

Fraser, Treagust, Williamson, and Tobin, (1987) reported that despite the existence of strong traditional classroom environment research at the primary and secondary level, surprisingly little work had been done at the higher education levels because of the shortage of suitable instruments. The College and University Classroom Environment Inventory (CUCEI) was developed in 1986 to fill this void (Fraser, Treagust, & Dennis, 1986). The CUCEI was specifically designed for small class sizes of about 30 students for upper secondary and tertiary levels utilising either seminar or tutorials as the mode of delivery. The seven-scale, 49-item instrument was designed with both a student and instructor version for the actual and preferred classroom environment. The seven scales in the CUCEI are Personalisation, Involvement, Student Cohesiveness, Satisfaction, Task Orientation, Innovation, and

Individualism. The CUCEI is available in the actual and preferred versions. The actual version measures the participants actual perception of their classroom learning environment whereas the preferred form measures perception of the classroom learning environment preferred by the students in a study.

Another view of the dynamics of classroom environment looks at a broad milieu of interactions among individual teachers and their students. Here the reaction of a student influences the actions of a teacher, which in turn stimulates more reaction from students. The circular process both consists of and determines behaviour in the classroom. From the theoretical work of Timothy Leary (1957) an instrument called the *Questionnaire of Teacher Interaction* (QTI) was developed in The Netherlands during the past decade (Wubbels, Créton, & Hooymayers, 1985). An American version (Wubbels & Levy, 1991) and an Australian version (Fisher, Rickards, Goh, & Wong, 1997) have also been developed. One of the primary advantages to using the QTI is that results may be obtained using the perceptions of interpersonal behaviour of either students or teachers.

It was not until the 1990s that attention was turned to the principal area that demarcates science learning from many other disciplines — the science laboratory. The *Science Laboratory Environment Inventory* or SLEI (Giddings & Fraser, 1990; Fraser, Giddings, & McRobbie, 1992) was developed with both actual and preferred versions of the instrument. The use of two separate forms allows for a comparison between actual and preferred classroom environment. Each form has five scales with each item offering five choices for response (Almost Never, Seldom, Sometimes, Often, and Very Often). In the actual form, items are worded so that students respond to what they actually perceive their classroom environment to be. In the preferred version of the form, the same items are worded so that each student responds to what their ideal classroom environment should be.

In addition to work in the area of science classrooms, attention has turned to issues concerning technology and classroom environments. Some of the first work looking at technology issues and the use of computer-assisted instruction in schools in relationship to classroom environments (Teh & Fraser, 1994) has been carried out only recently.

Some of the latest research into educational environments has gone beyond the classroom and looked at the school and its administration as a whole. There has been work in the area of school-wide environment assessment using *the School-Level Environment Questionnaire* (SLEQ), bringing together research concerning school-level environment and teacher-student relationships within individual classrooms (Fisher, Fraser, & Wubbels, 1993). In a like manner, a *Principal Interaction Questionnaire* (PIQ) has now been designed to measure a principal's interaction style with staff members (Fisher & Cresswell, 1997).

In all the studies using such classroom environment inventories, there are commonly used statistical tools used to obtain reliability and validation information. These are the *Cronbach alpha reliability* scores, discriminate validity, and an *Analysis of Variance* (ANOVA). Cronbach alpha reliability scores look at how consistently each student responds to items included in each scale. These data provide information supporting the internal consistency of the scales involved and alpha coefficient scores in excess of 0.60 are generally considered to demonstrate a satisfactory degree of internal consistency (Nunnally, 1967). The discriminant validity provides an estimation of the uniqueness of each scale of the questionnaire and is given by the mean correlation of scores on one scale with all the other scales of the questionnaire. ANOVA scores allow for a check on whether an instrument differentiates between perceptions of students within different classrooms. In other words, students within one class should have a relatively common perception of that classroom environment, whereas students in another teacher's class would most likely have different perceptions based on that particular classroom environment.

These methods of checking reliability are fairly consistent in the field of classroom environment survey development and are used time after time in validating new instruments. A representative example of the employment of these statistics can be found with every instrument mentioned: LEI (Fraser, Anderson, & Walberg, 1982), CES (Fraser & Fisher, 1983), CUCEI (Fraser, Treagust, Williamson, & Tobin,1987), ICEQ (Fraser, 1990), QTI (Kremer-Hayon & Wubbels, 1993), SLEI (Giddings & Fraser, 1990; Fraser, Fisher, & McRobbie, 1996), SLEQ (Fisher, Fraser, Wubbels, & Brekelman, 1993), and the PIQ (Fisher & Cresswell, 1997).

2.4 Classroom Use of the Internet

> The old Chinese curse has come true: we are living in interesting times, and interesting times always provide opportunities for those who are willing to follow their instincts. The super searchers who will survive and prosper in the next few years will have to demonstrate three qualities: flexibility, an open and inquiring mind, and a prodigious sense of humour (Basch 1995, p. 284).

The explosion of the technology of integrated circuits and the impact this technology has had on the world can not be overestimated. On February 14, 1996, the University of Pennsylvania celebrated the fiftieth anniversary of ENIAC (Electronic Numerical Integrator and Computer) — the world's first computer. United States Vice President Al Gore was the guest speaker at the event, which happened to coincide with Valentine's Day. Gore pulled out a Valentine's greeting card he had obtained for his wife and when he opened it, it played the song *"You Are My Sunshine."* He pointed out that the chip in that couple-dollar greeting card had more computing power than the ENIAC had, and that the original computer filled an entire floor of a building (Rodin, 1996).

There can be no doubt that the technology revolution is explosive. Why? For starters, two so-called "laws" sum up the exponential expansion of telecommunications in the latter part of the twentieth century (Smith, 1996b):

- *Moore's Law* (named after Gordon Moore, co-founder of Intel Corporation) proclaims that every eighteen months the capacity of the microchip doubles while its price is reduced by half.
- *Metcalf's Law* (Bob Metcalf, the inventor of the Ethernet) proclaims that the more people connected to any network, the more valuable it becomes.

In the case of telecommunications, Moore's Law has resulted in a fifteen-year precipitous decline in the cost of computer hardware all the while seeing computing capacity soar. And considering the exponential growth of the Internet over the past decade that has been documented earlier in this paper, Metcalf's Law seems more applicable than ever. Both these axioms have dominated every aspect of educational technology for the past decade to decade and a half. Certainly it would be difficult to make an informed decision to exclude the use of computers and telecommunications from the classroom. Research in the 1980s concluded that computer competence has become the fourth basic skill in addition to the “Three Rs” mentioned in the USA Department of Education’s *“Nation At Risk”* report in 1983 (Sutton, 1991). The convergence of widespread use of computers along with a fast, global network has presented a tool that explodes on the education scene. Additionally, the commitment of major human and financial resources by organisations, companies and governments to the expansion of the Internet has resulted in this sudden surge of information available (Tennant, 1996).

It can be argued that this is as it should be. Contrary to some who may contend that technology dehumanises the user, Ihde (1990) takes the exact opposite tact, presenting the view that technology is truly species specific and that “human activity from immemorial time and across the diversity of cultures has always been technologically embedded” (p. 20). The tools developed by technological cultures allow humans to extend their vision, hearing, touch, and all senses to realms never before open to them, bringing the vast world into a clearer and more personal context. The very “…essence of technology allows us to see, to order, to relate to the world in a particular way” (Idhe 1983, p. 33).

But isn’t this all too artificial? Does not technology still remove society from what is in the final analysis most human? Not at all according to Ong (1982) who writes that though technology may at first glance appear to be artificial:

> …artificiality is natural to human beings. Technology properly interiorised does not degrade human life but, on the contrary, enhances it. The modern orchestra, for example, is the result of high technology. A violin is an instrument, which is a tool (p. 83).

So too is the computer and all the technologies related to its use. It is the contention of this researcher that the Internet and its use in secondary science classrooms should be viewed in this context — the World Wide Web offers a powerful tool to be used by educators and students everywhere.

So the case is made for the growth of information technology and the Internet into secondary schools, but does that say anything at all about the effectiveness of the technology? Is the use of the Internet in education “probably the greatest development since the printing press” (Newsted, 1996, p. 10) or are we at the point where “the glut of information no longer adds to our quality of life, but instead begins to cultivate stress, confusion, and even ignorance?” (Shenk, 1997, p. 15). Certainly it is too early to make any definitive judgement on that question, but if we can learn anything from history, the outcome of this new technology on education will be overwhelmingly determined by thousands of individual teachers around the globe. As a matter of reference, we can use the term telecommunications almost interchangeably with the Internet. Telecommunications is the transmission of electronic signals as text, images, or other data between two or more computer systems. This exchange of information can be used for information retrieval, electronic mail, or electronic bulletin boards (Shepardson, 1995). Joseph Licklider called by many the *“Father of the Internet”* pressed this idea back in the early sixties. In 1962, he expounded on the idea that computers where not just simple adding machines developed to a higher order. Proposing the first steps that eventually would lead to the establishment of what we now call the Internet, Licklider professed that computers held the promise to act as an extension of the person. Anticipating an extensive network of computers knowing no spatial bounds, he visualised a tool that could amplify the range of human intelligence, could extend the mind and body, and could expand the range of our analytical powers dramatically (Hafner & Lyon, 1996, p. 27).

As noted above in this paper, constructivist theory gives rise to an educational approach that places the focus of initiative and control of learning activities largely on the individual student. Most often these activities often involve student-initiated inquiries prompted by the individual student's curiosity and need to know. Many times these activities involve group activities allowing students with different interests and backgrounds to interact and to teach each other with benefits derived to both the tutor and tutee. President Clinton's Committee of Advisors on Science and Technology in a March 1997 report *"Report to the President on the use of technology to strengthen K-12 education in the United States"* maintain that this constructivist approach also develops higher-order thinking skills, including how to learn as well as how to recognise and resolve flawed mental models. Concerning the use of technology in general and the Internet in particular, they point specifically to the constructivist classroom. Pointing out that the technology is likely to find use within a number of more traditional instructional roles as well, the Committee deems it likely that the student-centred constructivist paradigm may ultimately offer the best approach for more fully implementing the promise of technology to education (PCAST, 1997).

But why should this be so? It could be argued that a new "technological epistemology" has been developing throughout much of the twentieth century. Schank (1990) suggests that "story" is the principal and most efficient method humans have to learn. One does not encode abstract ideas and make them part of one's life in any meaningful or significant way without "story."

> We can tell people abstract rules of thumb, which we have derived from prior experience, but it is very hard for other people to learn from these. We have difficulty remembering such abstractions, but we can more easily remember a good story. Stories give life to past experiences (p. 10).

Here Schank would argue that students could conduct a science experiment, but that the abstract principles demonstrated in this work never become part of the individual's knowledge base unless the laboratory assumes the structure of a story.

Bruner (1996) continues with this idea of "story" in the process of encoding knowledge. He offers the following insight:

> It is through our narratives that we principally construct a version of ourselves in the world, and it is through its narratives that a culture provides models of identity and agency to its members. Appreciation of the centrality of narrative comes not from any single discipline, but from a confluence of many; literary, socio-anthropological, linguistic, historical, psychological, even computational (p. xiv).

Certainly many have contended the necessity of a broad milieu needed to "educate" the individual, but Bruner argues that in many ways, even the way the mind works is dependent on what tools it has at its disposal. It is within this concept of the mind's dependency on tools that one finds the key to Harlow and LaMont's (1998) so-called "epistemology of technology." In their view, the computer places the individual at the centre of control, allowing the learner to have access to a multitude of resources as she or he constructs stories.

Maddux, Johnson, and Willis (1997) categorise computer use in education as Type I or Type II usage. Type I use allows the user to apply the same techniques used without technology in quicker, more efficient ways (e.g., sorting a list or calculating a list of values). Type II use challenges the user with intellectual activities not possible without the new technology (e.g., word processing and spreadsheets, world wide web applications). Here the learner is presented with an enormous variety of resources useful in story telling with tools ranging from text and colour pictures to video and sound. "Children can act as writers, directors, and producers in developing productions that explain simple to complex ideas in story form" (Harlow & LaMont, 1998, p. 18).

Probably one of the best arguments in favour of using the Internet is that anywhere in the world students in schools with limited resources can easily gain access to unlimited information. Although telecommunications can certainly provide rich experiences not otherwise available to science (and other) classrooms, it does not ensure any higher quality of education will result. There is no doubt that only a high degree of communication, collaboration, and a free exchange of ideas among fellow students and teachers can accomplish this quality across the network. Again it should be noted that in the final analysis, it will be individual teachers who have the ultimate responsibility for the effectiveness of the Internet in educational situations.

In many ways, there has probably never been a piece of technology more fittingly applicable to the constructivistic philosophy of education. Early on in-service teachers learn that the effectiveness of web browser tools such as Mosaic, Internet Explorer, or Netscape, must by necessity be built on *constructivist orientations* to teaching and learning (Collier & Le Baron, 1995). This explosion of technology requires that students become active learners, that classroom teachers become co-learners and that the principal becomes the head learner (Loader, 1991). In this paradigm, more and more of the responsibility for learning shifts to the learner and the learner turns more and more to technology for content, freeing the teacher to focus her or his expertise on process and interpersonal relationships (Davis & Botkin, 1994).

There are many reasons why a constructivist educator would want to use the Internet in the classroom (Williams, 1996).

- The Internet presents real-world examples of integrated knowledge.
- The use of the Internet is enhanced by teamwork, thus it promotes collaborative learning.
- There are tremendous opportunities for telementoring — students and teachers can meet and learn from people all over the globe using the Internet.
- The Internet is all about communicating with peers and educators anywhere in the world.
- The Internet caters to different learners in different ways – print, sound, diagrams, photographs, video — each can learn at their own level.
- The Internet brings new meaning to equality — it is culturally, racially, physically, and sexually blind.

This interaction of one learner with another is a key tenet of constructivism and the “trying out” of new constructs on peers in an effort to gain input and feedback is essential. Collaboration is of prime importance in learning and the Internet provides an almost limitless amount of “virtual collaboration” around the world (Schmidt, 1996b).

2.4.1 Getting the Technology into the Schools

Schools are charged with the task of tying into the Internet both by political directives (Gore, 1994) and societal paradigm shifts. When one considers that the half-life of a college graduate engineer is now put at four years, the age of life-long learning has certainly arrived (Davis, 1996). Because of the vastness and immediacy of the World Wide Web, it will become a primary tool to the lifelong learner in the twenty-first century. The promise of the WWW is boundless, allowing students to use e-mail converse with others around the world, browsing Vatican art collections, studying weather satellite maps and viewing live pictures from the Martian surface. But there is a dark side to this technology, too. The Internet has made school walls become transparent and permeable, allowing young people access to some very objectionable stuff (Futoran, Schofield, & Eurich-Fulcer, 1995). However, on the whole, there are many positive experiences reported concerning educational uses of the Internet.

The Christopher Columbus School in Union City, New Jersey represents an interesting undertaking looking at effects of Internet usage in a public school (Smith, 1996a). Columbus School is predominantly minority students heading for early school dropouts. Before Atlantic Bell sponsored “Project Explore,” the average kid in the seventh grade there would write one or two sentences in an entire week. Project funding placed computers throughout the seventh grade in school and gave each of 135 students and their teachers their own personal Internet-equipped computer at home. The kids started e-mailing their teachers and each other, writing more and more as the experiment continued. They used the Internet to do research, to help write papers, to communicate and collaborate. The project raised literacy levels beyond any expectation at the beginning of the project as students largely from immigrant, blue-collar families are now outperforming comparable students from other districts in New Jersey. Standardised test scores have improved, absenteeism has decline, and many more students are moving into the district than are transferring out (Honey & Henriquez, 1996).

In some ways, one of the most sweeping of all technology-in-education trials has to be the experiment undertaken by Methodist Ladies' College in the suburb of Kew, just outside of Melbourne, Australia. Under the direction of former principal David Loader (1991), the school introduced its first class to personal laptop computers in 1989 and today has over 2,200 women and several hundred faculty and staff all using their own laptop PCs. Here there was a purposeful infusion of technology into the educational process with the express intent of pushing learning more in the direction of constructivist principles. As students moved further and further away from dependence on textbook learning, more student-centred, cooperative learning projects have been undertaken, resulting in the student taking charge of her own education to a much fully extent.

A recent experimental notebook-in-schools program, the “Anytime, Anywhere Learning” project, is working with a diverse range of United States schools from rural to suburban to urban areas. In a jointly sponsored project, Microsoft and Toshiba Corporations have supplied 8,000 Pentium notebook computers loaded with Microsoft software to students in grades K-12. As is the case with the MLC program, these systems are available to every teacher and every student for all classes, not just computer science courses. One pilot project spawned by this initiative is found at Cincinnati Country Day School. The 600 students included in this program from grades 5 through 12 now has her or his own laptop computer with Microsoft Office software and Internet capabilities (Toshiba America Information Systems, 1996). Here all the students have access to technology 100% of the time, both at school and at home. One teacher here found that one of the biggest changes in the student-teacher relationship brought about by the program is that now often the student is the teacher. Here the school's web page serves as the key source of information for students and teachers to distribute "handouts" electronically using the home page and/or e-mail communications.

Entire states are implementing initiatives designed to connect all schools to the information highway. The Nebraska K-12 Internet Evaluation is a five year, on-going investigation of the use of telecommunications in Nebraska public schools. The Internet is seen as breaking down the classroom walls and linking a classroom microcomputer into the entire global network. Generally, the Nebraska evaluation looked at three types of data: teacher surveys and interviews, machine usage data, similar to that gathered in this thesis, and documentation of classroom usage (Topp, Grandgenett, & Mortenson, 1995).

Several observations of just which teachers were most likely to use the Internet were seen quite early in the study (Langan & Flynn, 1995):

- A variety of teachers in all disciplines were involved.
- The teachers involved in the project had a widely varied background in the use of computers.
- Most teachers entered training with apparently no plans or expectations for use of the Internet in class and with students.
- The first teachers involved in the project seem to be the ones who support non-traditional, student-centred activities in their classrooms.

These are just a few of the nearly countless approaches different schools are using in infusing technology into their curricula. But New Jersey and Nebraska and Australia are not alone — state after state and country after country have all jumped on the bandwagon to wire nearly every school in the Western world to the Internet during the next few years. But merely wiring rooms will be no assurance of a positive educational impact.

Historically, the most important reasons why the promise of computer technology to revolutionise the classroom has not been fully realised is that of false promises and misunderstanding of technology. “A lot of people are cynical about technology in education because it has been over-hyped and has failed to deliver on its promises” (Gates, 1996, p. 210). Many schools have taken a one-time investment approach to computer technology and have not provided the professional development needed for faculty to maximise use of the equipment. The implementation of PCs and Internet technology in the classroom is not the type of neatly packaged “program” that can be dumped into the schools and left to develop on its own. A great deal of foresight, planning, and leadership are essential to successfully integrate this technology in a way that revolutionises the way children learn.

2.4.2 Development of Educational Web Sites and Programs

> Parents and educators agree that if you give a child a pencil, they'll take that pencil as far as it goes. If you give the child a laptop, they'll take that laptop as far as they can, and we don't yet really know how far that is (Toshiba America Information Systems, 1996).

The age of the digitised library is here. In literally a blink of the eye, digital libraries have become one of the foremost topics in all of education. All of this is due to the convergence of several technologies: new computing hardware, easier to use software and a fast, open, global network provided by the Internet. “The digital library is not a single entity; it uses technology to link the resources of many in a manner transparent to the end user…” (Tennant 1996, p. 37). There can be no doubt that this explosion of on-line information will revolutionise how students and their teachers hunt for information and conduct research. Along these lines there are a number of sites and programs, many aimed specifically at secondary science students and many with a more general academic purpose.

One project developed by the University of Minnesota called "Web66" (after the told trans-America highway with those same numbers) aims to link K-12 schools all over the world and to act as a catalyst for integration of the Internet into ongoing curricula (Farynski, 1995). Countries involved in this early web project include a number of developed nations such as the USA, Australia, Canada, Germany, United Kingdom, along with many less developed and more remote locations such as Brazil, Estonia, Malaysia, and Turkey.

The Open Learning Initiative of the Australian government was established in 1995 as an outgrowth of earlier projects. One project in particular, Open Net, was set up to serve as an Internet service provider for the entire educational sector. (Quinn, 1996). Another Australian program called "Australia Remembers" put children in the role of evaluators (Wild, Oliver, Oliver, & Omari, 1996). Here students were given the task of gathering memories from relatives and friends concerning memories of World War Two.

