MULTIMEDIA INNOVATION IN HIGHER EDUCATION: AN EXPLORATORY CASE STUDY

by

AJIBOLA O. AJAYI

B.Sc., The University of Ibadan, Nigeria, 1985

Diploma in Education, The University of Lagos, Nigeria, 1987

Diploma in Computing Studies Education, The University of British Columbia, 1992

A Thesis Submitted in Partial Fulfilment of the Requirements for the Degree of Master of Arts

in

The Faculty of Graduate Studies

Department of Curriculum Studies

We accept this thesis as conforming to the required standard

THE UNIVERSITY OF BRITISH COLUMBIA

January, 1995

In presenting this thesis in partial fulfilment of the requirements for an advanced degree at the University of British Columbia, I agree that the Library shall make it freely available for reference and study. I further agree that permission for extensive copying of this thesis for scholarly purposes may be granted by the head of my department or by his or her representatives. It is understood that copying or publication of this thesis for financial gain shall not be allowed without my written permission.

Department of Curriculum Studies

The University of British Columbia
Vancouver, Canada

Date 31st January, 1995

DE-6 (2/88)

ABSTRACT

This study investigated a professor's first attempt at incorporating multimedia technology as an instructional tool in a first-year level Astronomy course at the University of British Columbia. The issues explored were the kinds of planning, organization, and implementation that were undertaken, as well as the effects of the technology on teaching and learning.

A qualitative case study research methodology was employed in this investigation. The theoretical frame that informed the study was a holistic world view of education. The analyzed records consist of fieldnotes and videotaped records of the planning stages, observations, tutorial and lecture sessions, and interviews with the instructor and four volunteer students.

The emergent issues were categorized into two major themes, practical and pedagogical issues. Issues of convenience, technical knowledge, software and time were four categories identified within the practical theme. Interest and motivation, and concept development were the two categories identified within the pedagogical theme. Recommendations for the successful implementation of multimedia technology as an instructional tool arising from the analysis of these six categories are provided.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ACKNOWLEDGMENTS

I am very grateful to Drs. Jaymie Matthews and Greg Fahlman of The Department of Geophysics and Astronomy at UBC for their support in the writing of this thesis.

I thank my thesis committee members, Drs. Janice Woodrow, Anthony Clarke and Karen Meyer, for their insightful comments and constructive criticisms which has contributed to the successful completion of this thesis.

The technicians and the secretaries in the Department of Curriculum Studies at UBC have been a wonderful support throughout my graduate carrer, and I thank them very much.

I appreciate the support I received from fellow graduate students.

I am grateful to all my teachers who at various stages of my educational career have contributed tremendously to the making of ME.

I am particularly indebted to my brothers and sisters in Christ for their unconditional love and prayers, my family and in-laws for their support in so many ways, and my mother, who gives and gives and is still giving.

Our preschool aged boys, Segun, Seun and Seyi, have brought so much richness to my life that I thank God continually for the privilege of motherhood. I thank them for providing the necessary disturbance from academics.

Finally, I dedicate this thesis to the Glory of the Almighty God, and to my dear husband, Debo, whose love and commitment to me continues to humble me.

CHAPTER ONE

INTRODUCTION TO THE STUDY

1.0 BACKGROUND

The move into the technological age is very much evident in today's society. Offices and banks are flooded with computers. Similarly, grocery shops make extensive use of technology (e.g. bar code pricing and inventory). These days, the use of multimedia technology has captured the attention of educators as well as the business world. Many educators are concerned with being technologically competent as well as equipping learners to live in the 21st Century. Consequently, there is much interest in ways of effectively implementing technology as tools in the classrooms. At one point in time, the chalkboard was considered to be modern technology. The focus of educators now is on using multimedia and information technology as powerful educational tools. Hence, educators are interested in exploring different ways of implementing computer technology in their classrooms to enhance students' learning and skill development.