In the United States, a wide variety of WWW sites have been designed particularly for both primary and secondary school students. One example of this is the Cornell Theory Centre's "Math and Science Gateway" for grades 9-12. It is designed to present the best WWW resources in a manner that is logically organised and easily understood by students and teachers alike. Taking advantage of the ease of editing, the choices available are constantly updated with new information added and old removed on a frequent basis (Hecht & Barbieri, 1996). Another is a National Science Foundation project at the University of Colorado at Boulder that capitalises on the communicative attributes of the Internet to bring together educators, scientists and software developers in an innovative project called *Kids as Global Scientists* (KGS). Established in 1992, the program has involved over 4500 students in more than 60 world-distributed locations including Australia, Canada, Brazil, Finland, Hong Kong, Israel, Scotland, and the United States (Devaul & Songer, 1996). An eight-week curriculum has been developed to aid students in collecting their own weather data, sharing these data with fellow students, and developing theories, predictions and reports with collaborators, sometimes as far away as the opposite side of the Earth (Songer, 1996). A third project sponsored by the United States government is the *Global Learning and Observations to benefit the Environment* (GLOBE). Currently there are over 4,000 schools in over 60 countries participating in this project, including one of the schools in this study's sample. The purpose of this program is to have students make a core set of environmental observations near their schools on a regular basis and report them through the Internet web site. Additionally students receive comparative data from other sites around the world and use these data as a basis for studies on environmental topics (GLOBE, 1997).

Private industry has taken a lead in educational Internet activities also. The Hewlett-Packer E-Mail Mentor Program is one of the largest programs of its kind, allowing grade 5-12 students and teachers throughout the USA to develop one-to-one relationships with HP scientists around the globe. The purpose of the program is to not only share information and facts, but to allow "students to develop skills to pursue their passions by pairing them with adults who already live that dream" (Mather, 1997 p. 16).

Providing schools with interactive forums involving learner-to-educator, educator-to-learner, and peer-to-peer communications is the goal of a project sponsored by Manchester Metropolitan University. The use of "special occasion events" such as UK National Science Week is used to bring together the universities, schools and colleges and industry a collaborative effort to share methods, materials, and knowledge. From these specialised events, Manchester Metropolitan University developed its unique Passport to Knowledge (PTK) based on concepts developed by NASA in their K-12 Internet Initiative (Mothobi, 1996).

As one searches ERIC, the WWW, and other data bases looking for experiments in implementing the Internet into the classroom, one is easily overwhelmed with thousands of individual proposals, some sponsored by governments and some funded by private sources. Though computer and technology initiatives have been underway for the past two decades, actual implementation of Internet-based undertakings in secondary schools traces its first roots to the early 1990s with a flood of schemes not really initiated until after 1994 and later. The above programs and initiatives are in no way meant to be an exhaustive listing of the technology and Internet projects underway worldwide, but to merely give a flavour for the scope of programs being implemented.

2.4.3 The Role of the Teacher

Those apprehensive that student Internet usage will somehow replace the teacher and rob our children of needed interpersonal relationships should rest assured that that eventuality is nowhere on the horizon. A prevailing theme found throughout the review of the literature seems to indicate that in and of itself, the Internet is not a teacher and can not provide the guidance students need to effectively research questions, plan searches and analyse the results of their inquiries. This need for direction provided by the educator is supported by study after study, only a representative handful of which are reported here.

A University of Michigan project concludes time and again that students require a great deal of support to be successful in World Wide Web searches (Lyons, Hoffman, Krajcik, & Soloway, 1997). Without some baseline knowledge of the subject of interest, students repeatedly miss opportunities to find information and waste a tremendous amount of time going down dead ends. That the classroom teacher provides a rich background of data relevant to the student's search is essential to successful outcomes. Because the WWW is so comprehensive and unorganised, student-teacher interaction is a necessity.

Researcher after researcher has told us that a constructivist classroom is not one without leadership on the part of the teacher (Ward, Dubos, Gatlin, Schulte, D'Amico, & Beisenherz, 1996; Fisher, Henderson, & Fraser, 1995; Plomp & Voogt, 1995; Hewitt, 1990). Certainly the classroom that attempts to utilise the Internet is no exception. The very limitless nature of the resources available to students via this technology can be in and of itself a frightening spectacle. "The temptation is to make the system so free and interactive that users have complete control at every moment. While this is a praiseworthy goal, users can often feel bewildered and overwhelmed by choices and uncertainty" (Friedlander, 1989). Though Friedlander was speaking more in terms of non-linear navigation through the hyperlinks of multimedia laser disks, a realistic inference to Internet applications can be drawn.

Another reference initially made concerning hypermedia in general can be more specifically applied to educational applications of the Internet.

> The danger lies in getting caught up in the delightful concept of empowering students to do their own learning. Students should be the navigators, but what you don't want is just a lot of random learning about a given subject. You want a presentation that has some built in direction; something that leads the student from one important piece of information to another (McCarthy, 1989, p. 26).

Both teachers and students can be overwhelmed by the sheer amount of information available to them on the World Wide Web. First-timers need to be eased onto the

Information Superhighway, with teachers showing them how to use the technology and pointing out interesting side road along the way. Courses and workshops consistently underscore the importance of the teacher as model, both of using the Internet as a tool and of the positive attitude often needed to overcome the frustration of dead ends and crashes (Collier & Le Baron, 1995).

2.5 Evaluation Projects and Findings To Date

Though the use of the Internet in secondary science classrooms is a new occurrence over the past few years, the introduction of new technology is not a unique event. One could look at the introduction of various innovative technologies from the ballpoint pen to the computer and in each case review the literature involved in evaluating that implementation. However, through the mid-1990s, much of the literature involving Internet usage in education dealt with "how to" type of issues. During this exponential growth phase there was great preoccupation with hardware and software and how the systems work, quite analogous to our grandparents' fascination with the ever awkward, quite unsophisticated crystal radio sets. But as the "cyberspace technology" matures, one can be certain that we will more and more turn away from the technology and towards the content of information conveyed (Berghel, 1995). Indeed it is only in the past year or so that the first studies looking into the effectiveness of Internet usage in education are finally being reported. But the question arises time and again of just what value does this technology have on the learning process?

The March/April, 1997 issue of *Educom Review* aptly points out the difficulty in trying to pinpoint the overall effectiveness of the Internet to date. In an interview with Larry Irving, administrator of the National Telecommunications and Information Administration (NTIA), Irving answers a question concerning the importance of Internet access for kids. "Study after study is beginning to demonstrate that students who use technology learn better and learn differently from kids who don't" (Irving, 1997, p. 35). In that same issue Thomas Russell, Director of Instructional Telecommunications at North Carolina State University questions the benefit of the latest educational technologies (e.g., interactive software and the Internet).

> The value of interactivity — especially synchronous interactivity — according to comparative research is at best, suspect. When one adds to the 'no significant difference' results of such studies the cost and time/place inflexibilities, one must question many of the claims made for interactivity… The best thing many of the newer technologies have going for them is the public's favourable perception, based on media-driven hype, and the fact that the proponents enjoy a clear majority over the doubters. This is one situation where the perception has, in a sense, become reality (Russell, 1997a, p. 45).

Why the controversy? Certainly educational uses of the Internet receive more than their fair share of print in both professional publications and the mass media. A large amount of literature has been published concerning how to fund, purchase, and install hardware needed to wire schools. Article after article can be found detailing the intricacies on the newest software bundles needed to surf the 'net. Nearly every educator in the Western World is continually bombarded with mailings, magazine pieces, and newspaper supplements listing thousands upon thousands of URLs (*Universal Resource Locaters*) appropriate to classroom use. Yet, because the utilisation of the Internet in secondary classrooms has only come into widespread use during the past few years, studies concerning effectiveness are currently very sparse. Still there is precedent from which to draw.

As mentioned earlier, though the use of the Internet in secondary schools is very new, certainly the application of new technology in the classroom is not. Furthermore, the evaluation of these new technologies also has been a rather common occurrence. Thomas Russell (1997b) points out that though the comparative impacts of educational technologies remain of paramount importance, few generalisations can be made concerning technology affecting student outcomes. Starting with the first reported research using radio as an educational tool (in 1945), Russell compiles studies looking at the educational effects of motion pictures (from 1949), open-circuit television (starting in 1952), closed-circuit television (first in 1955), colour versus black and white television (in 1960), tape-recorded lectures (in 1961), video tape presentations (initial studies in 1972), computer assisted instruction (in 1979), teleconferencing (from 1983), the electronic blackboard (in 1984), and World Wide Web materials (in 1996). In his summary, he covers all levels of education from primary to adult, and a broad scope of subjects is included. These studies mostly look at outcomes as either achievement (measured by a variety of different methods) or student attitudes towards the subject at hand. The point to his work is this: time and again hundreds of research studies concerning new technologies used in the classroom report student outcomes as “no significant difference” between those using the technology and those not using it. The point of his research is not that these technologies are not effective tools for use in the classroom, only that studies set up comparing “users” and “non-users” invariably result in ambiguous conclusions.

At this point one may conclude that all the research and evaluations are useless, but that is not the point to be made from Russell's assertions. Rather one needs to be cautious in carrying out comparative research with new educational technologies, of merely comparing the "haves" and the "have-nots" when evaluating a new educational tool such as the Internet. Russel reasons that there are simply too many other factors to be considered in researching the effectiveness of new technologies. Certainly no one would argue with a blanket statement that the educational use of television and video and computers has not had a positive impact on education during the second half of the twentieth century. However, many studies report on particular uses of these technologies that may be more or less effective in their implementation. In other words, one needs to look at how these technologies are used and in what ways they may or may not be found as effective tools in the educational setting.

Similarly, Jones and Paolucci (1998) analysed 834 educational technology journal publications from 1992 through 1996 in an attempt to establish the effectiveness of technology from a learning outcomes perspective. They conclude that the result of this array of scientific research seems to be mixed and inconclusive. Again they do not call for a cessation of technology in the classroom, but rather for more research “that identifies and tests specific dynamics and components of the teaching/learning process involved in technology…” (p. 14).

Could it be that a range of studies accessing the effects of the Internet on classroom achievement and environments may also result in nebulous outcomes? Neither Russell nor Jones and Paolucci looked specifically at the use of the Internet, though several Internet-related studies were included in both of their works. Furthermore both studies were evaluating learning outcomes (e.g., achievement) and not looking at classroom learning environments, as is the case with this study. The question of why such nebulous outcomes seem common piques the researcher's curiosity. Several reasons are worth mentioning as to why this might be so:

- Possibly researchers are not asking the proper questions. Jones and Paolucci (1998) point out that 50% of the studies in their sample were directed at methodologies, applications and installing these technologies. Many of the studies aimed specifically at "learning outcomes" are qualitative in nature and that by their analysis, "only 12% of total research being published is associated with quantitative documentation of learning outcomes and achievement… [and] 5% of total research is conducted using formal methods such as control groups with *comparative* learning outcomes (i.e., experimental)" (p. 12).

- Many researchers argue that the effectiveness of educational technologies can not be adequately captured by the use of the standardised tests currently available (Hawkins, 1993; Rockman, 1993).

- Others point to the dichotomy between the high level of resources appropriated for technology acquisition and the usual minuscule funding given to the professional development of faculty and staff (Fulton, 1996).

- Certainly in terms of student Internet usage, it becomes more and more difficult to find a control group of students within comparable environments. In the course of this study, of the initial 431 students in the sample in January 1997, only eight girls and one boy had <u>never</u> used the Internet alone. By the time personal interviews were conducted in April and May of that year, several of these "non-users" had become users (Fisher & Churach, 1998). In short, it may no longer be possible to find an urban control sample in most cities of the Western World.

That said, one could look at some questions that have yielded important information. Since the 1960s, the popular image of the computer revolution has rested on individualised computer-assisted instruction (CAI) and the bulk of literature deals with this type of computer use in education, with 9631 citations found during a 1995 ERIC search (Russet, 1995). This type of software teaches by offering some text or multimedia instruction, asking the student questions, and providing feedback and new instructional material based on the students' answers. Each student moves through the materials in a different way, and at a different rate. Kulik and Kulik (1991) and their colleagues at the University of Michigan have summarised the vast array of research concerning such software by re-analysing data from large numbers of small studies in order to draw more general conclusions. Their basic finding was that this method results in a substantial improvement in learning outcomes and speed, perhaps around 20% or more on average. Such instruction works best, of course, in content areas where the computer can tell the difference between a student's right answer and wrong answer, e.g., in mathematics or grammar exercises. Few other teaching methods have demonstrated such consistently strong results as this type of self-paced instruction.

One of the earliest projects to link together students in different secondary schools using the Internet was the Global Thinking Project (Hassard & Weisburg, 1992). The 1990-1991 international project was designed to help students understand the scope and importance of environment issues and to teach "global thinking." Cross-cultural, interdisciplinary materials were developed and teams of students in American schools (Georgia and Pennsylvania) and Russian schools (Moscow and St. Petersburg) networked using the AppleLink telecommunications network. In October of 1991, the Russian teachers and their American counterparts held a three-day retreat in Georgia to review their experiences and make recommendations for future Internet programs. Among the recommendations they made were the following:

- Collaborating students should be matched for age and subject matter.
- Classes should work cooperatively and not competitively in an attempt to complete joint projects.
- Teachers should not dominate communications between students.
- Administrators need to be flexible enough to allow scheduling of "global think time" so that it is convenient to each classroom in both continents.
- Participants should focus on practical applications for global topics.
- Because of timing factors, an accelerated version of the global thinking curriculum may be necessary.

One of the most compelling outcomes of the project was the realisation of how much the social structure of the world has changed. Though the tasks at hand involved a great deal of e-mail exchanges concerning air pollution, rain forest destruction and ozone depletion, it was quickly obvious to all the students that they live in a world of global independence. The students became acutely aware of the fact that their interest went far beyond a mere science class and involved disciplines from geography and economics to culture and politics. This level of global thinking and interdisciplinary reflection would be difficult if not impossible to provide without the direct, timely communication among students provided by the Internet.

A recent RAND study (Glennan & Melmed, 1995) looked at the effectiveness of computer and network-based technology in elementary and secondary education in the United States. A small number of privileged schools, with resources enough to have technology seemingly everywhere, showed the potential for a total restructuring of the educational process. In these "pioneer schools," technology has been used to manage complex, standards-related instructional processes in ways that have only been achieved by the most skilled of teachers in the past. Faculty, students, administrators, and families have been linked with improved communications, fostering a greater involvement among all of these participants. Their research has suggested that when properly implemented computer and network-based technology contributes greatly to educational outcomes. However, the study cautions that these trials have been in a few select schools where "ubiquitous technology" abounds. Abundant resources such as these (e.g., computers for each child, extensive intranet and Internet connections) are not at all common and the few schools able to acquire these levels of technology are few and far between. Because of this it remains to be seen if similar results can be obtained as more and more schools acquire similar levels of technology.

The RAND study goes on to propose several principles to be considered as American schools introduce more technology into their classrooms:

1. *"The introduction of educational technology should occur as a component of a broader effort of school reform to improve the learning of all children."* Technology without reform will have little value and reform without technology is most likely impossible.

2. *"Over time, the cost of educational technology should be built into school budgets as a normal component of recurring costs."* One-shot, pilot-type projects are fine to prove the concept, but for technology to play a meaningful role in improving schools, it must become a part of the on-going educational process.

3. *"Public authorities at all levels should work with the private sector to see that all schools have access to the national information infrastructure at reasonable costs."*

4. *"All levels of government should monitor the access to technology that exists for traditionally disadvantaged populations and be prepared to do what is possible to ensure equality of access."* Surveys used in preparing the report showed a relative uniformity of technology in government supported schools serving minority, poor, and special needs populations as compared with averages for all schools taken as a whole. The real disparities appear when the technology available out-of-school and at home are considered with disadvantaged populations having significantly less access.

5. *"All levels of government should seek to learn and use the lessons from schools and school districts that pioneer the creation of technology-rich learning environments."*

6. *"The federal government's role should involve leadership, dissemination of information on effective practices, fostering the development of organisations capable of assisting schools to make effective use of technology, and funding research and development."*

In the summer of 1994 (and reported in 1995), a survey of primary and secondary USA educators asked the following questions (Pool, Blanchard, & Hale, 1995):

1. Should there be more computers in classrooms?

2. How is the Internet currently being used educationally?

3. What benefits does the Internet provide for teaching?

4. What type of future does the Internet have in education?

The conclusion of the survey was overwhelmingly in favour of increasing the use of the Internet at all levels of education. A majority of respondents expressed the feeling that those in charge of money distribution were slow to commit resources in this direction. Of course, this “foot dragging” may be understandable in that many school districts are afraid of the experiences over the past decade in which “leading edge” technology was purchased only to see it become outdated within a year or two.

The large majority of Internet-In-Education evaluation projects to date have been more concerned with how widespread usage is within designated school systems. Most of the quantitative data concern numbers of machines networked, system up times and student and teacher frequency of usage. Effects of the Internet on educational achievement or classroom environment generally have been very anecdotal or qualitative in nature. The Nebraska K-12 Internet Evaluation is a five year project that began to look at usage across the state in 1994 (Langan & Flynn, 1995). Data collected from teachers and administrators across Nebraska indicated that teachers used the Internet often as an information-gathering tool and means of communication, though in-school availability of networked equipment was often minimal. Concerning student usage, teacher interviews and classroom observation reveal that:

- Student use appears to be the critical component to ‘innovative’ curricular use.
- Student ‘research’ using the Internet appears to be at a considerably higher level that in more traditional activities.
- Most innovative curricular uses were multi-disciplinary in nature.
- Innovative uses by teachers typically overcame significant technical and instructional barriers.
- Innovative classrooms often accessed ‘non-traditional’ classroom resources (Langan & Flynn, 1995, p. 4).

In another study conducted by Ruth (1997), a university undergraduate class at George Mason University provided the students for the sample. In his classes, he tried to use every possible technology available (including the use of e-mail and WWW) and then evaluated the outcomes to see if there were improvements in results. He found that the students did achieve more, but he attributed this to the fact that his personal approach to teaching was changed. First of all, he approached the class in such a way that each student became a *"co-discover"* of knowledge and his role was one of seeing that this discovery took place. Secondly, he had more time to spend with each individual student personally, thus getting to know each better than in the traditional classroom. He was quick to point out that though his experiment was at the undergraduate level, the same techniques would apply to secondary levels. In the end, Ruth summarises his investigation as follows: "…I have visited the promised land of technology and I have found that it helps, but it is not the main answer. Good content and good teaching, along with the model of the student as discoverers, not as receptacles — is what makes the difference" (p. 36).

One of the most appropriate studies relating to this research to date did not look at secondary students and did not use science classes for its sample. The Centre for Applied Special Technology (CAST) conducted a study in seven major American cities (Chicago, Detroit, Memphis, Dayton, Miami, Oakland, and Washington, D.C.) during the 1995-96 academic year (Follansbee & Gilsdorf, 1996). The goals of the study were:

1. To measure the effects of online use on student learning including information processing, communications, and presentation skills.
2. To gain insight as to what made for effective use of online communications in the classroom (p. 1).

The study was very insightful because it was a first in many ways, looking at student outcomes as opposed to merely generalised curriculum goals. Additionally, it was a controlled study using both an experimental and a control group of classrooms. The study looked at online use as applied to existing curriculum and distinguished Internet applications as distinct from other technologies in general.

The study included 500-600 students in 14 experimental classes (evenly split between fourth and sixth grades) with online Internet access and another 500-600 students in 14 control classes (also evenly split fourth and sixth grades) that had no Internet access. Additionally, the experimental group was further divided into high structure (where staff support and training was extensive) and low structure (where the staff received a one time basic online training session). The study looked at a specific Civil Rights Unit all schools covered within their existing curricula and this unit included common activities for all students. A curriculum framework, supporting worksheets, and a standard structure for carrying out and evaluating student projects was distributed to all participants. Of particular interest is the fact that both the experimental and control classes were encouraged to take advantage of computer tools and resources in the project, targeting online use as the key differentiating factor in student performance in this study.

The work was evaluated on a four-point rating scale according to nine learning measures: effectiveness of presentation, effectiveness of stating the problem, accuracy of information, completeness of scope, demonstration of insight to civil rights, effectiveness of bringing together different views, completeness, organisation, and demonstration of "best work" efforts. At the end of the project evaluations were tabulated, observations and interview data were collected, and results were compiled. Several key findings are worth a look at in this study:

1. The sixth grade students in the experimental group scored higher than the control group in nine of nine learning measures. The fourth grade experimental group scored higher in seven of nine areas. All experimental groups scored significantly higher in measurements on information management, communications, and presentation of ideas. Some fourth grade teachers commented that the project was "a stretch" for their students and could be due to developmental differences of the two age groups.

2. Overall, the experimental group students produced better projects than the control group students. Within the experimental group, the high-structured classes (i.e., the teachers received more Internet training) had lower mean scores than the low structured classes, seemingly indicating that additional teacher training and support was counterproductive. However, there were extraordinary circumstances (e.g., teachers strike, change of administration) that may have confounded these results.

3. Students with online access became more confident and those without online access became less confident in activities directly related to the thrust of the unit — that is developing and presenting a research paper.

4. The experimental students with online access learned more in the Civil Rights Unit than those who did not go online. Anecdotal evidence seems to indicate that the online students found information faster, found resources from a larger number of sources and in a wider variety of formats, and used the information in ways that made the material more relevant to their lives.

5. Students with access to the Internet used computer technology more than those who did not. At first this seems obvious, but it really is not. The control group students had the same access to computer technology as the experimental group, but it was the experimental group who used the computer more and better learned to take advantage of this powerful tool. In other words, the experimental group students learned to better use word processors, spreadsheets, and graphic applications through the course of the project.

6. Teachers in the experimental group personally dealt with a wider range of information and reported that they learned more about civil rights than teachers in the control group did. Most of this learning was attributed to personal online access, however online teachers also reported acquiring more information from their students than the control teachers did.

7. Interview data suggested that the online teachers had more positive interactions with parents because of more parent visits to the classroom, communication with parents via e-mail, and more positive parent-teacher conferences. Because there were so few teachers, these data only suggest trends found in the study.

In summary, the CAST study suggests that online access to the Internet may increase student learning and facilitate students to become independent, critical thinkers. It also offers evidence that student Internet use may help them better find needed information, organise and evaluate it, and then effectively present their new knowledge in profound ways.

2.6 Using the Internet in Constructivist Classrooms

In the traditional, linear learning model teachers lecture to students sitting in neat rows and cover the same material for all. Of course in this case, all students <u>must</u> proceed at the same pace or they will "not do well" in the class (e.g., get a bad grade). In this traditional case, the variable is the student's grade and the time and educational path are fixed. In the *hyperlearning model*, students may have a path suggested to them, but they are able to "jump" from one point in the curriculum to another, spending as much or as little time as the individual student may need on a given topic. Once the student has mastered the material, she or he may demonstrate that mastery through self-assessment. Here the grade is fixed (all students master all the material), but the amount of time needed and the path taken are both variables (Denning, 1996). This is exactly what the World Wide Web brings to learning — a student-centred, hypertexual organisation that encourages shared learning (Polyson, Saltzberg, & Godwin-Jones, 1996).

The World Wide Web lends itself to student-centred learning simply because of the nature of hypertexual organisation (Polyson, Saltzberg, & Godwin-Jones, 1996). The fact that individuals can "jump" from one reference to another without any predetermined pathway to follow allows material to be presented at different levels and at different degrees of difficulty. In this way students create their individual paths to master their desired goals in their own way and at their own speed. As opposed to linear learning, the hypertexual model more closely mimics human thought and in that sense can be a superior tool for the constructivist educator.

The constructivist teacher believes that the nature of science is both empirical and socially constructed. Historically, "doing science" has always entailed corroboration, communication, and dissemination of data among scientists. Now the rapid expansion of Internet communications emphasises this interactive notion of science. "Introducing students and teachers to the social structure of scientific communication as part of a hands-on, minds-on approach can help increase students' knowledge and interest in the sciences (Bartolo & Palffy-Muhoray, 1998, p. 133). Certainly educators have always supplied a great deal of classroom input concerning the empirical development of scientific concepts, but often have been less creative in involving students in constructing their own meaning through social interaction. This interaction — or collaboration — is essential and "in some of the world's most creative classrooms, computers and communications networks are facilitating collaboration already" (Gates, 1996, p. 215).

The true constructivist realises that students can not be just knowledge “absorbers,” but must be knowledge “presenters” too. This interaction and sharing of knowledge is exactly where the Internet comes to the fore. Students and teachers rapidly become active participants in the Internet world, a real world of people and events that engage one another as global citizens. The culture of the ‘net is as grassroots as it gets, empowering participants to create and share with others as much information as they take away for themselves (Kellogg & Viehland, 1995).

An example of one of these creative classrooms is found in the *Sensational Student Science Simulations* project at the Baker Demonstration School of National-Louis University in Deerfield, Illinois. Here eighth grade students design and carry out chemistry and physics experiments, and then publish multimedia documents detailing their findings using either HyperCard or HTML (Thurber & Dipinto, 1996). The target audience is the grade four and five students at the Demonstration School, but more generally, anyone interested in reviewing these postings on the World Wide Web.

A constructivist classroom embodies a rich learning environment consisting of as great a number of easily accessible resources as it is possible to collect in one location. Ideally students would have unlimited access to materials anywhere in the world. By using the Internet, we have recently found student interest going beyond merely worldwide and reaching for the stars. In the statewide Nebraska K-12 Internet Evaluation project, nearly all of the teachers interviewed and surveyed reported increased student enthusiasm and motivation due to Internet-related research and activities. One high school that carried out a project involving the study of the planet Mars reported that increased science course enrolments were directly attributable to Internet activities (Langan & Flynn, 1995, p. 24).

Consider a case where not one teacher or one classroom, but an entire school has transitioned to a more constructivist approach to learning. Certainly one of the pre-eminent experiments in applied constructivism combined with the ultimate in computers in education must be that of Methodists Ladies’ College in Melbourne, Australia. Starting in 1990, a program was implemented to equip all 2200 young women in the school with personal, networkable laptop computers.

> While traditional curriculum dominates at Methodist Ladies' College, every attempt is being made to move to a more constructionist approach which is learner centred. This approach is based upon Piaget's 'constructivism' where knowledge is 'built by the learner, not supplied by the teacher.' This idea has been extended by Seymour Papert to 'constructivism' which includes 'the further idea that this happens especially felicitously when the learner is engaged in the construction of something external or at least sharable… a sand castle, a machine, a computer program, a book…' (Loader, 1991, p. 4.1).

Phasing in over a period of several years, computer ownership at Methodist Ladies' College has evolved to a point where all students from fifth grade through high school along with all the staff have their own laptop computer. Loader goes on to say:

> These are not school computers, but the personal computers of students and staff. Students have the opportunity to use a personal computer for what they see as appropriate to their needs and interests. The student owner is responsible for determining the use of the machine. A personal computer needs to be compared to a student's notebook or to a student's textbook which has underlined sections and comments in the margins. On a personal computer students create their 'knowledge space' with their ideas, data and software. It is ownership not just of a machine, but of knowledge and power. The 'personal computer' policy was born out of educational philosophy, but there are good practical reasons for it too! There is the prohibitive cost for the school to buy computers, special desks and chairs, provide power outlets, et cetera. If the school had bought laptops, there would have been the problem of trying to keep track of them afterwards. A positive outcome of students owning their computer is that they value them more and therefore look after them better (Loader, 1991, p. 4.1-4.2).

The MLC project has been underway for the better part of a decade now. In the past few years, there has been a marked increase in Internet usage by both students and faculty. Where technology generally plays a peripheral role in education in the past with the teacher remaining the focus of the classroom, at MLC the teacher has joined the students as part of a learning community. "With the introduction of laptops at MLC the trend has moved away from 'computerising' towards an approach based on Piaget's 'constructionism' whereby knowledge is 'built by the learner, not supplied by the teacher.' This has resulted in changes to the curriculum and learning strategies, whereby learning becomes a three-mode affair — teacher exposition, self study and peer learning” (Smith & Carroll, 1995, p. 222).

As the teacher engages the student, the student interacts with her or his environment, the teacher, and other students. This interactive engagement represents the core of constructivist education. Hake (in press) defines interactive engagement as "heads-on (always) and hands-on (usually) activities which yield immediate feedback through discussion with peers and/or instructors" (p. 1). He summarises research on Interactive-Engagement compared to traditional methods of teaching the mechanics portion of introductory physics and talks of the pressure among physicists to shift away from lecturing and toward more inquiry-based, collaborative approaches to learning. Master teachers like Hakes (in press) and Hewitt (1990) lament of the fact that even "A" students often fail to grasp some of the most elementary ideas in the course. Regrettably, an innate talent for mathematics and a keen ability to follow directions can disguise their lack of understanding of basic physics principles. It does not matter how great a lecturer one is, you cannot "tell" people physics — it just cannot be done. Students need to touch and feel, to discuss, to place key understandings within some sort of contextual framework. And this may be of even greater importance to the population at large. Matthews (1989) points out that learning science in this broader scope (which includes historical and philosophical underpinnings) may be even more important when dealing with non-science majors simply because it is they who must learn <u>what</u> science is in the cultural sense, in the historical context.

2.7 Summary — A Gap in the Literature

To date, most of the research dealing with Internet usage in secondary schools has been at best sketchy. Of course that is to be expected because the technology has only reached widespread use in secondary schools during this current decade. As mentioned earlier, of the thousands and thousands of articles published concerning Internet usage in the schools, by far the most common theme deals with "how to" topics concerning funding sources, hardware acquisition, and the physical installation of school-wide and system-wide networks. By the mid-1990s more and more "resource-type articles" were being published with extensive listings of URLs and Web sites specifically for secondary science students. Early qualitative research includes a great deal of time log statistics and the coding of anecdotal data.

Furthermore, as has been pointed out above, hundreds of research projects offer mixed and inconclusive results relating to the effectiveness of technology to learning outcomes and many of these studies have been less than scientific (Jones & Paolucci, 1998). One of the best studies to date was the CAST study described above in which a controlled experiment was set up in which a Civil Rights Unit was taught in Internet and non-Internet schools. Though the study was done at the primary level and with social studies classes, much was gleaned from this work. Yet there is a glaring need for more research to be done on the educational use of the Internet in secondary science classes and just what effects this usage has on learning environments and learning outcomes. In particular, no literature can be found regarding associations between secondary science student use of the Internet and those students’ perceptions of their classroom learning environment. The research described in this study is a first attempt at assessing these relationships. The methodology of how this is achieved is detailed in Chapter Three.

CHAPTER 3

METHODOLOGY

> *Learning with and through technology has been a shared experience. As we have dared to be innovative and to take risks, so we have grown and our vision of what is possible has expanded. The now seemingly small and tentative first step of introducing laptops into some classrooms in 1990 has mushroomed into the development of an entirely different school culture in which technology is not a novelty, but an all-pervasive influence. It has become a medium for constructing one's one learning which is taken for granted in much the same way as pens and paper were previously. Many of the benefits of the personal computer were just what we had hoped for when we began the program, but the exciting thing was the synergistic effects that were over and above what we had envisioned. Technology proved to be more than a catalyst for change in learning and teaching practices; it also ushered in an entirely new culture in which the school became a community of learners, where co-operative and collaborative learning became the norm.*
>
> (David Loader, *Reflections of a Learning Community,* 1991, p. 1)

The last chapter presented a review of literature and pointed out that a gap exists in our knowledge of secondary science students' use of the Internet and the way those same students perceive their classroom learning environment. In this chapter, the details of the methodology used to explore this topic are described. A review of the sample is made looking at the particulars of the five high schools included in the study. This is followed by a detailed analysis of the quantitative methodology used together with a description of the questionnaire. Finally, the qualitative aspect of the study is presented with an explanation of how the student and teacher interviews were carried out as well as the use of classroom observations.

3.1 The Sample Schools: The Catholic Schools Department of Hawaii

The survey was administered to a sample of 431 students in five high schools in the Hawaii Catholic School Department between November, 1996 and January, 1997. Follow-up student interviews were conducted with about 10% of the students. School visits, classroom observations, and teacher interviews were carried out throughout most of this academic year from October 1996 through to May 1997. The sample is described in greater detail below.

- Sample High School One: 496 all boys (9-12): All science classes were connected to the Internet with eight terminals in the classroom visited (mostly Apple Macintoshes). The student sample here consisted of three physics classes, one teacher, and 56 students (56 male, 0 female).

- Sample High School Two: 550 co-ed (9-12): There were no Internet connections in individual classrooms, but the Resource Centre had 16 Internet terminals and 16 student computers (all PCs). This school was in the second year of their change over to the Essential Schools Program (intensive scheduling/trimesters). The student sample involved four classes (AP Physics, AP Chemistry, Chemistry, Global Science), one teacher, and 68 students (33 male, 34 female, 1 no gender answer).

- Sample High School Three: 997 girls (650 7-12): Each science classroom involved in the project had one Internet computer. There was a science computer centre (the "Shack" with 12 PCs), and the school's resource centre had 12 Internet computers (all PCs). Here a total of six classes participated in the project (4 Chemistry, 1 Earth and Space Science, 1 Physiology), two teachers, and 107 students (0 male, 107 female).

- Sample High School Four: 430 girls (6-12): There was one Internet computer in two of the three classrooms visited and 12 Internet terminals in resource centre (all PCs). The sample here involved eight different classes (4 Biology, 1 Honours Biology, 1 Physics, 1 Physical/Earth Science, 1 Earth Science), three teachers, and 108 students (0 male, 108 female).

- Sample High School Five: 285 co-ed (7-12): Each science class has one Internet computer and the computer lab and resource centre has about 20 more Internet terminals (all PCs). There were eight classes participating here (2 Chemistry, 1 Physics, 1 Organic Chemistry, 1 Physiology, 2 Biology, 1 Marine Science), three teachers, and 92 students (55 males, 37 females).

3.2 Measuring Classroom Learning Environments

Over the past few decades contributions to the study of classroom environments have been made by both quantitative and qualitative methods. As discussed in the previous chapter, quantitative assessments are typically collected by means of a widely applicable, broadly distributed questionnaire or survey to large samples of students, often in different regions or countries in cross-cultural studies. Large samples numbering into the hundreds of classrooms and thousands of students are more readily reported using this technique. A qualitative approach employing on-site observations and personal teacher and student interviews historically has been better suited to smaller samples that are usually studied in greater depth. Fraser and Tobin (1991) argue for a combination of both qualitative and quantitative methodologies, allowing the researcher to better triangulate findings and therefore offer greater credibility to inferences that are based on a range of different data-collecting techniques. Of course this combination of complementary qualitative observational data and quantitative classroom environment data contribute to the richness of the analysis as a whole.

Additionally, studies point out the predilection of certain target students to skew quantitative data concerning classroom environments (Tobin, 1987, Tobin & Gallagher, 1987b, Tobin & Malone, 1989). Here it was found that certain subgroups of students within the classroom perceive different environmental realities because of differential treatment by the teacher. These "target students" tend to consistently rate the class and teacher in a more positive light than other subgroups of students do, especially in areas of involvement and rule clarity. This of course is due to the fact that target students are called on to the exclusion of others and find themselves the centre of attention within a given class. These findings raise caution to the practice of using a class mean on a survey as the unit of analysis of classroom environments and reinforce the need for a follow-up, qualitative dimension to the study.

That said, this research was designed to employ both the quantitative nature of the CLES, the student attitude scale, and Internet survey questions along with the qualitative techniques of observations, interviews, and the teacher-researcher's personal classroom experiences. Classroom observation was carried out employing the more qualitative "naturalistic enquiry" technique described by Fisher (1992a).

3.3 Quantitative Methods

The quantitative methods involved in this study included a student questionnaire and a teacher questionnaire. The student questionnaire combined the Constructivist Learning Environment Survey (CLES) and a scale from the Test of Science Related Attitudes (TOSRA) along with a Student Internet usage scale.

3.3.1 The Constructivist Learning Environment Survey (CLES)

Traditionally, teachers have been "transmitters" of information and students have been "receivers" of this information. It can be argued that even the more recent "discovery learning," or "hands on" approach to education implicitly emphasised a set body of knowledge that each student had to "discover" in order to pass the class. However, as outlined in the previous chapter, there has been a movement in recent years towards an understanding of a more personal cognitive process, one in which each individual constructs her or his own meaning in the context of past experiences. Because the individual is part of a social environment, this construction of knowledge involves negotiation with others and an on-going process of building one's own knowledge.

If one accepts the idea of educational constructivism, it follows that exemplary teachers are ones whose students perceive their classes as more "involving" (Tobin & Fraser, 1990), but a tool was needed by which to appraise this inclusive environment. Therefore, a new classroom environment instrument was designed to assess the degree to which constructivist principles are implemented within individual classrooms. The questionnaire was named the Constructivist Learning Environment Survey (Taylor & Fraser, 1991; Taylor, Fraser, & Fisher, 1997) and made it possible for teachers and researchers to monitor the development of a constructivist learning environment in science (Taylor, Dawson, & Fraser, 1995). The initial development of the CLES was guided by four criteria (Taylor & Fraser, 1991):

1. The authors wanted it to be consistent with von Glaserfeld (1981, 1988) and the "radical" theory of constructivism in which students participate in the management of their own learning activities.

2. It had to be worded in such a way as to obtain each respondent's perception of her/his own subjective perception of the classroom environment independent of the views of classmates.

3. Its construction had to be efficient enough so that it could be administered and scored in a quick and easy manner. The revised CLES used in this study has only 30 items.

4. The instrument had to be deemed salient by researchers, teachers, and students. This was accomplished by conducting interviews with teachers, researchers, and students at the secondary level.

An initial attempt at designing a constructivistic classroom inventory was field tested and validated with a sample of 508 secondary science and mathematics students in 26 Australian schools.

A revised version of the CLES was completed in 1993 and reported in the following year. This version also incorporated a *critical theory* which acknowledges the socio-cultural framework of learning environments (Grundy, 1987; Habermas, 1972, 1984). In this newer version of the CLES, the authors develop the *critical constructivist* theoretical framework of science education (Taylor, Fraser & White, 1994), recognising the reality of existing curricula and assessment policies. Based on the theory of Habermas mentioned above, the *critical constructivist* counterbalances this traditional approach of controlled curricula with *emancipatory interests* of the individual allowing each to become critically aware of the cultural myths that frame understanding of self and the environment. In short, critical constructivism concedes that the cognitive constructive activity of each individual student occurs within, and is restricted by, a socio-cultural context. “Significantly, constructivism and critical theory share a non-functional epistemological principle: Because scientific knowledge arises from our attempts to impose order on our experiential worlds, scientific knowledge may have only a provisional (rather than absolute) status” (Taylor, Dawson, & Fraser, 1995, p. 2).

In a practical sense, Taylor and Fraser (1991) called on teachers to present opportunities for their students to:

- negotiate with the teacher concerning the nature of their learning activities;
- be involved with the determination of evaluation criteria and undertake self and peer assessment;
- participate in collaborative and open-ended dialogue and inquiry with classmates; and
- share in reconstructing the social norms of the classroom.

As will be documented below, the revised CLES has been designed to give insight into these aspects of classroom environment.

The third version of the CLES, used in this study, was revised so that only one reversed score item (negatively worded) was included, avoiding some of the conceptually complex syntax found in the 1994 variant. Also, the version used in this study specifically referred to “this science class” as opposed to mathematics class versions of the instrument. The CLES is available from Curtin University of Technology in a *Student Perceived Form*, a *Student Preferred Form*, a *Teacher Perceived Form*, and a *Teacher Preferred Form.* As mentioned earlier, both the perceived and preferred include the same items, but the wording is such that the respondent assesses what is actually perceived in the classroom (actual form) as opposed to what she or he would like the classroom environment to be (preferred form). Sample questions are:

Student Perceived Form:

- In this class I get the chance to talk to other students.
- In this class I help the teacher plan what I am going to learn.

Student Preferred Form:

- In this class I wish that I got the chance to talk to other students.
- In this class I wish that I could help the teacher to plan what I am going to learn.

Similarly, the teacher perceived and teacher preferred forms are designed to assess how the teacher believes her or his students see the constructivist classroom environment and what they would prefer it to be. This battery of CLES versions is often times used to affect change within the classroom, but since that was not the purpose of this research, only the *Student Perceived Form* was used in the study.