While primary and secondary educators have done extensive work in incorporating multimedia into both teaching and learning, higher education has been shown to lag behind (Sammons, 1993). This discrepancy between public and post-secondary education's use of multimedia is a recently addressed issue. Currently, universities are beginning to investigate ways in which multimedia technology can be used in order to enhance students' learning and skill development. A few universities in the United States, such as Wright State University, University of Delaware, Washington State University, and others are beginning to explore the uses of multimedia as instructional tools (Sammons, 1993). These universities have individually established campus-wide multimedia centers which support faculty members with equipment and personnel. However, the innovation process documented in this thesis was based on a different type of initiative; the decision to integrate multimedia technology as an instructional tool was a personal choice rather than part of a university-wide program.

Few professors attempt to integrate the use of technology into their teaching, especially when there is no technical or administrative support from the university. If and when they incorporate the use of multimedia technology for the first time, what does the exploration look like? This thesis documents the case of implementing multimedia instructional technology in Astronomy 101/102.

1.1 RESEARCH FOCUS

The focus of this study was an investigation of a professor's first attempt at incorporating multimedia technology as a teaching tool in a first-year level Astronomy course.

1.1.1 Research questions:

Based on the research focus, the following two research questions are addressed:

- What planning, organization, and implementations were undertaken to incorporate multimedia during the innovation?
- What aspects of multimedia technology were salient to its implementation, and how did they affect teaching and learning in Astronomy 101 and 102?

1.2 THE RESEARCH SITE

The site for this study was the Astronomy 101/102 winter 1993-94 class at the University of British Columbia. The choice of the research site was guided by the following four considerations suggested by Marshall & Rossman (1989).

1. Accessibility.

   The instructor of the course was willing to have his exploration of the use of multimedia technology tracked and documented.

2. Ease of entry.

   The instructor of the course and the professor who initiated the course had been involved in other collaborative studies with the Faculty of Education, hence, they were comfortable with the concept of researching their exploration attempt with multimedia technology.

3. Relevance of the research question to the site.

   I did not set up the phenomenon observed, i.e., the instructors were not asked to embark on this innovation so that they could provide data for a Master's thesis. They had planned to start the innovation with multimedia technology during the 1993/94 academic session. Hence, the research focus of this study was based on a real situation as opposed to having the situation arranged as a research exercise.

4. Opportunity to capture data that would be both credible and of a measurable quality.

   This exploratory innovation attempt embarked upon in the Department of Geophysics and Astronomy lends itself to providing credible data. The information gleaned from the study is valuable, useful and of measurable quality as reflected in the section on the implications of the study.

The principal participants in the study were:

- Dr. Jaymie Matthews, the instructor of the course.
- Dr. Greg Fahlman, the initiator and former instructor of the course.
- Four male student volunteers from the class.

(All the participants gave permission to have their actual names used in this study, except in the case of the four volunteer students where pseudonyms were used.)

For this innovation attempt, the following elements of the multimedia technology were used:

- Computers (laptop and desktop)
- Liquid Crystal Display projection panel
- Laserdiscs and player, with barcode readers and barcode software
- CD-ROMs and readers
- Hypercard stacks
- Powerpoint/Toolbook/Videostack (Macintosh & IBM) presentation packages
- Computer simulation software

1.3 JUSTIFICATION FOR THE METHODOLOGY

A qualitative case-study research strategy was employed in this study. The nature of the research focus and research questions necessitated this approach. A case study is defined by Yin (1994) as

...an empirical inquiry that

- *investigates a contemporary phenomenon within its real-life context, especially when*

- *the boundaries between phenomenon and context are not clearly evident. (p.13).*

The purpose of this study is to gain insight into a process of technological innovation rather than specific outcomes. This investigation was conducted in the natural setting (i.e., the classroom), taking the dynamics of the classroom into account. Hence, this study considers teaching and learning from a holistic perspective and not as a set of dependent and independent variables. To strengthen the case study design and enhance the accuracy of the data, multiple sources of evidence were employed as recommended by Yin (1994), Merriam (1991), and Marshall and Rossman (1989). The following sources of data were utilized:

- interview transcripts from four volunteer male students
- interview transcripts from the instructor
- interview transcripts from the initiator of the course
- field notes from informal interviews and conversations with the students
- field notes from classroom observations with and without the use of multimedia
- field notes from observations of the tutorial sessions
- field notes from observations of some of the instructor's preparatory activities
- the course outline and laboratory manual and
- course and teaching evaluation forms completed by the students.