Several studies have validated the CLES using Cronbach alpha reliability, discriminant validity, and one-way Analysis of Variance as mentioned previously in context with other classroom environment instruments. Taylor and Fraser (1991) used a sample of 508 Western Australia secondary science students to test an early version of the CLES and the … “scales were found to display satisfactory internal consistency, discriminant validity, and predictive validity" (p. 3). Work continued in Western Australia as Taylor, Fraser, and White (1994) used a revised mathematical form of the CLES and reported that the Cronbach alpha reliabilities ranged from 0.54 to 0.68. Here several negatively worded items (e.g., answers are scored in reverse) seemed to make little or a negative contribution to the scales in question. A new, 30-item version of the CLES was trialed on 494 students by Taylor, Dawson, and Fraser (1995). This form was the first to employ the six-item, five-scale array used in this study. Here the alpha reliability coefficients ranged from 0.72 to 0.91, easily exceeding the 0.60 level needed to be considered satisfactory (Nunnally, 1967). Another study of 1600 students in 120 grade 9-12 science classes in Dallas Public Schools in the United States had similar results (Taylor, Fraser, & Fisher, 1997). Here the alpha reliabilities for four of the scales were above 0.80. The exception was the Uncertainty Scale where the figure was 0.61. Additionally, a factor analysis conducted in this study indicated that the CLES was indeed composed of five factors equivalent to the five scales. In this investigation the CLES again proved of great value in monitoring the development of constructivist environments in school learning environments. However, this study marks the first use of the CLES in Hawaiian Catholic Schools.

3.3.1.1 The Scales of the CLES

The CLES instrument was designed to measure five areas of interest concerning the classroom environment.

1. *Personal Relevance Scale:* Considering the fact that each student arrives in the class with a set of preconceived ideas concerning how the physical world works, it is important to take these past experiences into account. This scale probes the student's perceived relevance of her or his science class with her/his out-of-school experience. In other words, how well is each student's real-world experiences utilised in order to develop her or his scientific knowledge? Sample questions are:

- I learn about the world outside of school.
- I learn about how science can be part of my out-of-school life.
- I learn interesting things about the world outside of school.

2. *Student Negotiation Scale:* In recognition of the idea that learning is a social activity, students need the opportunity to interact with each other, testing new ideas and constructions of knowledge on their peers. Only by the process of reflection and reality testing of each other's ideas can the student develop new knowledge in a meaningful way. The Student Negotiation Scale assesses how free the student perceives the environment in allowing collaborative interaction. Some sample statements are:

    - I talk to other students about how to solve problems.
    - I explain my ideas to other students.
    - I ask other students to explain their ideas to me.

3. *Shared Control Scale:* In order to develop as an autonomous learner, the student needs to exercise a degree of control over the learning environment. The Shared Control scale asks if students have a voice in the planing and implementation of learning activities, in the determination of assessment objectives and tools, and in the negotiation of classroom norms and rules. Some sample questions are:

    - I help the teacher plan what I am going to do.
    - I help the teacher to decide how well I am learning.
    - I help the teacher to decide how much time I spend on activities.

4. *Critical Voice Scale:* Knowing full well that the teacher is constrained by the reality of existing curricula and that the "delivery of mandated course content" is decreed by external authorities, the teacher can still be accountable to their students for their pedagogical actions. The Critical Voice Scale questions the extent to which the social climate allows students to question her or his teacher's actions, plans, and methods, and permits individual students to voice concerns about any perceived obstacles to their learning. Sample questions are:

- It's okay for me to ask the teacher "why do I have to learn this?"
- It's okay for me to question the way I'm being taught.
- It's okay for me to express my opinions.

5. *Uncertainty Scale:* In rejection of the Western concept of a "universal, unchanging truth," above and beyond any social or cultural considerations, a constructivist classroom provides opportunities for students to experience the uncertainties and limitations of scientific knowledge. This scale looks at what chances students have to encounter scientific knowledge as always evolving and changing and based on cultural and social environment. Some sample statements used are:

   - I learn that science cannot provide perfect answers to problems.
   - I learn that science is influenced by people's values and opinions.
   - I learn that science is about inventing theories.

There are six items in each of these scales designed to measure a student's individual perception of her or his constructivist science classroom learning environment. Students are asked to respond how often the behaviour occurs in their classroom. The response options are: almost always = 5, often = 4, sometimes = 3, seldom = 2, almost never = 1. The inventory is scored by adding the six items and calculating an average score for that scale with a range from more non-constructivist (towards 1) to more constructivist (towards 5). As any student perceives her or his classroom environment as being more constructivist, the average score would be higher (closer to 5).

3.3.1.2 Administering the CLES

Generally the CLES is best administered about midpoint in whatever educational cycle is employed by a particular school (e.g., year-long schedule, trimester schedule), since that much time is needed for students and teachers to have developed an environment particular to that classroom. In this sample, four of the five schools were on a semester schedule with each class running a full, two-semester academic year. In Hawaii, semester one generally runs from August through December and semester two runs from January through May. The fifth school used a trimester plan in which each class met for only one trimester (trimester one from August into November; trimester two from November into March; trimester three from March through May). In the case of the four schools operating on a full academic year schedule, the instrument was administered during January 1997 at the start of the second semester. In this case, the students and their respective teachers had settled into a reasonably stable state and the classroom environment had been well established. In the one school operating on a trimester plan, the entire course was taught in one twelve-week period with a particular chemistry or physics class meeting for a two-hour block each day. Because of this, the first sample of students to complete the questionnaire completed the survey instrument in November 1996, approximately nine weeks into their twelve-week trimester. This was the only data collection that was carried out without the researcher going into the classroom and by simply mailing the instruments out for the teacher to administer. In every other case the author administered the surveys and tabulated results that were entered into a spreadsheet for statistical analysis.

3.3.2 Student Attitude Towards Science: The TOSRA Items

Though it is not a part of the CLES instrument, an additional scale was included in the questionnaire used in this study in an attempt to better understand each student's attitude towards her or his science class. This seven item scale was based on the *Test of Science Related Attitudes* (TOSRA) developed by Fraser (1978) and queries students concerning their anticipation and enjoyment of their science class. The initial long form showed strong internal consistency as indicated by high alpha coefficients (Fraser, 1981). Fisher, Henderson, and Fraser (1995) used the shortened version of the student attitude towards science scale and they have reported similar alpha coefficients, also greater than 0.80, indicating strong internal consistency.

3.3.3 Measuring Student Internet Usage

Internet usage information was gathered using questions categorising the terminal location(s) at which the student used the Internet, the total time the student used the Internet, and the stated intention the student had while using the Internet. Eight questions required simple yes or no answers (e.g., "Do you ever use the Internet by yourself? Do you use the Internet in this science classroom? Do you use the Internet at any other computer or terminal in the school? Do you use the Internet at home?). A yes answer was scored as 1 and a no answer scored as 0. Two questions inquired about time of usage and required progressive answers (e.g., How many times a month do you use the Internet? How much time per session do you use the Internet?). These two questions were scored from 1 to 5 and 1 to 4. Consequently, the minimum Internet usage total was scored a 0 for the nine students in the 431-student sample who indicated they had never used the Internet. The maximum Internet usage score was 17. Though it was not possible to actually weight these Internet scores, an ordinal ranking of student totals assumes that a higher score was associated with greater Internet usage.

A full version of the instrument used in this study including the CLES, student attitude, and Internet items is included in Appendix A.

3.3.4 Teacher Questionnaire

A *Teachers' Form* of the data collection instrument was given to each teacher in the sample and is included in Appendix B. This form was distributed in April 1997 and each teacher filled it out individually. This form asked the same Internet questions as were asked of the students, but did not include the classroom environment scale questions. From this survey, each teacher was assigned an Internet usage score using the same process as that used for the students.

3.4 Qualitative Methods

Quantitative methods have been used to collect data on classroom environments for several decades now, most employing some form of classroom questionnaire. However there are potential advantages to employing both quantitative and qualitative methods with in the same study (Fraser & Tobin, 1991). Often, a combination of both quantitative and qualitative methods can yield a rich understanding of classroom learning environments not available to either method alone.

> The combination of qualitative and quantitative methods in the studies… can be considered noteworthy for several reasons. First, the complementarity of qualitative observational data and quantitative classroom environment data added to the richness of the data base as a whole. Second, the use of classroom environment questionnaires provided an important source of students' views of their classrooms; for example, it is noteworthy that the classes of teachers identified as exemplary by their teaching peers also could be differentiated from non-exemplary teachers' classes in terms of student perceptions of classroom psychosocial environment. Third, through triangulation of quantitative classroom climate data and other quantitative information, greater credibility could be placed in findings because they emerged consistently form data obtained using a range of different data collection methods. Clearly, a confluence of qualitative and quantitative methods is a desirable future direction for research ion learning environments (Fraser & Tobin, 1991, p. 290).

The qualitative methods involved in this study included classroom observation, student interviews, and teacher interviews. The student interviews were more formal in that a set of questions was followed during the interview process. The classroom observations and teacher interviews were of a more open nature with no set questions asked, since the researcher had regular communications with most of the teachers in this study and was able to visit classrooms on more than one occasion.

3.4.1 Teacher Interviews and Classroom Observations

On site classroom and school observations were carried out regularly throughout the study, though that was not the extent of personal site visits. Because the author was a member of the Hawaii Catholic Schools Science and Technology Committee, he was well acquainted with all the school sites and many of the teachers included in the sample. Because of this familiarity, students and teachers alike easily accepted the researcher into their surroundings and allowed him access to many facets of the environment. Though there were no formal teacher interviews in the same sense as the student ones detailed below, there was an on-going dialogue between most of the teachers in this study and the researcher throughout the project. Though there is no separate reporting of these teacher comments, information gained from them is reported throughout the paper.

3.4.2 Student Interviews

Personal interviews were held with 36 of the 431 students involved in this sample. Three of the students actually were in two of the classes in the study. The time spent by the researcher interviewing students proved very revealing. Several studies comparing computer-based learning with non-computer methodologies do not always provide great insights to what goes on with students employing instructional technology. Even in situations where pre and post tests are used, a great deal of detailed analysis of student interactions with hardware, software, and fellow students is needed (Berger, Lu, Beltzer, & Voss, 1994). For that reason follow-up interviews were conducted to give great insight to the answers recorded on the questionnaire administered earlier in the academic year. Interviewees were selected to include a spectrum of those responding that they used the Internet a great deal, that they used it very little, or that they used it an average amount compared to their peers.

Each interview was conducted during class time, but in a private setting away from teachers and classmates. In all but one case, students were interviewed individually in private conversations lasting anywhere from ten to twenty-five minutes. In one school, scheduling demands necessitated meetings with one group of three students and one group of four students. In all cases, students were asked for their permission to have the session audiotape recorded after assurance of confidentiality, especially concerning conversations regarding their teacher. In order to maintain uniformity in questions from student to student and to act as a refresher to the interviewer concerning that student's particular questionnaire answers, a simple question form was used and is included in Appendix C.

First the student was reminded of how they said they used the Internet on the original survey some two to three months previous to the interview and were asked how their habits may have changed. Second, students were asked to comment generally on how they used the Internet, how they perceived their science class, and whether or not the Internet had any effect on that perception. Third, the interviewees were asked about their perception of the five individual CLES scales and the student attitude scale in an attempt to clarify and provide depth to their numerical answers. Finally, a general question was asked regarding how the individual saw the Internet affecting their school experience, especially related to their science class. In every case, open-ended responses were encouraged in an attempt to get beyond yes and no answers. This approach provided a rich, insightful look into each student's perception of her or his classroom environment and offered a fine opportunity for open-ended responses.

3.5 Discussion of the Study

It needs to be emphasised here that this study was carried out within five Catholic high schools and that the fact that these schools are Catholic must be taken into account. Certainly the Catholic Church asserts that its schools have a different learning environment than the government-run, public schools, with Christian values and practices running through the entire curriculum, not simply in separate religion classes. Randhawa (1991) studied learning environments in three Saskatchewan, Canada schools (one Catholic girls school, one Catholic boys school, and one government school) used the 15-scale Learning Environment Inventory. With the boys, he found significantly lower scores for the Catholic students over the public school students on Goal Direction and Democracy, but higher scores for Cohesiveness, Friction, Favouritism, Disorganisation, and Competitiveness.

Likewise Dorman, Fraser, and McRobbie (1994) conducted a much larger study in 10 Catholic non-order schools (co-educational and lay administered), 10 Catholic order schools (single-sex schools and administered by a single order of nuns or priests), and 12 government schools in Queensland, Australia. In general the findings of the study were in agreement with Randhawa's findings. Government schools scored significantly higher than both order and non-order Catholic schools on the Interaction scale and higher than Catholic non-order schools on Task Orientation.

However, the situation in the United States is somewhat different. Because of USA Constitutional issues, no religious schools receive any government monies in that country, whether that money be in the form of vouchers, tuition waivers, or any other form of subsidy. In an *U. S. News & World Report* cover story entitled "The Exodus" (December 9, 1991) it is pointed out that the mission of the Roman Catholic education system within the United States has changed. Established in the 19^{th} century to educate the children of Catholic immigrants, it always offered an inexpensive alternative for blue-collar families. Now because of shifting demographics, the Catholic schools are more and more called upon to educate large numbers of inner-city minority students, with an ever-increasing percentage of student populations being non-Catholic. Between 1970 and 1990 the percentage of non-Catholic students in US Catholic schools rose from 11% to 23%. In the State of Hawaii the percentages are even greater, though exact numbers are difficult to find. At one of the sample schools for which information can be found, during the last accreditation report for the 1992-93 academic year, 34% of the students registered from grades 7-12 were non-Catholic (Churach, 1993). It is reasonable to believe that the percentage in the five high schools included in this sample is at least that high.

Additionally, all five schools involved in this sample have overwhelmingly lay faculties and 100% of the teachers involved in this study were lay teachers.

3.6 Summary

In summary, the CLES was chosen for use in this study because it gives a particularly good insight of students' perceptions of their constructivist classroom learning environment. In order to obtain an assessment of student attitudes towards their science classes, a short seven-item scale from the TOSRA was added. Both have been used in a variety of other studies in several countries. Their reliability and validity have been established through the internal consistency of the items within each scale (as indicated by Cronbach alpha reliability scores), the mean correlation of a scale with the other four scales, and their ability to distinguish between different classrooms (as indicated by a one-way Analysis of variance. The data in this study were collected between November 1996 and May 1997. Because the author had been previously involved in working with the staff in all five schools before this project was undertaken, he was able to observe and interact with both faculty and students in a mostly unobtrusive way. Once all the data had been collected, the quantitative results were tabulated and entered into a spreadsheet and the qualitative observations and interview material were transcribed for analysis. These analysis are reported in Chapters Four and Five.

CHAPTER 4

QUANTITATIVE RESULTS

Since Cyberspace is still in its infancy and we don't yet depend on it for our survival, it can still be enjoyed. Like a good cruise, much of the fun is just going somewhere.

(Hal Berghel, 1995, p. 11)

Chapter Three reported on the quantitative and qualitative methodologies used in gathering data used in this research. This chapter details the quantitative results found in the collection of these data. The statistical treatments used to validate the questionnaire scores and associations found between classroom environment scales and student Internet usage scores are presented. Additionally, associations between how individual teachers use the Internet as opposed to how their students use it are discussed. Finally, a case is made for the need to use a more qualitative methodology in order to complement the quantitative findings.

4.1 Compilation of Questionnaire Results

It is noteworthy to mention that much of the previous research with the CLES (as well as other classroom environment research) has been correlational in nature and investigates associations between various outcomes and different dimensions of the environment. Because of this, one needs to be cautious in not attempting to draw strict causal relationships (Fraser, 1994). Additionally, as was pointed out in the preceding chapter, studies involving the use of classroom environment scales have shown variations in psychosocial environments in Catholic schools as compared to public ones (Dorman, Fraser, & McRobbie, 1994). The author of this study has taken these cautions into consideration in making generalisations based on the CLES results. Nonetheless, certain trends and tendencies can be pointed out from the use of the survey.

Each questionnaire was scored by hand and statistical analyses of the quantitative data collected were conducted using Microsoft Excel (Microsoft Corporation, 1997) and the Statistical Package for the Social Sciences (SPSS, Inc, 1995) software packages.

4.2 Validation of the CLES

Alpha reliability figures (see Table 4.1) were calculated for the present sample in order to provide further cross-validation information supporting the internal consistency of the five CLES scales and with the individual student as the unit of analysis. It was considered that there were too few classes to make it appropriate to use the class mean as the unit of analysis. Generally, it can be concluded that the CLES does have satisfactory reliability for use with this population of students. The Cronbach alphas ranged from 0.64 to 0.92, all exceeding the recommended level of 0.60 (Nunnally, 1967). The seven-item student attitude scale was found to have a Cronbach alpha reliability of 0.89, also exceeding Nunnally's 0.60 threshold.

Another desirable characteristic of any instrument like the CLES is that it is capable of differentiating between the perceptions of students in different classrooms. That is, students within the same class should perceive it relatively similarly, while mean within-class perceptions should vary from class to class. This characteristic was explored for each scale of the CLES using a one-way ANOVA, with class membership as the main effect. It was found that each CLES scale differentiated significantly ($p<0.01$) between classes and that the eta^2 statistic, which is the ratio of 'between' to 'total' sums of squares and represents the proportion of variance in scale scores accounted for by class membership,, ranged from 0.10 to 0.28. This indicates that each scale of the CLES is capable of differentiating significantly between classes. The relatively low figure for the Uncertainty scale suggests that this dimension of the constructivist learning environment of most science classes is quite similar in Hawaii.

Additionally, one other feature considered important in a classroom environment instrument like the CLES is the discriminant validity of each scale of the instrument, that is, the extent to which the scale measures a dimension different from that measured by any other scale. In this study, the mean correlations of one scale with the other four scales ranged from 0.23 to 0.33. These values can be regarded as small enough to confirm the discriminant validity of the CLES, indicating that each scale measures a distinct, although somewhat overlapping, aspect of the constructivist classroom environment.

Table 4.1:
Internal Consistency (Cronbach alpha coefficient), Discriminant Validity (mean correlation of scale with other four scales), and Ability to Differentiate Between Classrooms for the CLES

CLES Scale	**Cronbach Alpha**	**ANOVA (*eta*^{2})**	**Mean Correlation**
Personal Relevance	0.81	0.22**	0.30
Uncertainty	0.64	0.10*	0.23
Critical Voice	0.88	0.28**	0.33
Shared Control	0.91	0.14**	0.33
Student Negotiation	0.92	0.25**	0.31

*p<0.05 **p<0.01 n = 431

Considering the Cronbach alpha and ANOVA analysis of the many classroom environment instruments mentioned in Chapter Three, the results of this questionnaire seem to be within the acceptable parameters for being considered a valid indication of what student perceptions of their classroom environments were in those classes studied. In particular, this result is comparable with the range of 0.61 to 0.89 reported by Taylor, Fraser, and Fisher (1997).

4.3 The Internet Usage Total

The Internet usage questions were collapsed into a condensed score and associations between these scores and the various classroom environment scales were examined. These quantitative data were augmented by the qualitative information obtained from the student and teacher interviews and the school and classroom observations.

Totalling responses each student made to the ten items assessing her or his personal Internet usage resulted in the Student Internet Usage score. For the first eight questions, a yes response was valued a one and a no response was valued a zero. For questions 9 and 10, progressively greater usage was valued a greater score. In question 9, less than one time a month was rated at one and more than fifteen times a month was valued at five. For question 10, less than fifteen minutes per session was given a score of one and more than an hour per session was rated four. After tabulation, each student was given an ordinal value *"Total Internet Usage Score"* of 0 through 17 with progressively higher scores indicating greater Internet usage. Table 4.2 below summarises the Internet questions asked and the range of scores possible for each. The entire instrument is included in Appendix A.

Table 4.2:
Summary Chart of Student Internet Usage Scoring

Question	Range of Scores
1. Have you ever used the Internet by yourself?	0 or 1
2. Have you ever used the Internet with someone else?	0 or 1
3. Do you use the Internet in this science classroom?	0 or 1
4. Do you use the Internet in any other science classroom in this school?	0 or 1
5. Do you use the Internet in this school's resource centre or library?	0 or 1
6. Do you use the Internet at any other computer or terminal in your school?	0 or 1
7. Do you use the Internet at home?	0 or 1
8. Do you use the Internet at any other location besides this school or your home?	0 or 1
9. On average, how many times a month would you say that you use the Internet during the course of a typical month while school is in session?	0 to 5
10. On average, how much time per session do you spend using the Internet?	0 to 5
Total of ten Internet usage questions.	0-17

Of the total sample of 431 students, only 11 respondents tallied a 0.0 Student Internet Usage Score, meaning they had never used the Internet at the time of the survey. The mean Internet usage score for the entire sample was 9.76 as shown in Figure 4.3.

4.4 CLES, Student Attitude, and Internet Usage Totals

Tabulation of CLES and TOSRA scores was rather straightforward. As mentioned previously, as a student perceives her or his classroom environment as more constructivist, the mean CLES score on each scale would be higher (closer to 5). The same is true of the TOSRA-based Attitude Scale. Though each CLES scale measures a different dimension of the classroom environment, all five CLES scores were totalled and a simple average score was calculated to gain insight as to the over-all constructivist nature of a classroom. In this sample of 431 students in the 28 classrooms studied, students generally seem to see their environments as constructivist and have a positive attitude towards their science classes. A mean of 3.00 indicates the midpoint between the least constructivist classroom environment (1.00) and the maximum constructivist (5.00). Considering that the means of four of the five CLES scales are in excess of 3.41, the classrooms represented by this sample are perceived by most students as constructivist in nature. Similarly, the 3.39 mean Student Attitude score indicates that students in the sample generally have a positive attitude towards their science classes. By far, the lowest mean (2.51) is found in the Shared Control scale, indicating that in general, these students perceived themselves to have only a less-than-average voice in the planning and implementation of learning activities, in the determination of assessment objectives and tools, and in the negotiation of classroom norms and rules. This can be explained considering the missions of the five schools included in this sample. In every case these schools catered to a population of students intent on gaining university entrance. Because of this teachers felt constricted by curriculum guidelines detailing course content needed to be covered in order to prepare students for national college entrance testing (e.g., Scholastic Aptitude Test). For this reason, most of these classrooms were run in what might be considered a very teacher-centred, “traditional” manner with the teacher setting the goals of content to be mastered and examinations given at regular intervals. In light of this, the above average CLES scale means are in many ways even more remarkable. The scale totals are given in Table 4.3.

Table 4.3:
Total Sample Raw Data for Internet Usage, CLES Scales, and Attitude Scale

Scale	Mean	s. d.
Student Internet Usage	9.76	3.26
Personal Relevance	3.73	0.70
Uncertainty	3.41	0.61
Critical Voice	3.52	1.00
Shared Control	2.51	0.90
Student Negotiation	4.00	0.86
Total CLES	3.43	0.55
Student Attitude	3.39	0.94

n = 431

Though statistics were compiled considering gender as a qualifier, the inclusion of all-boy and all-girl schools in this sample tends to skew those results. Though there were differences seen in male and female totals, caution must be exercised due to the large number of students in single-sex schools where differences could be an effect of the schools rather than gender. Table 4.4 shows the boy-girl tallies in the sample including only students attending the two co-educational institutions. Table 4.5 reports boy-girls scores for students attending single-sex schools (two all-girls and one all-boys schools).

Those who seem to use the Internet the most were the boys in the one all-boy school in the sample (11.86) and those who use it least were the girls in the all-girls schools (9.02). This does not seem to have any relationship to the availability of computers or Internet access, since all schools were well equipped for any students interested in using the Internet. Certainly other studies have shown that boys use the Internet more than girls do. In the USA, boys spend 45% more time online than girls do (Masten, 1997).

Table 4.4:
Sample Boy-Girl Totals for Co-Educational Schools Internet Usage, CLES Scales, and Attitude Scale

	Boys in Co-Ed Schools		Girls in Co-Ed Schools		Total Sample in Co-Ed Schools	
Total Students	88		71		159	
Scale	Mean	s.d.	Mean	s.d.	Mean	s.d.
Student Internet Usage	10.45	2.96	9.54	3.51	10.04	3.24
Personal Relevance	3.37	1.04	3.54	1.08	3.45	1.06
Uncertainty	3.46	1.16	3.42	1.16	3.44	1.16
Critical Voice	3.34	1.29	3.44	1.28	3.39	1.29
Shared Control	2.43	1.07	2.67	1.11	2.54	1.09
Student Negotiation	3.68	1.04	4.04	1.02	3.84	1.05
Total CLES Average	3.26	1.22	3.42	1.20	3.33	1.21
Student Attitude	2.88	1.26	2.89	1.25	2.88	1.25

Concerning the CLES scales, in single-sex schools both the boys (3.75) and girls (3.92) scored statistically significantly higher than their co-educational counterparts (co-ed boys = 3.37 and co-ed girls = 3.54). Also, the Student Negotiation scale was a great deal higher for boys in the all-boys school (4.04 versus 3.68 for boys in co-ed schools), though the difference was only marginal for girls (single-sex girls = 4.09 versus co-ed girls = 4.04). One of the only areas perceived as more constructivist by co-ed students was the Uncertainty scale where co-ed boys scored 3.46 to single-sex boys 3.36 and co-ed girls totalled 3.42 to the singles-sex girls 3.39.

Table 4.5:
Sample Boy-Girl Totals for Single-Sex Schools Internet Usage, CLES Scales, and Attitude Scale

	Boys in All-Boys Schools		Girls in All-Girls Schools		Total Sample in Single-Sex Schools	
Total Students	56		215		271	
Scale	Mean	s.d.	Mean	s.d.	Mean	s.d.
Student Internet Usage	11.86	2.46	9.02	3.25	9.61	3.31
Personal Relevance	3.75	0.54	3.92	0.60	3.89	0.59
Uncertainty	3.36	0.59	3.39	0.64	3.38	0.63
Critical Voice	3.68	0.75	3.57	1.06	3.59	1.00
Shared Control	2.55	0.90	2.47	0.93	2.48	0.93
Student Negotiation	4.04	0.88	4.09	0.89	4.08	0.89
Total CLES Average	3.48	0.43	3.49	0.58	3.48	0.55
Student Attitude	3.45	0.87	3.72	0.83	3.66	0.84

Generally, these co-educational students see their classrooms as a bit less constructivist than their same-sex school counterparts, though in most cases the differences are not great for the individual CLES scores or the overall CLES total. The general trends seem to be the same with the boys using the Internet more than the girls, but the girls viewing their science classroom environment as more constructivist in nature. By far the greatest difference found in this sample was in student attitude towards their science classes as measured by the seven-item scale derived from the TOSRA. Here the single-sex students had a much more positive attitude (boys = 3.45 and girls = 3.72) than the students in co-educational schools (co-ed boys = 2.88 and co-ed girls = 2.89). These gender differences are treated in greater detail in Chapter Five.

Table 4.6 reports results of associations found between Student Internet usage and student perception of her or his classroom environment and overall attitude towards her or his science class. Weak but significant correlations were found between student Internet usage and four of the CLES scales. Uncertainty, Critical Voice, Shared Control, and Student Negotiation were all positively associated with Internet usage. No significant correlation was found between Internet Usage and attitude to science.

Table 4.6:
Associations Between CLES Scales and Attitude, and Internet Usage in Terms of Simple Correlations (r)

Scales and Attitude Scale	Internet Usage
Personal Relevance	0.10
Uncertainty	0.11*
Critical Voice	0.12*
Shared Control	0.17**
Student Negotiation	0.15**
Student Attitude	0.06

$^{*}p<0.05$ $^{**}p<0.01$ n=431

Though the correlation coefficients are small, they are statistically significant. It is also of interest that all of the correlations are positive, certainly not the expected result if associations between Internet usage and perception of environment were a mere chance occurrence.

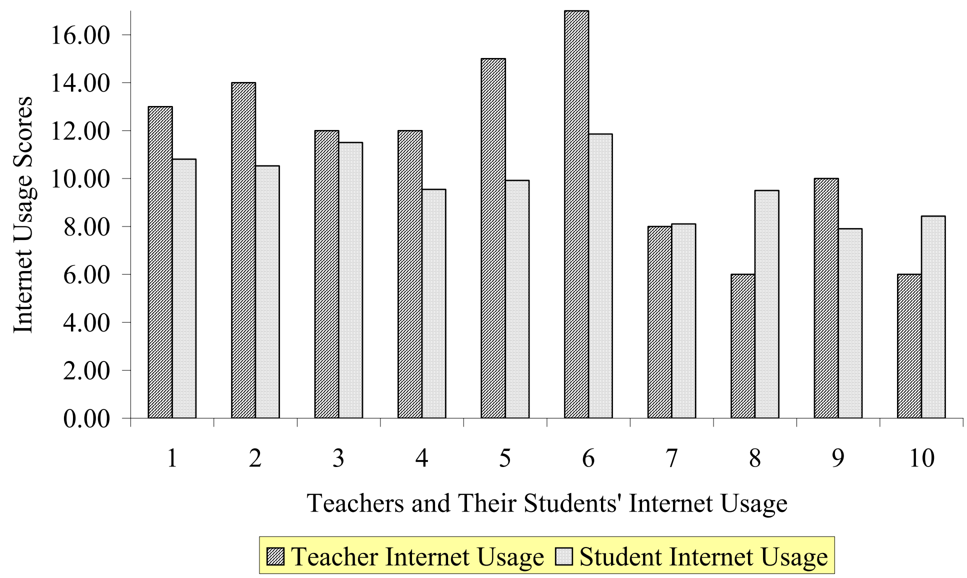
Certainly one could anticipate these associations, especially concerning the two highest correlations found here. Consider for a moment the Shared Control result. The more a student uses the Internet, the more one "feels" in control of her or his classroom situation, in control of her or his own learning. The Student Negotiation scale speaks to the interchange of ideas students have concerning the questioning of old ideas or trialing of new. As discovered through the student interview process discussed in Chapter Five, many of the students in this sample felt empowered by the Internet and used it to communicate with classmates and students in other schools using school web pages and e-mail.

Though Critical Voice had a lower correlation coefficient, it still seems a significant association can be established. Many times students who had a high Internet usage score tended to be the ones who were in the classroom more, spent a greater amount of time with their teachers, and developed closer ties with them. In many ways these students could often times be viewed as the "science class groupies," staying on after lessons and generally relating well with their mentors. There is no doubt that this would result in a greater bonding between student and teacher and lead to more open communications between them. As for the Uncertainty measure, it is almost obvious — the more any student uses the Internet, the more controversy and wide range of ideas concerning "the facts" they are exposed to. The Internet is not neat and tidy the way the old fashioned textbook is. One can most often find as many sides to an issue as one can imagine. It is here where the student-student and student-teacher interaction is most critical, allowing the novice scientist to sort out the real from the "junk."

4.5 The Teacher Survey

A Teacher Form of the Internet survey was distributed to the ten teachers involved with this sample. Though the forms differed somewhat (the teachers had no classroom environment scales), the *Internet Usage Total* was calculated using the same ten questions with possible scores ranging from a low of 0 to a high of 17 (See Appendix B). Because of the small number of teachers in this study, certainly no definitive conclusions can be drawn, though certain tendencies can be gleaned from the results.

Figure 4.1:
Comparison of Teacher Internet Usage Compared with Student Internet Usage for Students Within Their Classes



In general, the teachers had a higher Total Internet Usage Score than their students (teachers = 11.30 ± 3.74 and students = 11.00 ±2.85). It could be expected that the amount of Internet usage demonstrated by individual teachers would be reflected in their students' access to the Internet. Using a simple correlation (r) between the Total Internet Usage Score for the ten teachers and each teacher's students in the sample, a correlation of 0.55 ($p < 0.05$) was found. It could be expected that this correlation could have been even greater, though one must account for the fact that nearly all the students interviewed spoke of Internet usage for other teachers in other classes. Additionally, two teachers in the sample (teachers 8 and 10 in Figure 4.1 above) scored significantly lower in Internet usage scores than their students and this tended to skew results. It is logical to assume that students exposed to teachers who are high users of the Internet will place a stronger value on its use and that this value would be somehow communicated to their students. This seems to be the case in this study.

4.6 The Need for a Qualitative Assessment

One may have expected stronger correlations between student Internet usage and more positive CLES and attitude scores, but the broad spectrum of the sample may have precluded that result. Sherry Turkle (1984) points out that computer hackers illustrate another facet in man's emerging relationship with machine. Their response to the computer is artistic, even romantic. Certainly computer use means different things to different people. She draws an analogy between the computer and a Rorschach inkblot test, emphasising the powerful projective medium students find in PCs (p. 14). Unlike the stereotype of a machine with which there is only one way to relate (e.g. math drills, industrial applications), the computer is partner in a great diversity of relationships and is as many different things as there are people who use them. It could be argued, that in light of this, the variety of approaches employed by various teachers and individual students in the sample, the across-the-board positive correlations may be more than expected.

Thomas Russell (1997b) points out that though the comparative impacts of educational technologies remain of paramount importance, few generalisations can be made concerning technology affecting student outcomes. Starting with the first reported research using radio as an educational tool (in 1945), Russell compiles studies looking at the educational effects of motion pictures (from 1949), open-circuit television (starting in 1952), closed-circuit television (first in 1955), colour versus black and white television (in 1960), tape recorded lectures (in 1961), video-tape presentations (initial studies in 1972), computer-assisted instruction (in 1979), teleconferencing (from 1983), the electronic blackboard (in 1984), and World Wide Web materials (in 1996). He covers all levels of education in his summary from elementary to adult, and a broad scope of subjects is included. These studies mostly look at outcomes as either achievement (measured by a variety of different methods) or student attitudes towards the subject at hand. The point of his work is that time and again hundreds of research studies concerning new technologies used in the classroom report student outcomes as "no significant difference" between those using the technology and those not using it. A range of studies assessing the effects of the Internet on classroom achievement and environments may find the same nebulous conclusion. Does this mean comparative studies are useless? Not at all, but one must realise the difficulty that arises from the fact that each student approaches any "new technology" in quite a different way from anyone else. The caution is to look beyond sweeping generalisations and research the matter from both qualitative and quantitative aspects. For this reason both quantitative (CLES correlations here in Chapter Four) and qualitative (student and teacher interviews, classroom observations in Chapter Five) methodologies were carried out.

4.7 Summary

The quantitative data indicate that the CLES questionnaire is reliable and valid for the Hawaii sample used in this study. Positive correlations were found between student Internet usage and a more positive student perception of a constructivist classroom environment. Gender differences were found in that boys use the Internet more than girls and that girls generally perceive their classroom environments more favourably than boys. Additionally, the amount of time that a teacher uses the Internet is positively associated with the amount of time his or her students use the Internet for course activities. The qualitative findings are the focus of Chapter Five.

CHAPTER 5

QUALITATIVE RESULTS

> *Throughout the United States there are thousands of people in buildings without phone lines and without computers… we call them students and we call the buildings schools.*
>
> (Richard W. Riley, U. S. Secretary of Education, 1997)

The quantitative results of the study were presented in Chapter Four. These data are enhanced by the qualitative findings reported in this chapter. A combination of student and teacher interviews along with classroom observations provides a rich, deeper look into the way the Internet was used by students. Differing approaches to the use of the Internet by the teachers in the sample are explored. Student feelings and attitudes about the use of the Internet are presented with consideration of the differences in how the boys and girls use this technology. Finally, the researcher's own classroom experiences with student use of the Internet are reported.

5.1 Effects of the Individual Teacher's Internet Methodology

Traditionally, the purpose of formal education has been to impart knowledge to the student, or more correctly, have the student increase her or his knowledge. Of course this raises the question of exactly what is knowledge? It may advance this notion of knowledge to distinguish what it is not. Lewis Perelman differentiates among the terms message, information, and knowledge (Waite, 1996). A message is any coded difference. For example, black marks on a white page, a series of dots and dashes, or electronic switches on and off can comprise a message. Information on the other hand is a message that makes a difference. A message can not become information until it is communicated to and its meaning understood by someone, therefore making a tangible difference. Perelman speaks of Shannon's Law of Communication, which simply states that unknown data is utterly useless. Finally knowledge is a difference that makes a difference or the ability of connecting one piece of information to another in some meaningful way. Analogously, information is to knowledge as awareness is to meaning. The trouble is we have no real way of knowing exactly what anybody else actually knows. All we can really observe is how another performs. In short according to Perelman, most of modern education today measures performance, not knowledge.

Consequently there must be a stress placed on the process of learning and assessments made on student outcomes. On that note, Minister of Education, Colin J. Barnett, writes in the Foreword of the new *Curriculum Framework* (Curriculum Council of Western Australia, 1998, p. i) that the curriculum reform in Western Australia "is built upon commitment to the philosophy that learning is continuous and that educational process should strive for the improvement of all students."

Thus curriculum development and student learning does not occur in a vacuum and the use of Internet technology must be integrated within the curriculum as a whole. Fred Carrigg, Director of Academic Programs at the Union City Bell Atlantic project, mentioned earlier in this paper, speaks of the importance of this integration. "Technology is not a tool, not a philosophy… You can't isolate it; it's meaningless unless it's integrated into the curriculum" (Follansbee & Gilsdorf, 1996, p. 3). Carrigg's Bell Atlantic collaborator Rahman Karriem adds, "You can't throw technology against the wall and expect it to stick. You have to develop internal human infrastructure to make it work," (Follansbee & Gilsdorf, 1996, p. 3).

Human infrastructure? No matter if one looks at content, process, or both, the student can not be separated from the teacher. It can be asserted that "…the teacher is central to any implementation of computers in the classroom, and the school as well as the teacher must be involved in the changes that accompany integrating computers into instruction" (Collis & Moonen, 1995, p. 4). Though Collis and

Moonen were speaking more generally about computer technology as a whole, the same can be said of Internet usage in the Catholic schools of Hawaii.

For the most part, the ten teachers in this study were certainly exceptional educators as evidenced from CLES results as well as classroom observation. If one accepts the idea that exemplary teachers are those whose students perceive their classes as more “involving” (Tobin & Fraser, 1990), then all ten teachers in this sample would be considered "exemplary teachers" as evidenced by above average CLES scores in their science classes. The characteristics common to all exemplary teachers that Fraser and Tobin (1989) categorised in an extensive research project in Western Australia were as follows:

Exemplary teachers:

1. Manage their classroom effectively.
2. Use strategies aimed at assisting students to learn with understanding.
3. Display a strong knowledge of the content area within which they are teaching.
4. Encourage students to become actively involved with their learning.
5. Students of exemplary teachers perceive their classroom environment as being good for learning.

As has been mentioned previously in this thesis, it is at times difficult to separate the influence of one teacher on a particular student from other teachers involved in the educational process. In four of the five schools in the sample, traditional high school semester schedules were maintained in which students had an array of five to ten teachers with whom they had contact each week. The fifth school followed an intensive scheduling program and students came into contact with as few as three teachers during any given trimester. Nonetheless, the researcher was cognisant of the fact that many times individual student’s Internet applications were set by the high use or low use of their teachers, certainly in relationship to their science classes. Classroom observation and subsequent student interviews bore this out.

A prime example of this can be found in comparing one teacher who used the Internet extensively with one who used it very little. The teacher who totalled the highest Total Internet Usage Score of all the teachers in the sample was a physics teacher known as "the technology guy." He went out of his way to provide the equipment, expertise, and class time needed for his students to utilise the school's Internet facility to a maximum. In his classes students were posting laboratory results on the school's homepage, taking physics quizzes at home via an Internet connection, and doing corroborative research with students on other islands. A conversation with one of his physics students who had a very high total CLES score helps put this into perspective:

> *Q: When you have questions — just something you're curious about — are you able to find answers in this class whether it's in the curriculum or not?*
>
> *A: Yep — I can use the 'net.*
>
> *Q: How's that? How has the Internet affected that? Has it helped or hasn't it done anything?*
>
> *A: Well it's helped, because with the labs and stuff, you can do what you want. And the class leaves you free to kind of be the master of your own domain. Some of the reports that we have to do I have had problems with and if I see other people's work (posted on the physics homepage) I kind of see how to do it.*

Conversely, one biology teacher with the lowest Total Internet Usage Score almost never referred to the Internet in her class and when she did, it was only with a remark mentioning that it could be a possible resource for more investigation. She also ranked lowest in CLES average and classroom observations found her approach much more traditional, lecture-textbook oriented. Student interviews seemed to confirm that her class was not perceived as constructivist. A young man in one of her classes scored low on all scales of the CLES and had less-than-average attitude towards his science class offered the following:

Q*: Do you enjoy your science class?*

A: (Loud sigh) No, not really. I don't see what it has to do with anything. Like why do they make you take these classes, anyway?

Q: Do you see the Internet as having any effect on you in this class?

A: Are you kidding? All we do here is follow the textbook and colour pictures. I don't think she even knows the Internet exists. Nah, the Internet don't have no effect on me in this class…

After many hours of on-site observations and interviews with teachers and students, the researcher can point to much anecdotal evidence that the role of the teacher had a great deal to do with student Internet usage. Several teachers were very creative in their use of the Internet in their science classes. Some may use the Internet as an extension of self, enabling them to reach more students than they ever could otherwise. One teacher in this study does just that, posting assignments, exams, and laboratory results on the school's home page on the Internet. Another physics teacher worked with his students at "reverse engineering" kayaks and mountain bikes. After finding the objects they were after at certain Internet sites, the pupils would check angles, compare proportions, and glean all they could in an attempt to design their own, functioning models. In at least two cases, teachers posted class notes on the Web allowing them to spend their time in more personal sessions with students. This certainly allows for more efficient faculty time and allows students to carry "class time" beyond the normal school setting and school hours. In the long run this may point the direction in which education is going, with teachers providing experiences for students without always having to bring them all together at the same time (Wagner, 1996).

The following generalisations concerning teacher methodologies are based on field research utilising observation, interviews, and the student-teacher responses to the questionnaires:

- Of the ten teachers involved in this sample, all but one had at least one Internet-connected computer in her or his classroom.

- Though there was a variety of approaches to integrating the Internet in classroom work, all teachers at least referred to it as a possible resource for research or exploration.

- One class was written specifically to use the Internet and students met in an online computer lab at least one day a week.

- Several teachers integrated Internet usage into more traditional class structures by posting notes, laboratories, and assignments on the school’s home page, and communicating with students by e-mail.

- The specific method any of the teachers in this sample used in their classroom did not seem to have as great an effect on their students as did a positive attitude in respect to using the Internet as a tool. When demonstrated, this positive attitude seems to set the tone for constructive use of the Internet by students.

5.2 Gender Differences Noted in CLES Results

It was mentioned in Chapter Four that boys seemed to use the Internet more than their female peers. Interview data seem to indicate that the way boys and girls use the Internet is not always the same and some general trends may be explained from observation of, and conversation with, students and teachers. The following conclusions may be drawn:

- Many students use the Internet more than they think they do. This will be documented with more student interview data later in this chapter, but time and again students made statements that showed a lack of using the Internet for school work. Instances of getting notes from or posting homework to a school's homepage, communicating by e-mail, and using the WWW for science project resources were overlooked by students as "using the Internet for school." Because of this it is possible that students underestimated their own Internet usage and in seems that the girls were more apt to do this than the boys.

- In the few short months between data collection (mostly in January-February 1997) and the time interviews were conducted (April-May 1997), many students reported an increase in Internet usage. For that reason the study of any population is akin to studying a moving target. Again girls seem to have been more likely to have "discovered" the Internet over the course of the few months between the use of the questionnaire and the interviews.

- There is no doubt that in general, the boys use the Internet for a greater period of time than girls do. However, interview data, site observation, and the researcher’s own in-class experiences seem to indicate that there is a difference in how boys and girls use the Internet. Boys tended to play more games than the girls and in many instances spend hours involved in competitive games. Girls on the other hand seem to use the Internet more for interpersonal communications (e.g., e-mail and chat rooms). It was difficult to find much difference in usage between boys and girls as far as academic or classroom activities were concerned.

5.3 Classroom Observation and Student Interview Data

Personal interviews were held with 36 of the 431 students in the sample. As mentioned previously, students were chosen to represent the range of Internet users found in the sample with some high users, some average users, and some low users. Interestingly enough, by the time interviews were carried out several months after the questionnaire was administered, no student interviewed would admit to having never used the Internet.

Below are some of the responses individuals gave during the interviews including the context in which they were offered. These responses are representative of all the interviews conducted and indicate that student spoken perception of the Internet may be more favourable than their written responses as tallied in the questionnaire results. Possible causes for this could be the failure to be more specific in Internet-based questions and that the interviews were carried out three to four months after the in-class surveys were administered. These generalisations can be made concerning the findings of the interviews:

- Students were almost universally excited about their use of the Internet and time and again indicated an almost total acceptance of this technology as an educational resource.
- Students initiated much work using e-mail and the World Wide Web in school, at other community Internet sites, and at home.
- Most students used the Internet for science as well as other classes.

Between the student interviews and classroom observations within the sample schools, the researcher found time and again that the broad majority of students were enthusiastic with their use of the Internet for academic class-related activities. Somewhat surprisingly though, in many cases individual students, even those with high Personal Relevance scores, did not always relate their Internet usage to course objectives.

For example, there was a female physics student in a co-educational school who had very high CLES scores and expressed interest in majoring in some science on the university level. During the conversation she related her strong interest in the sciences and just how relevant she thought her studies were to the real world. She had done excellent work on her science fair project this year and even went on to win some awards at the state-level. She was an excellent student in all of her subjects. Her interview was revealing in that she tended to use the Internet for school work much more than she ever thought she did when she originally filled out the questionnaire.

Q: Did you feel you had a chance this year to explore areas that were of interest to you, or was it all just what the textbook said?

A: Well to a point you could, like in discussions you were pretty much able to go where you wanted to with it, but then you still had to cover the basics.

Q: Your science fair project was related to physics. Would you say you used the Internet at all for that?

A: I used it a lot.

Q: Okay. Well in terms of having control over what you wanted to learn — did the Internet have anything to do with that… in your physics class?

A: Well… the stuff I used the Internet for wasn't really for physics. Like I learned how to make the Wheatstone bridge. And I just didn't think that was for physics…

Since the schedule called for electricity and magnetism to be covered by the end of the academic year in her formal physics curriculum, she actually had no idea she was applying physics principles to her science fair project. When the researcher asked her if she was aware of the fact that the Wheatstone bridge was actually mentioned in her physics text (though far back in the book!), she was surprised. The interview continued:

Q: In general, do you enjoy your science class and look forward to being here and would you recommend it to someone you know next year?

A: Yeah, I liked it.

Q: That's good — physics can be stressful. Did the Internet have anything to do with your liking this class?

A: The student nodded her head in the negative, indicating it didn't, but then spoke. Well actually, getting the notes from the Internet is helping a lot.

Q: Oh, have you been using it for that? You didn't even tell me that.

A: And that's really useful.

Q: I wonder how many of your classmates are doing that?

A: Pretty much we all are. You can have the notes in front of you and underline, make comments… listen to class… You know, I never thought of the notes as being on the Internet… And the assignments are there, too…

In this school, the physics teacher had pasted class notes and assignments on the school's home page and this young woman used them as a resource extensively, never thinking that she was using the Internet. Another girl at the same school, but taking an organic chemistry class, made a similar response during the interview. She too scored quite high on the CLES scales and generally had a very positive view of her science class and science teacher.

Q: Do you feel that if you have a question on your mind that you can learn about that in this science class?

A: Yeah.

Q: Do you use the Internet at all to do that?

A: No… no, not really…

Q: Let me ask you a question. You did a very big science fair project this year and won all kinds of prizes with it. Did you use the Internet at all to research that?

A: Aha. [She nodded her head in the affirmative.]

Q: Did that cover part of your organic class or was that something you were interested in? [The topic she worked on dealt with transgenic (genetically engineered) papaya plants and was entitled Vitamin C Analysis of Nontransgenic and Transgenic Papaya.]

A: Well, organic a little bit, with the vitamin C.

Q: Who chose the topic?

A: I did.

Q: Okay. So I imagine it's something you're interested in.

A: Right.

Q: How much did you use the Internet to do your research here?

A: I used it a lot, because this is so new you can't go into the library and find anything, so…

Q: Now think of what you're saying to me. You're telling me that yes, you have some control over what you want to learn, but the Internet has nothing to do with it. And yet now you're telling me…
A: But I thought you meant for the class.
Q: I didn't say for the class, I said for what Katie wants to know about…
A: Oh yeah, I see what you mean.

Many students seem to think that if they enjoy a topic on which they are working, it must not have anything to do with course content! In yet another class, this one an all-boys physics class, the teacher had students write all their laboratory reports on the school's home page. This way they could corroborate with each other and compare their findings with those of classmates. In several interviews here though, again students often did not realise posting their results, for example, on a web page was "using the Internet for school activities." The author found this unconscious use of the Internet as a tool in learning science over and over again in field investigations and speculates that a re-designed questionnaire may better quantify this usage.

Usage of the Internet seemed to contribute a great deal to the students experiencing the uncertain nature of the sciences and the variations introduced by socioeconomic and cultural and differences. The CLES results for a boy at another co-educational school indicated he found his science class relevant and that he had gained an appreciation for the uncertainty of the sciences, but his attitude towards science was fairly negative.

Q: In this class, would you say that you learned that science is more universal and unchanging — the same everywhere — or in this class would you say that you learned that science is more cultural dependent and uncertain?
A: Yeah, yeah — it's changing. There's other schools that had home pages and it was really different when we had to read their schools and the description of the area around them. These were like in Russia and the islands…

Q: You kind of answered exactly what I was going to follow up with as to what effect the Internet has. So in that case, the Internet must have had some effect, because…
A: Oh, it had a big effect.
Q: You said Russia?
A: Yeah Russia and the USA — Wisconsin, Ohio…
Q: Would you say in general to your academic experience that the Internet has been positive, negative or nothing and why?
A: It's like meeting people, like from other lands. You don't know how they are and they don't know how you are before hand. You can exchange environments.
Q: And you have been able to do that using the Internet?
A: Yeah.

Yet another girl, this one in a physics class at an all girls school, related her excitement at communicating with "real scientists." This young woman had a very positive view of her physics teacher and felt as though she had a great deal of control over her own learning, but her attitude was only average when compared to her peers.

Q: You say you did reports… What did you do your reports on?
A: There was one on how come rain drops don't kill us when they fall. So I went and I signed up on a science page so I could get in there and ask questions. And the other one was why do pregnant women lean backwards.
Q: That's good, too. Now were those topics assigned to you?
A: Yep. We all had to do that.
Q: So everybody took those topics. You used the Internet for that, but didn't really pick the topic?
A: Yeah.
Q: Would you say that in your high school career — in your academic career — would you say that the fact that the Internet exists has been positive to your education, negative to your education, or didn't matter to your education and tell me why?

A: Positive.

Q: Okay, tell me why.

A: It made it easier to research things, because I didn't have to go to the library or if I wanted to I could hook up to the library and find books. And pictures – nicer, cause you can find pictures on anything without having to look through books. And then the interaction — like if I needed to do like my research for the physics class, I wrote a scientist and he e-mailed me back.

Q: That's really interesting. I'm going to ask you questions about this because you seem to use the Internet quite a lot. Tell me how you found the scientist to write to.

A: I looked up raindrops and I then I went through all these pages until I finally found the Science Emporium or something like that and there was this e-mail address at the bottom saying 'questions.' I shook my head, yes I do. And I just wrote him, a real scientist.

Q: Neat. How long did it take to get an answer?

A: It took me a little over the week, I think. I started early…

At times students would use the Internet as a starting point and then spin off of that to find an answer to their question. One chemistry student at a co-educational school did just that. This young man had reasonably high CLES scores, but had a somewhat negative attitude towards science and an even lower feeling regarding personal control of his learning. In his case, it seemed the only time he felt he had any power over what he wanted to learn was when he used the Internet.

Q: How much control do you feel you have over the learning environment in here, over what you learn and how you learn it?

A: The only time I felt that we got to choose was probably when we had projects, because we got to chose our own topic. But other than that, we had to just learn whatever the teacher wanted us to.

Q: Okay. Tell me in terms of the projects how the Internet affected you if at all.

A: It helped a lot, because I could get like information and facts — a place to start.

Q: What was your topic?

A: Iron and cereal.

Q: What did you find out?

A: Well we found out that cereal with vegetables in it — like rice and corn — they had the most iron like compared to other cereals.

Q: Did you do that experimentally.

A: Yeah.

Q: Titrations?

A: Well, we burned the cereal and made different solutions and then mixed the cereals with the solutions and, depending on what colour the solution turned after the cereal was mixed in we could tell how much iron was in it.

Finally, one young lady at an all-girls school was taking two science classes both involved in this study. She had one of the highest CLES totals of all the students in the sample and was excited to talk about both the sciences in general and her science classes in particular. She said that because of work in her science classes, she had increased her use of the Internet dramatically in the few months between filling out the student questionnaire and the time of the personal interview.

Q: Back in January, you said you were using the Internet once or twice a month — not too much. [Pause as interviewer looks at his sheet.] No, it says your were using it less than once a month. Would you say your habits have changed any since then?

A: Yeah, because of this class.

Q: Oh, okay — so because of this class you are using it more?

A: Aha. And our teachers are requiring like projects that require that we go on the Internet. And it's so much easier than to go look it up or if we can't find information in school that we need and we can find it on the Internet.

Q: You say your teachers, so it's more than just this class?

A: Yeah — like history and English, too.

Q: Are you kind of a science person?

A: I love science.

Q: *How relevant is this class to your life? …In terms of relevance, how much does this relate to your everyday sort of thing? Is it all in the textbook, or are there things that are very practical about…*

A: *Well I use this class — I mean when I associate with other classes — because they get me into the Internet. So I know more when I use it in other classes, I can help other students. In chemistry, we deal with Link Way and this class [Exploring Earth in Space], so it's much easier for me in chemistry when we did Link Way projects.*

Q: *What's Link Way?*

A: *It's a computer program. We make our own program. You know how there's computer programs in the computer? But we make our own. We think up everything, the buttons, we write up the page. We find out information and put it on…*

Q: *Does the Internet have anything to do with this?*

A: *Well the information I get from it — most of the information we get is from the Internet.*

Q: *So for Exploring Earth in Space, the Internet is almost a textbook in a way?*

A: *Yeah… But it's hard using the Internet sometimes for information because you don't know — it's not published work — so you don't know if it's actually accurate sometimes.*

Q: *Good. That's perceptive of you to know that. …That's a very good point.*

A: *So we sometimes have to use textbooks to just back up information.*

Q: *To verify?*

A: *Yeah.*

Q: *Now I'm curious here. What makes you say that? Did you learn that on your own or did your teacher talk to you about that?*

A: *Well both, because we were talking about — I asked her if we should use the books, too. Because a lot of the information we just don't know who puts it on there... like Heaven's Gate… [This was only a few weeks after the tragic cult mass suicide took place in Southern California.]*

> *Q: So your Internet usage has really undergone a dramatic change, hasn't it?*
>
> *A: I never, never used the Internet before. Using the Internet is easier sometimes, but it can be stressful when it takes too long. [laughing]*
>
> *Q: This is interesting, because you have really — in the past few months, you have really begun using the Internet a lot more, haven't you?*
>
> *A: Yes.*
>
> *Q: Would you say that your whole educational experience — science in particular — is better, worse, or the same because of the Internet and why?*
>
> *A: Better… It would be… better in some ways… because I learn new things. But what I might be learning from the Internet — like I said — might not be always be true. That brings up different ideas… yeah, I learn from the Internet and I think it is good for students…*

It seems that the common thread running through all these interview notes is the fact that students seem to use the Internet to find out what they need to know when they need to know it. All the schools in this sample were highly academic institutions and the classes were structured in a teacher-centred way in order to cover the material needed to prepare students for standardised exams, hardly the situation one would expect a highly constructivist approach to education. In many ways, it is somewhat surprising that the average student perceived her or his class in a constructive light at all. That said, the most negative feelings expressed were for Shared Control. A possible explanation for this may be that the teachers in this sample tended to stick to a structured curriculum aimed at the standardised exams. Consequently, if any area within the constructivist learning environment needs a boost, it would be that of Shared Control.

Interview responses indicate that the area of Shared Control gains the greatest benefit from the use of the Internet. A possible explanation is because in spite of the tendency for adherence to a structured curriculum, nearly all the teachers in the sample called on their students to develop individual science projects. As indicated in the interview excerpts, this seems to be exactly the area that the Internet proves most useful, offering the student the chance to be in control of their own learning.

Additionally, the Internet allowed for increased communications between students and teachers, students and other students, and students and off-campus researchers. This communication allowed teachers to better distribute “facts and figures” via posting of notes, glossaries, and assignments on the schools web page. From the students’ points of view, they were better able to verbalise findings, ideas, and questions by sharing experimental results, academic questions, and problem solutions using the both e-mail and web pages.

5.4 Personal Experiences with Student Internet Usage

Though this study does not represent "action research" in the classical sense, the researcher was a member of the Hawaii Catholic Schools Science and Technology Committee with several participant teachers and was involved with inter-school projects involving these people before the study began. Additionally, he was on unpaid educational leave from one of the schools involved in the study. Though none of the students surveyed and interviewed here were current students of the researcher at the time data were collected, he did know several of the interviewees and a few dozen were former students of his. However, if one understands action research to be "engaging in enhanced normal practice in collaborative groups, and then making public to others not in the groups their new knowledge and understanding of educational situations" (Feldman, 1996, p. 536), then this project could be considered to include a degree of this “enhanced normal practice” mentioned above. The fact that the investigator had been a long-term secondary educator in the system under study, greater access was had to the schools and classes under study. In that respect, it was possible to bridge the gap between university researchers and classroom teachers in the sense that the researcher was in fact a fellow teacher (Cox & Craig, 1997).

In a sense this project was contrived out of necessity, a necessity of teaching in a less-than-perfect world. Having spent half a lifetime following curriculum guidelines set by “others” working in far away offices, this researcher time and again was forced to choose between preparing his students for standardised exams or to encourage individual enthusiasm for the sciences. On one hand the experienced teacher wants to feed that burning curiosity found in many high school science students, but on the other, there is always a fear that university entrance exam scores may suffer in because of it (Fisher & Churach, 1998). Like other teachers, this researcher employed a variety of project-based tasks in an effort to feed the natural curiosity many students displayed, while using class lectures to cover course materials needed in order for to perform well on college entrance exams

During the 1995-96 academic year in Hawaii, this researcher for the first time had access to the Internet in a chemistry-physics laboratory. Though several units were requested, financial considerations only allowed for one unit (a P-75 IBM compatible computer with a 56.6k direct line connection to the Internet) to be purchased. The researcher’s initial expectation was rather low, imagining that with only one Internet terminal very few children would benefit. Yet a very different observation was made as more and more students gathered around the terminal to explore topics and issues together. The social interaction among the students often carried well beyond class time into recesses and lunches. As an added bonus, the teacher became more personally involved with the students, since many began to spend more and more of their out-of-class time in their science classroom. The Internet proved to be an almost limitless source of information, allowing students to go far beyond the bounds of the set curriculum and standard textbook contents. Many students became more and more excited about their finds on the ‘net and relished in sharing these finds with others, some even using the new-found medium of e-mail to communicate with students on other campuses. Suddenly there seemed to be a reversal of just who was popular. For the first time in the researcher's teaching career he watched as a "computer-nerd" kind of student, who did not generally interrelate well with others, suddenly became more and more of a social focus with his classmates. This shift in social standing was attributable to the fact he knew how to do it (use the computer and Internet), his classmates valued his knowledge, and many wanted him to share his knowledge with them.

The author has seen the use of student Internet usage aid the development of student cohesiveness and collaboration and engender within the students an excitement about science and a willingness to interact with cohorts both in their own school and at other institutions. No doubt this development of a *"scientific community"* of learners contributes a great deal to positive outcomes in secondary classrooms (Smithenry & Bolos, 1997). One of the projects undertaken the year before this study was conducted was the *Big Island Science Odyssey* (BISO) in which 24 year seven and eight students, eight year 10, 11, and 12 students, and six teachers were brought together from a dozen schools throughout Hawaii for a four day intensive science field trip of the Big Island of Hawaii. Part of the experience of that project was giving each student an e-mail address accessible from their own school (and from home for those with home computers). Students worked corroboratively before the experience and seemed to continue their long distance conversations long after the project was completed. A separate web page for the *BISO* was designed and students were encouraged to contribute their own work to its content.

A lack of computers did not seem to cause any problem. Contrarily, a high student-to-computer ratio actually seems to enhance interpersonal activities. This lack of computers in the researcher's own school and other schools in this study caused students often to work in small groups of two or more. This unanticipated finding of the <u>increase</u> in human interaction using computers has been noted before. In one study of microcomputer-based labs, it was found that cooperation among students was greatly promoted (Linn & Songer, 1991). Cox (1992) found the same thing — collaborative learning was enhanced by the use of database and simulations because students shared computers.

In short, the interview and observation data seem to confirm the idea that student Internet usage has a positive effect on classroom environments in science classes within the schools in this sample. It was shown in Chapter Four that the CLES does have internal consistency (Cronbach alpha scores) and may be used with confidence in Hawaiian Catholic schools and that positive associations exist between all CLES scales student Internet usage. In particular, significant associations were found between Internet Usages and the CLES scales of Critical Voice, Shared Control, Uncertainty, and Student Negotiation. In Chapter Five, the interview data, classroom observations, and personal experience support these findings. The interview data seem to confirm that students have accepted the use of the Internet to such a degree that they often do not know they are using it. Furthermore, Internet usage seems to be much more social than one can imagine. These finding vary between boys and girls, and yet both sexes are affected positively by their individual use of the Internet. In other words, science classes that have higher student Internet usage seem to be more constructivist in nature. Finally, the role of the teacher played a large part in determining how valuable Internet usage was to the student. It was the individual teacher who seemed to be instrumental in keeping students focused on the task at hand, whether that was accomplished through assigned projects or simply made part of the on-going structured curriculum.

5.5 Summary

Nearly all the teachers included in this study seemed to be exceptional in that they all had developed positive classroom environments, which fit well with the constructivist philosophy. Except for one class in which the program was specifically written to make use of the Internet, each teacher integrated Internet usage into the existing curriculum framework. In general, most of the students used the Internet more than they realised and were often unconscious of its use. It seems that most students were excited, enthusiastic, about using the Internet for course-related research. For many students, the use of the Internet resulted in greater student feelings of personal relevance and shared control; students felt more in charge of their learning. The implications of these findings are explored in the next chapter.

CHAPTER 6

CONCLUSIONS

> *"In the age of the computer, lock-stepping educational programs are at best quaint and at worst stultifying. The curriculum is dead. Long live the age of the individual — and the computer. Let students build their education the way they build their résumés and the way they build their lives — as unique human beings.*"
>
> (John Gehl, Educom Review, 1996, p. 5)

In this chapter, the purpose of the study is reiterated — a gap in the literature exists between the explosive growth of a newly acquired tool (the Internet) and its effects on constructivist classroom environments. The findings concerning each research question proposed in Chapter One are reported from both the quantitative and qualitative perspective. Additional findings are also reported, as are the implications of the study for secondary science teachers. Finally, the limits of the study are acknowledged and recommendations for further research are made.

6.1 Constructivist Classrooms and the Internet

When one considers that the half-life of a college graduate engineer is now estimated to be four years, the age of life-long learning certainly has arrived (Davis, 1996). Thus, the foremost role of a teacher today should be to teach students how to learn. In that regard, there has probably never been a piece of technology more fittingly applicable to this constructivist philosophy of education than the Internet. Early on teachers learn that the effectiveness of web browser tools such as Mosaic, Internet Explorer, or Netscape must by necessity be built on constructivist orientations to teaching and learning (Collier & Le Baron, 1995). More and more, the responsibility for learning shifts to the learner who turns to technology for content, freeing the teacher to focus on the process of learning and interpersonal relationships (Davis & Botkin, 1994). This explosion of technology requires that students become active learners, that classroom teachers become co-learners (Loader, 1991).

During the past few decades many studies have examined classroom learning environments (Haertel, Walberg, & Haertel, 1981; Fisher, 1984; Fraser, 1986; Fisher & Fraser, 1990b; Moos, 1991; Fraser & Tobin, 1991; Fraser, 1994). Similarly, much work has been done on the effects of computer use in the classroom (Loader, 1991; Glennan & Melmed, 1995; Russell, 1997b; Jones & Paolucci, 1998). It has only been in the past few years that projects designed to look specifically at the use of the Internet in education have been conducted (Langan & Flynn, 1995; Toshiba America Information Systems, 1996; Smith, 1996b). In general, these early studies have been broad-based (K-12 or K-tertiary) and looked at effects across the entire curriculum, not at just one subject area.

This study has looked at the impact of a particular piece of technology that has exploded on the secondary school scene in a very short span during the second half of the 1990s. In particular, it marks the first attempt to examine the extent and nature of Internet usage and its impact on the constructivist learning environment and students' attitudes towards science.

6.2 Overview of the Study

This thesis presents the findings of a project aimed at assessing the effectiveness of Internet usage of secondary science students on their classroom learning environment and on student attitudes towards science.

A review of literature in Chapter Two looked at a spectrum of work done during the past several decades involving classroom learning environments and learning outcomes. Related studies looking at educational computing and the introduction of the Internet into the classroom were also included. One study in particular that actually looked at the relationship between educational Internet usage and learning outcomes was conducted by the Centre for Applied Special Technology (CAST). Here a sample of more than 1000 year-four and year-six students was drawn from seven major American cities (Chicago, Detroit, Memphis, Dayton, Miami, Oakland, and Washington, D.C.) during the 1995-96 academic year. A specific curriculum covering a civil rights unit was distributed and followed by both experimental and control groups (Follansbee & Gilsdorf, 1996). The findings here suggest that online access to the Internet may increase student learning and facilitate students to become independent, critical thinkers. It also offers evidence that student Internet use may help them better find needed information, organise and evaluate it, and then effectively present their knew knowledge in profound ways. Still, the CAST project dealt with primary-aged children, employed a social studies framework for the subject area, and was evaluated using learning outcomes, not classroom environments. However, there existed a gap in the literature with no studies found looking at Internet usage effects on secondary science classroom environments.

In Chapter Three, the methodology employed in this project was detailed, including the use of qualitative (observation, interview) and quantitative (student and teacher surveys) techniques. The development and use of the Constructivist Learning Environment Survey was detailed and the rationale for its use in this study was presented. The addition of an attitude scale based on the Test of Science Related Attitudes was also described, along with the Internet usage questions, and the design of the final survey instrument used.

Results of the study were presented in Chapters Four and Five. Quantitative results (Chapter Four) including the validation of the CLES for use in Hawaiian schools and associations found between student Internet usage and items in the CLES and attitude scale were reported. Chapter Five detailed the results of student interviews, classroom observations, and the author’s own classroom experiences as a supplement to the numerical data reported earlier.

6.3 Major Findings of the Study

The first research question proposed for this study was:

> *Is the Constructivist Learning Environment Survey (CLES) a reliable and valid instrument for use in Hawaiian (USA) Catholic Schools?*

Quantitative Findings

As reported in Chapter Four, Cronbach alpha reliability figures were calculated for the 431-student sample in order to provide further cross-validation information supporting the internal consistency of the five CLES scales with the individual student as the unit of analysis. Generally, it can be concluded that the CLES does have satisfactory reliability for use with this population of students. The ANOVA scores were used to determine whether the instrument differentiates between perceptions of students in different classrooms (e.g., do they see the same teacher in a similar way and different teachers in a different way). It was found that each CLES scale differentiated significantly ($p<0.01$) between classes and that the eta^2 statistic indicating the variance attributable to classroom membership ranged from 0.10 to 0.28. Additionally, the mean correlations of one scale with the other four scales ranged from 0.23 to 0.33 and these values can be regarded as small enough to confirm the discriminant validity of the CLES, indicating that each scale measures a distinct, although somewhat overlapping, aspect of the constructivist classroom environment. Thus, it has been demonstrated in this study that the CLES may be used with confidence in Hawaiian Catholic Schools. Additionally, the seven-item Attitude scale was found to have a Cronbach alpha reliability of 0.89, indicating that researchers and teachers can also use it with confidence in the described sample.

Qualitative Findings

Student interviews and classroom observations supported the validity and reliability of the CLES by showing a similar classroom picture to that indicated by the CLES scores. Two contrasting interviews offer a fine example of this. One interview (see pages 101-103) was with a student taking two science classes simultaneously, both of which were perceived as constructivist in the quantitative findings. This student in particular had one of the highest CLES total scores in the entire sample and had a very favourable Attitude score. The interview with her was quite memorable in that she was very excited about her curiosity to learn, her willingness to find answers to her own questions, and her love of the sciences in general. The conversation tended to support the numerical findings with the student's verbal praise of her science classes and teacher. On the other hand, a student in a biology class perceived as having one of the least constructivist classroom environments communicated a sad reflection on just why he was made to take the class in the first place (see page 92). This student had quite low scores on the CLES scales and had a below average attitude towards the sciences. Though these are only two examples, throughout the course of the interviews, similar findings were made in conversation that seemed to support the quantitative findings of the CLES. It seems reasonable to suppose that the CLES and Attitude scale were both reporting valid findings in this sample.

The second research question proposed in this study was:

> *What are the various approaches and methodologies of student Internet usage employed by individual schools and teachers (e.g., Internet usage integrated into the standard classroom curriculum, World Wide Web used as an adjunct resource tool, e-mail utilised as a communications tool, etc.)?*

Quantitative Findings

The ten teachers in this study were certainly exceptional educators (Fraser & Tobin, 1989) as evidenced from the CLES results, in that the mean of four of the five CLES scales indicated that students perceived their science classes as above the mid score. Specifically, Personal Relevance (3.73), Uncertainty (3.41), Critical Voice (3.52), and Student Negotiation (4.00), as well as the Student Attitude scale (3.39) all were above the mid score of 3.00. The only scale that had a score of less than 3.00 was the Shared Control scale (2.51). In general then, these teachers employed a more constructivist methodology and the students viewed the environment in these classrooms as positive. Additionally, students generally had a more positive attitude about their science classes. Though there were as many individual approaches to the use of the Internet by teachers as there were teachers in the sample, there was a definite association between teacher and student Internet usage. This was shown by a simple correlation (*r*) between the Total Internet Usage Score for the ten teachers and each teacher's students in the sample, a correlation of 0.55 ($p < 0.05$) was found. Figure 4.1 on page 85, Comparison of Teacher Internet Usage Compared with Student Internet Usage for Students Within Their Classes, provides a graphical presentation of this association. In short, it seems the most important factor involved with how much a student uses the Internet in her or his science class is the example set by the teacher. The more the teacher uses the Internet, the more average the student uses it.

Qualitative Findings

Classroom observation and communications between individual teachers and the researcher appeared to support the quantitative findings concerning effects of teacher Internet usage on students. In all cases, these teachers demonstrated qualities of exemplary teachers as outlined by Fraser and Tobin (1989). These characteristics included excellent classroom management, strong knowledge of the content material in question and involving of their students in classroom activities. As has been mentioned previously in this paper, it is at times difficult to separate the influence of one teacher on a particular student from other teachers involved in the educational process. Traditional high school semester schedules were followed in four of the five schools in the sample and students had an array of five to ten teachers with whom they had contact each week. The fifth school followed an intensive scheduling program and students came into contact with as few as three teachers during any given trimester. Individual students' Internet applications were many times governed by the high use or low use by their teachers, certainly in relationship to their science classes. Classroom observation and subsequent student interviews supported this. In every case, the direction offered by the individual teacher to her or his students in terms of Internet usage allowed the student to better focus on the assignment at hand. Teachers were also instrumental in helping their students to be more critical of the resources acquired using the Internet. In the final analysis, it was not so much the specific method any teacher used within the classroom setting, but the positive attitude presented to her or his students that set the tone for constructive use of the Internet.

The third research question proposed in this study was:

> *What relationships or associations can be found between student Internet usage and the individual student's perception of the constructivist classroom environment?*

Quantitative Findings

Though correlational data are weak, positive associations were found among all five CLES scales and Internet Usage Total scores. Significant associations were also found between Internet usage and total CLES scores, Shared Control, Critical Voice and, at least for the boys, Personal Relevance. The highest association found between Internet usage and any CLES scale was with Shared Control (0.17 $p< 0.01$). Thus, quantitative data seem to support the notion that there is a positive association between Internet usage and students' perceptions of the constructivist classroom environment.

Qualitative Findings

Though only one class involved in this study specifically included the use of the Internet into its lesson plans or program, nearly all the teachers in the sample called on their students to develop individual science projects. As detailed in Chapter Five, this seems to be the aspect in which the Internet proves most useful in providing students with feelings of involvement and control. Interview data confirm the notion that teachers who used the Internet more tended to have more students who perceived their classroom environment as constructivist. For example, the teacher known as "the technology guy" had a predominance of students who used the Internet regularly (see page 91) and viewed that science class environment as being very constructivist. However, a student of one teacher identified as using the Internet least, stated adamantly that he would not use the Internet in that class (see page 92) had low CLES scores and a poor perception of classroom environment. Again there appeared to be a link between how a student used the Internet and how her or his students perceived the classroom environment.

It was also found that the Internet allowed for increased communications between students and teachers, students and other students, and students and off-campus researchers as shown in one interview reported (see pages 99-100). This communication allowed teachers to better distribute "facts and figures" via posting of notes, glossaries, and assignments on the school's web page. From the student's point of view, they were better able to verbalise findings, ideas, and questions by sharing experimental results, academic questions, and problem solutions using both e-mail and web pages. These areas of increased communications because of the Internet tend to be reflected in positive feelings concerning Personal Relevance, Critical Voice, and Student Negotiation.

The fourth research question proposed by this study was:

> *In regard to student Internet usage, are there any apparent differences in individual student's perception of classroom environment based on gender?*

Quantitative Findings

Though there were differences seen in male and female scores, caution must be exercised due to the large number of students in single-sex schools. In general, the study found that girls in co-educational schools find their classroom environment slightly more constructive (3.42 CLES Total) than the boys (3.33 CLES Total) in the sample did. In looking at the total sample, boys (11.86 average Internet Usage Score) tended to use the Internet more than the girls (9.02 average Internet usage Score) did. These findings with Internet data seem to extend work done in the past looking at gender differences in relationship to overall computer usage. Many studies throughout the 1980s showed that boys had greater access to the use of computers than girls. A few studies showed boys and girls had equal access, but not one study was found showing that girls had greater access than boys did (Sutton, 1991). These same results were found in a variety of studies conducted in the USA, Israel, Canada, and Britain. Recent research seems to indicate that many USA teens are using the Internet in place of the phone. For example, one study showed that teenagers used the Internet 8.5 hours per week talking with friends on e-mail and chat programs and only 1.8 hours per week for school work (Masten, 1997).

Qualitative Findings

Certainly interview and observation findings support the differing use of the Internet by boys and girls. However, talking to a group of students or watching them use the Internet can be quite revealing. Boys tend to play games a great deal more than girls do. Often these "game playing" episodes using network or Internet games can last for hours, as boys seem excited at the competition offered by this new technology. At the same time girls seem to be the first to ask for e-mail accounts and are quick to gravitate towards chat rooms. Several interviews confirmed this observational data as boys use free time on the Internet to compete and girls use this free time to communicate and socialise. But when it comes to actually using the Internet as a research tool for any given science class, there seemed to be little difference between boys and girls. Whether it was the boy looking for information concerning iron in cereal (see pages 100-101) or the girl finding directions to build a Wheatstone bridge (see page 96), the Internet proved to be a quick, efficient way to gather needed information.

6.4 Additional Findings

An unexpected finding was the almost nonchalant attitude many students have towards Internet usage. It was apparent that students use the Internet more than they think they do and in many cases, do not realise that they use it for educational purposes (e.g., project research, class notes, e-mail assignments, lab postings, etc.). Often student Internet usage is a social and interactive activity among two or more students and students and teachers which is probably a major reason why students perceive a more constructivist learning environment when the Internet is in use. In the five-school sample included in this study, the Internet has become a major tool for use in the constructivist classroom. Time and again the author was struck by the near invisible nature the use of the Internet has taken. So complete was this integration in many students' lives that they often were not aware of using this new technology until reminded that "getting notes from the home page" or "sharing laboratory results using the WWW" was indeed using the Internet (Churach & Fisher, 1998a).

6.5 Implications for Science Teachers

So where do we go from here? Ray Smith (1996a) tells the story of the backlash that occurred from those who said their oral history would be lost when first writing and then printing were originally developed. Predictions were made that minds would be destroyed and that humans would lose the ability to memorise and think (as if those two acts were one and the same to start with!). Well obviously those critics were wrong – writing and printing have extended the human mind in ways no one could have predicted, enabling us to record and store data from one generation to the next and to reason innumerable times more than we could before. There will always be Luddites crying wolf at the appearance of any new technology. Today's computer and Internet connection are the new paper and pencil of the education world (Churach & Fisher, 1997).

As was pointed out in Chapter Six, the diversity of the sample may preclude any neat statistical findings separate from qualitative explorations. Ehrmann (1997) paraphrases a story Roxanne Hiltz used to tell concerning the early days of CAI (Computer Assisted Instruction). She spoke of two pieces of bad news about the experimental English composition course where students used computer conferencing. The first bad news was that, over the course of the semester, the experimental group showed no progress in their ability to compose an essay. The second piece of bad news was that the control group, taught by traditional methods, showed no progress either.

Nonetheless, the fact remains that for the large portion of students in this study, the use of the Internet related to their science studies did have a significant impact on their learning, even though they may have spent a great deal of time tinkering with their terminals. The process of tinkering reminds one of learning. Learning consists of building up a set of materials and tools that one can handle and manipulate. Perhaps most central of all is that it is a process of working with what you have got. One tries out all the old notions and experiences to see if they will work to solve a problem (Papert, 1980). Internet usage in this sample of high school students seems to have worked that way.

Chapter Two details many studies that support these findings, though the technology is so new that first results are only now starting to come in. A few notable examples include the Collier and Le Baron study (1995) which argued that WWW browsers must be built on constructivist principles. Honey and Henriquez (1996) evaluated the Bell Project in New Jersey where they found that the addition of the Internet in the classroom and at home increased standardised test scores, decreased absenteeism, and resulted in many more students moving into the district than transferring out. The CAST study reported by Follansbee & Gilsdorf (1996) has shown one of the strongest links yet between student Internet usage and educational outcomes with users scoring higher in all nine areas measured. However, this study involved primary students in social studies classes.

In the final analysis it is the interaction of the teacher and student that may best be advanced by the advent of this new tool. Langan and Flynn (1995) found that in spite of a wide variety of technical problems (e.g., slow dial-up connections, scarcity of terminals, equipment failure, etc.), the Nebraska experience shows that innovative teachers and students overcome a wide array of technical and instructional barriers. They have also found that innovative classrooms access “non-traditional” resources on a regular basis and that students who use the Internet tend to research at a higher level than those using more traditional activities. This study made similar findings. Classroom observation and student interview data in Chapter Six indicates that teachers and students in the sample overcame a variety of technical limitations and difficulties and were able to explore areas previously not possible with existing resources in Hawaii.

There can be little doubt of just what a sweeping resource the Internet (especially the World Wide Web) can be, offering a wealth of information to even the most remotely located schools on the planet. However, having information available for a student's use is only a small part of the process. After the cognitive process of delivering that information to a student's brain occurs, a second essential element is needed — the teacher.

> The second element guiding the student is more interactive. Once the learner has been introduced to new information, it is the teacher's responsibility to act as a guide through the concept or process being taught. The guidance method may vary according to the nature of the material being presented. Nevertheless, the role of the teacher is to cut a clear path for the student by monitoring each student's performance and correcting any misinterpretations or distortions of information (Pellone, 1995, p. 71).

This research hypothesised that the use of the Internet in secondary science classrooms will enhance classroom environment. The quantitative and qualitative data collected on the five-school, 431-student sample seemed to support this hypothesis. Certainly there is ongoing debate concerning the appropriation of funds for Internet endeavours throughout the Western world, but the inevitable evolution of the use of technology in the classroom can not be ignored. During this transition period that may be measured in years or decades, the traditional methods of secondary education will not be supplanted by the new technological paradigm, but will coexist with it as the technology is perfected.

But change is difficult. Education has traditionally been a very conservative discipline. In some ways that has been positive, not allowing every unproven idea in vogue at the time to become the new focal point around which all educators rally. And yet this conservative nature of the profession has also had negative consequences. In the USA, the entire teaching profession has historically been held in low esteem.

> Reforming the sorry situation has been the topic of many commissions and consortiums over the past two decades. A 1986 report, Tomorrow's Teachers, by the Holmes Group, a coalition of 100 leading universities, scolded, 'If someone had argued that doctors should practice modern medicine with the terms of an 1850s job description… he would be ridiculed by any audience. Yet most Americans think nothing of requiring teachers to carry out a late-20th century assignment when locked into a mid-19th

> century job description. Nor does it strike them odd to them blame teachers for a job badly done' (Wulf, 1997, p. 25).

In that respect it is hoped that this research can contribute in some way to the improvement of teachers and students, and to the future of society for which they are responsible. While the new technology will not entirely replace some of the traditional methods adhered to for centuries, there are three major factors that need to be considered in this light:

First, the old ways are not always the best and new ways may be more appropriate to a changed society and generation of students. To ignore the new technologies such as the Internet and not to incorporate them fundamentally and significantly within our schools is counter-productive for contemporary and productive learning. The world is changing at an ever-increasing pace and a major principle mechanism forging that change is the networking of computers and the instant communication of ideas that result from it. Education must prepare students for the real world. Attendance at any professional educational research conference today will confirm that study after study pronounce the use of classroom lecture and "the old pedagogy" as dead — standard lectures are becoming less and less effective and less and less relevant as the primary means of information and education delivery. The modern students look to better and more modern ways. The only thing that can be said with certainty is that the old ways will evolve into new ways.

Second, the information technologies in general and the Internet in particular are making such profound changes in the way the modern world works that we are undergoing a revolution in education unparalleled since education moved from the farmhouse to the one room schools in the 1800s. Society is changing more profoundly now that it has since the Industrial Revolution and formal education had better follow or it will become anachronistic and irrelevant. Of course there is not enough solid research yet done on these technologies, but that is only because Internet applications are so new and so evolutionary that much of what is written now is anecdotal and "how to do it" in nature.

Third, this study seems to indicate that teachers teach by example as much or more than by words. Many times students seem to mimic their teacher's attitude towards and use of the Internet. Time and again the researcher found that those teachers who were comfortable with the Internet and used it more than their colleagues tended to have students in their classes who used the Internet for academics more than their peers. Certainly the implication here is that administrators can not simply allocate funds for lines, hardware, and software. There is a dire need for concerted, broad-based professional development for all educators. Whenever possible this professional development needs to encourage teachers to have access to computers and the Internet at home, because only then do they seem to become truly comfortable with the technology. In summary, it is simply not good enough to merely place a computer with an Internet hookup in a classroom and expect it to be utilised to the fullest extent. Teachers need to be trained in the effective use of these latest technologies and encouraged to integrate them into the existing structure of their curriculums, lesson plans, and programs.

6.6 Limitations of the Study

A large number of science students in five of the seven Catholic high schools in the State of Hawaii were included in this sample. This represented a large proportion of the schools in this system. However, because of the fact that these students all attended Catholic schools in Hawaii, caution is needed in generalising the results of this study to the wider American population.

Second, the method used to quantify Internet usage was of an ordinal nature and proved impossible to weight. That means that though a student's Internet usage score ranged from 0-17, there was no implication made that a score of 10 was twice that of a 5.

Finally, though the researcher was on an un-paid leave during the data collection portion of this project, he had been a teacher in one of the schools involved in the study for over ten years. Additionally, he served as a member of a science and technology committee on which several other teachers in this study had served. Though care was taken to remain as unbiased as possible during the research, some teacher and student interviewees could have slanted responses because of their personal relationship with the researcher.

6.7 Future Research

It has been pointed out previously that individuals are greatly affected by the social milieu in which they function. This study looked to identify and quantify the effects of Internet usage on classroom environments. However, no individual student lives within the confines of that one science classroom, or even within the confines of the school itself. Moos speaks of (at least) three settings in which an individual interacts, all of which have profound effects on their spiritual and cognitive maturation as well as the development of a strong work ethic (Moos, 1991). These settings are the classroom, the work, and the family environments. Moos goes on to point out that in all these settings, a greater amount of individual participation and personal involvement with decision-making fosters higher degrees of task performance and learning. This researcher suggests that student Internet usage offers a high degree of individual participation and personal involvement with decision-making. It should be pointed out however, that it is difficult if not impossible to separate effects of an individual student's life away from the science classroom and in the work or family environment. It is also important to consider the overlapping of settings in a broader milieu. For example, the student's school setting is the teacher's work setting and the interaction of both can have major influences on classroom environments. Additionally, even the mere task of trying to pinpoint what technology each student uses is difficult at best. Besides the explosive growth of Internet usage over the duration of this study, the physical location of the technological environment in which students in this sample live could never be pinned down, since there is Internet availability in almost any conceivable setting. Much work remains in trying to isolate many of these issues.

Future research could choose a more balanced sample to explore gender differences with Internet usage and classroom environments, since the predominance of single-gender schools skew these results. It would also be of value to look at similar research carried out in public (government) schools and in settings away from the Hawaiian Islands.

6.8 Final Comments

The purpose of this thesis is to present a comprehensive study assessing the effects of secondary science students' Internet usage on their perceptions of the constructivist nature of their science classroom environment. The results of the study indicate that there is an association between greater student Internet usage and a positive perception of classroom environment. The major findings of the study can be summarised as follows:

Generally, this research seems to confirm the idea that student Internet usage has a positive effect on the constructivist nature of classroom learning environments in science classes within the schools in this sample.

The CLES does have internal consistency as measured by Cronbach alpha scores. This, in addition to one-way ANOVA and discriminant validity results indicates that the CLES may be used with confidence in Hawaiian schools. Positive associations exist between student Internet usage and the CLES scales of Critical Voice, Shared Control, Uncertainty, and Student Negotiation. Classroom observations and personal experiences support these findings. In other words, science classes that have higher student Internet usage seem to be more constructive in nature.

The role of the teacher played a large part in how valuable Internet usage was to the student. It was the individual teacher that seemed to be instrumental in keeping their students focused on the task at hand, whether that was accomplished through assigned projects or simply made part of the on going structured curriculum.

Of the ten teachers involved in this sample, all but one had at least one Internet-connected computer in her or his classroom.

Though there was a variety of approaches to integrating the Internet in classroom work, all teachers at least referred to it as a possible resource for research or exploration.

Use the Internet was written specifically into one class and students met in an online computer lab at least one day a week.

Several teachers integrated Internet usage into more traditional class structures by posting notes, laboratories, and assignments on the school's home page, and communicating with students by e-mail.

The specific method any of the teachers in this sample used in their classroom did not seem to have as great an effect on their students as did a positive attitude in respect to using the Internet as a tool. When demonstrated, this positive attitude seems to set the tone for constructive use of the Internet by students.

Students have accepted the use of the Internet to such a degree that they often don't know they are using it.

Internet usage seems to be much more social than one may imagine with students communicating with classmates gathered around a computer terminal and with others at remote sites.

These findings vary between boys and girls, and yet both sexes are affected positively by their individual use of the Internet.

These findings could have a practical impact on classroom science teachers attempting to develop a more positive classroom environment within the constructivist model. Additionally, the study has implications for school and district administrators facing the appropriation of funds to acquire more Internet-related technologies and providing that hardware and training for more students and staff.

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APPENDIX A

Questionnaire Including Demographic Data, the CLES, Student Attitude Towards Science, and Student Internet Usage Information

What happens in my science classroom?
• Student form •

DIRECTIONS

1. **Purpose of the Questionnaire**
This questionnaire asks you to describe important aspects of the science classroom which you are in right now. There are no right and wrong answers. This is not a test and your answers will not affect your assessment. Your opinion is what is wanted. Your answers will enable us to improve future science classes.

2. **How to Answer Each Question**
On the next few pages you will find 37 sentences. For each sentence, circle only one number corresponding to your answer. For example:

	Almost Always	Often	Some-times	Seldom	Almost Never
In this class…					
8 The teacher asks me questions	5	4	3	2	1

- If you think this teacher *almost always* asks you questions, circle the 5.
- If you think this teacher *almost never* asks you questions, circle the 1.
- Or you can choose the number 2, 3 or 4 if one of these is a more accurate answer.

3. **How to Change Your Answer**
If you want to change your answer, cross it out and circle a new number. For example:

8 The teacher asks me questions	5	4	3	2	1

4. **Course Information**
Please provide information in the box below. Please be assured that your answers to this questionnaire will be treated confidentially.

a. Name	b. School
c. Grade	d. Sex (Please circle one) Female Male
e. My last grade for this subject was? (Circle one answer. If you need help, ask your teacher.) A B C D F	

CLES, Taylor & Fraser, Curtin University, November, 1994

5. **Internet Usage Information**
Please answer the questions below concerning your personal use of the Internet.

Have You Used the Internet? (For each, circle yes or no.)

1.	Have you ever used the Internet by yourself? (In other words, you sat at the keyboard and decided where to go.)	Yes	No
2.	Have you ever used the Internet with someone else? (In other words, you were together with another person and didn't use the keyboard by yourself.)	Yes	No

If you answered *YES* to either question **1** or question **2** above, please complete questions **3** through **13** below. If you answered *NO* to *BOTH* questions **1** and **2** above, please go on to Section 6 of this survey, Completing the Questionnaire. Once again, please answer the questions below concerning your personal use of the Internet and make sure to answer every question.

How Do You Use the Internet? (For each, circle yes or no.)

3.	Do you use the Internet in this science classroom?	Yes	No
4.	Do you use the Internet in any other science classroom in this school?	Yes	No
5.	Do you use the Internet in this school's resource center or library?	Yes	No
6.	Do you use the Internet at any other computer or terminal in your school?	Yes	No
7.	Do you use the Internet at home?	Yes	No
8.	Do you use the Internet at any other location besides this school or your home? (For example, the state library, a friend's home, at a youth center, etc.)	Yes	No

9. If you answered yes to question **8** above, please name this other location (or locations). In other words, *what other computer access sites* to the Internet do you have (name the places).

More Concerning Your Internet Usage… **(Circle one answer only.)**

10. On average, how many times a month would you say that you use the Internet during the course of a typical month while school is in session. Include all the times you use the Internet, whether alone or with others and at any location.

    a. less than one time per month
    b. 1 to 3 times per month
    c. 4 to 8 times per month
    d. 9 to 15 times per month
    e. more than 15 times per month

11. On average, how much time per session do you spend using the Internet?

    a. less than 15 minutes each session
    b. 15 to 30 minutes each session
    c. 30 to 60 minutes each session
    d. over one hour each session

12. Most of the times that you use the Internet, do you generally use it for (choose one answer):

    a. having a good time just *"surfing the net"*
    b. looking specifically for information in which I am personally interested
    c. looking for information concerning a required homework or project assignment
    d. both *'surfing the net'* and looking for specific information

13. All things considered, which of the following best describes your personal Internet usage?

    a. I enjoy using the Internet and use it even though I do not have an assigned task to complete.
    b. I enjoy using the Internet, but don't use it much unless a teacher gives me an assigned task to complete.
    c. I really don't enjoy using the Internet and only use it if my teacher gives me an assigned task to complete.

6. Completing the Questionnaire
Now turn the page and please give an answer for every question.

Learning about the world…	Almost Always	Often	Some-times	Seldom	Almost Never
In this class…					
1. I learn about the world outside of school.	5	4	3	2	1
2. My new learning starts with problems about the world outside of school.	5	4	3	2	1
3. I learn about how science can be part of my out-of-school life.	5	4	3	2	1
In this class…					
4. I get better understanding of the world outside of school.	5	4	3	2	1
5. I learn interesting things about the world outside of school.	5	4	3	2	1
6. What I learn has nothing to do with my out-of-school life.	5	4	3	2	1
Learning about science…	**Almost Always**	**Often**	**Some-times**	**Seldom**	**Almost Never**
In this class…					
7. I learn that science cannot provide perfect answers to problems.	5	4	3	2	1
8. I learn that science has changed over time.	5	4	3	2	1
9. I learn that science is influenced by people's values and opinions.	5	4	3	2	1
In this class…					
10. I learn about the different sciences used by people in other cultures.	5	4	3	2	1
11. I learn that modern science is different from the science of long ago.	5	4	3	2	1
12. I learn that science is about inventing theories.	5	4	3	2	1
Learning to speak out…	**Almost Always**	**Often**	**Some-times**	**Seldom**	**Almost Never**
In this class…					
13. It's okay for me to ask the teacher "why do I have to learn this?"	5	4	3	2	1
14. It's okay for me to question the way I'm being taught	5	4	3	2	1
15. It's okay for me to complain about activities that are confusing.	5	4	3	2	1
In this class…					
16. It's okay for me to complain about anything that prevents me from learning.	5	4	3	2	1
17. It's okay for me to express my opinions.	5	4	3	2	1
18. It's okay for me to speak up for my rights.	5	4	3	2	1

CLES, Taylor & Fraser, Curtin University, November, 1994

Learning to learn…	Almost Always	Often	Some-times	Seldom	Almost Never
In this class…					
19. I help the teacher to plan what I am going to do.	5	4	3	2	1
20. I help the teacher to decide how well I am learning.	5	4	3	2	1
21. I help the teacher to decide which activities are best for me.	5	4	3	2	1
In this class…					
22. I help the teacher to decide how much time I spend on activities.	5	4	3	2	1
23. I help the teacher to decide which activities I do.	5	4	3	2	1
24. I help the teacher to assess my learning	5	4	3	2	1

Learning to communicate…	Almost Always	Often	Some-times	Seldom	Almost Never
In this class…					
25. I get the chance to talk to other students.	5	4	3	2	1
26. I talk with other students about how to solve problems.	5	4	3	2	1
27. I explain my ideas to other students.	5	4	3	2	1
In this class…					
28. I ask other students to explain their ideas.	5	4	3	2	1
29. Other students ask me to explain my ideas.	5	4	3	2	1
30. Other students explain their ideas to me.	5	4	3	2	1

Learning in this class…	Almost Always	Often	Some-times	Seldom	Almost Never
31. I look forward to this class.	5	4	3	2	1
32. I feel confused during this class.	5	4	3	2	1
33. This class is a waste of time.	5	4	3	2	1
34. This class is among the most interesting at this school.	5	4	3	2	1
35. The work is hard in this class.	5	4	3	2	1
36. The thought of this class makes me tense	5	4	3	2	1
37. I enjoy this class.	5	4	3	2	1

APPENDIX B

Teacher Questionnaire Including Demographic Data and Teacher Internet Usage Information

How I Use the Internet
• Teacher Form •

DIRECTIONS

1. Purpose of the Questionnaire

Students in your science class(es) answered an Internet usage and Contructivist Learning Environment Survey instrument I have used in my research in the Catholic Schools of Hawaii. It would be quite helpful to now see how the teachers in this sample use the Internet. Please answer the following questions by circling the choice that best describes <u>your</u> Internet habits.

2. Personal Information

Please provide information in the box below. Please be assured that your answers to this questionnaire will be treated confidentially.

a. Name	b. School
c. Grade levels taught this year	d. Gender (Please circle one) Female Male
e. Subject(s) taught this year.	

3. Internet Usage Information

Please answer the questions below concerning <u>your personal use of the Internet</u>.

Have You Used the Internet? (For each, circle yes or no.)		
1. Have you ever used the Internet <u>by yourself</u>? (In other words, you sat at the keyboard and decided where to go.)	Yes	No
2. Have you ever used the Internet <u>with someone else</u>? (In other words, you were together with another person and didn't use the keyboard by yourself.)	Yes	No

If you answered *YES* to either question **1** or question **2** above, please complete questions **3** through **15** below. If you answered *NO* to *BOTH* questions **1** and **2** above, please go on to question 15. Once again, please answer the questions below concerning <u>your personal use of the Internet</u> and please answer each question.

How Do You Use the Internet? (For each, circle yes or no.)

3.	Do you use the Internet in <u>your science classroom</u>?	Yes	No
4.	Do you use the Internet in any other science classroom in this school?	Yes	No
5.	Do you use the Internet in this school's resource center or library?	Yes	No
6.	Do you use the Internet at any other computer or terminal in your school?	Yes	No
7.	Do you use the Internet at home?	Yes	No
8.	Do you use the Internet at any other location besides this school or your home? (For example, the state library, a friend's home, etc.)	Yes	No

9. If you answered yes to question **8** above, please name this other location (or locations). In other words, *what other computer access sites* to the Internet do you have (name the places).

What Class Internet User Are You? (Circle one answer only.)

10. Which of the following best describes <u>your personal</u> level of Internet usage?

a. I use the Internet to find information using a web browser such as Microsoft Internet Explore or Netscape.

b. I use the Internet to find information using a web browser as above, but also am active in communicating over the Internet using e-mail, bulletin boards, or similar services.

c. I use the Internet to find information using web browsers and use e-mail and the like as described in choices a and b above, but also have done presentation work using HTML or software designed to allow me to create home pages or other web-based materials.

More Concerning Your Internet Usage… **(Circle one answer only.)**

11. On average, how many times a month would you say that you use the Internet during the course of a typical month while school is in session. Include all the times you use the Internet, whether alone or with others and at any location.

    a. less than one time per month

    b. 1 to 3 times per month

    b. 4 to 8 times per month

    d. 9 to 15 times per month

    e. more than 15 times per month

12. On average, how much time per session do you spend using the Internet?

    a. less than 15 minutes each session

    b. 15 to 30 minutes each session

    c. 30 to 60 minutes each session

    d. over one hour each session

13. Most of the times that you use the Internet, do you generally use it for (choose one answer):

    a. having a good time just *"surfing the net"* with no real destination in mind

    b. looking specifically for information in which I am personally interested

    c. looking for information concerning class preparation or school related work

    d. both *'surfing the net'* and looking for specific information

14. All things considered, what effect has your use of the Internet had on your teaching?

    a. my Internet usage has had a negative effect on me as a teacher

    b. my Internet usage has had no effect on me as a teacher

    c. my Internet usage has had a positive effect on me as a teacher

15. All things considered, what effect has student Internet usage had on your science classes?

    a. student Internet usage has had a negative effect on my science classes

    b. student Internet usage has had no noticeable effect on my science classes

    c. student Internet usage has had a positive effect on my science classes

Thank you for allowing your students and you to be a part of this research project. I will be certain to let you know the findings as soon as they are determined.

APPENDIX C

Student Interview Form Used by Researcher

Student ID Number ______________________________ Date _____________

Student Name ______________________________ Class _____________

- *Do you mind if I tape this interview?*
- *What we talk about here will be confidential, the same as the written questionnaire you filled out back in January.*

1. You said you used the Internet about ______________________________. Tell me about how you use the Internet.

2. Have your habits changed since you filled out the form?

3. Think about the three classes of Internet users we can imagine today: The first class user just sits at a terminal and uses a WWW browser like Internet Explorer or Netscape. The second class user still uses a browser, but also communicates over the Internet, using things like e-mail or web talk capabilities. The third class user does both of the first two activities, but also creates WWW material (using HTML) like home pages and the like. How would you classify yourself?

   ___________ class user

4. Would you tell me about why you see yourself that way?

5. Would you say that the way you use the Internet is a social activity or an individual one? In other words, most of the time do you experience the Internet alone or by interacting with others? Explain. *("Interacting with others"* could be two or more people using one terminal or you using e-mail to correspond with other interactive uses.)

I want you to answer the following questions in terms of THIS science class and how YOU use the Internet for it.

6. *Personal Relevance* _______ - In your opinion how connected would you say the things you learn in here are to your past experiences and the "real world" outside the classroom?

   How does your Internet usage effect this?

7. *Student Negotiation* _______ - Tell me to what extent you feel free to discuss your views and ideas concerning scientific concepts presented in here with your classmates?

   How does your Internet usage effect this?

8. *Shared Control* _______ - How much control do you feel you have over the learning environment in here, over what you learn and how you learn it?

   How does your Internet usage effect this?

9. *Critical Voice* _______ - How free are you to question your teacher concerning how this class is run or to express ideas critical of her/his methods?

   How does your Internet usage effect this?

10. *Uncertainty* _______ - In this class, would you say you learn that science is more universal and unchanging or more culturally dependent and uncertain?

    How does your Internet usage effect this?

11. *Attitude* _______ - In general, do you enjoy this science class and look forward to being here? Would you recommend it to someone else to take next year?

    How does your Internet usage effect this?

12. Would you say your experience in school (especially your science class) is any better, worse or the same because of your Internet use? Explain?

APPENDIX D

A Copy of the Letter to be Sent to Administrators at the Request of Classroom Teachers

1635 Oneawa Place
Hilo, Hawaii 96720
808-959-4414
churach@inter.net

Dan Churach

Dear

Thank you for allowing one of your teachers, _______________, to participate in my research into the effects of Internet usage on secondary science classroom environments. I have worked closely with _______________ over these past few years on the Catholic Schools Science and Technology Committee and we have developed a fine working relationship.

In this study, I will administer a questionnaire to _______________ classes. This questionnaire consists of 13 student Internet usage questions, the 30 questions of the Constructivist Classroom Environment Survey (CLES), and a 7-question student attitude towards science scale taken from the Test of Science Related Attitudes (TOSRA). This questionnaire will only take between fifteen and twenty minutes to administer and I be in class to do so personally. Later in the Spring Semester, I will return to your school to interview approximately ten percent of the students in this sample. These student interviews will be arranged with the classroom teacher at a time that will be least disruptive to regular classroom activities.

Though each student will be asked to write her or his name on the survey so that I can match responses to interview data, the information for individual students will of course be kept confidential. Only class data will be made available to participating teachers and schools in this sample and the highest ethics in educational research will be followed throughout this study.

I hope to have a preliminary analysis of the data by early 1998 and will provide you and the involved staff with the results of this project as soon as I am able. It is laudable that you have agreed to participate in this study and I thank you in advance for your participation. If you have any question at all, please feel free to contact me at my home address or phone as listed on this letter.

Thank you once again for your cooperation.

Aloha,

Dan Churach