All the interviews, and some field observations were videotaped by me. A more detailed account of the methodology is presented in chapter three.

1.4 IMPLICATIONS OF THE STUDY

This study is important for the following reasons:

1. No study has been reported on this kind of innovation in which the faculty member was the initiator of the innovation.
2. There are few studies that use a process-oriented approach to investigate innovation, especially technological innovation.
3. This study will describe, document and attempt to explain what worked and what did not work, and make recommendations to guide future attempts at introducing instructional technology.
4. This study will be a useful guide for other faculty members who are planning similar kinds of innovations.
5. Since the field of multimedia technology in Education is an emerging one, this study will contribute to the body of literature in that discipline.
6. Finally, this study is another example of the usefulness of case study research methodology in gaining an in-depth understanding of a phenomenon.

1.5 OVERVIEW OF THE STUDY

This study is presented in five chapters. *Chapter One* consists of the background to the study, research focus and the two research questions to be answered. A brief description of the methodology and the implications of the study are also presented. In *Chapter Two,* a review of selected literature is presented. *Chapter Three* consists of the design and methods used to collect, classify and interpret the data. Also addressed in this chapter are the issues of validity and reliability of the study. The story of the innovation is presented thematically in *Chapter Four.* Finally, a discussion of the answers to the research questions, conclusions, recommendations for the successful implementation of multimedia technology as an instructional tool as well as recommendations for further study are presented in *Chapter Five.*

CHAPTER TWO

LITERATURE REVIEW

2.0 INTRODUCTION

This study investigates a professor's first attempt at integrating multimedia technology into his teaching practice. This chapter reviews the literature pertaining to multimedia innovation in Education.

The chapter is divided into three sections. The first section is a review of the literature on innovation. The second section reviews technological innovation in Education. Finally, a review of the literature regarding recent developments in the area of multimedia technology in general and its use in higher education in particular is presented in the third section. Areas for further research are identified in each section.

2.1 INNOVATION

Innovation is defined by Levine (1980) as "any departure from the traditional practices of an organization" (p.4). Organizations could be business, educational, or social institutions. Fullan and Stiegelbauer (1991) define educational reform as "changing the cultures of the classrooms, the schools, the districts and the universities..." (p. xiii). Although Fullan and Stiegelbauer (1991) claim that educational *reform* rather than educational *innovation* honors the complexity of *change*, they have not made a strong case for this distinction as evidenced by the fact that they used these three terms interchangeably in their book. From the literature, innovation, change and reform essentially mean the same thing especially when applied to the field of Education. The three terms are often used interchangeably even in the same articles e.g., Fullan & Stiegelbauer (1991), and Wunsch (1992). In this thesis however, for the purpose of consistency, the term innovation is used even though the ideas are drawn from the literature on all the three concepts.

2.1.1 Educational Innovation

The field of Education is a dynamic one. Educators, from time to time, reflect on their own practices, on institutional practices, as well as on societal practices or needs. These reflections very often result in actions in the form of innovations, some of which are radical, others less so. The history of Education is replete with innovations, from major innovations involving the establishment of entirely new organizations or colleges to minor ones involving peripheral changes to existing organizations (Levine, 1980). Levine (1980) identified five basic types of educational innovation:

1. Establishment of new colleges.
2. Establishment of innovative enclaves within existing colleges.
3. Holistic changes within existing organizations.
4. Piecemeal changes within existing organizations.
5. Peripheral changes outside of existing organizations.

The major difference among these five categories is the extent of the change from established norms within the organization. Sarason (1990), however, broadly distinguished between first and second-order changes. First-order changes do not disturb the basic organization features. That is, the different roles within the organization are not altered. Second-order changes involve the definition of new goals, structures and roles in an organization. Second-order changes are larger in magnitude and would include Levine's first three categories, while the last two categories of Levine constitute first order changes for Sarason. Levine, (1980) came up with many reasons why innovations fail, and draws upon vignettes from the field of higher education as examples. However, these vignettes lacked particularity about technological innovation in higher education. This study will focus on a case of technological innovation in higher education. This type of innovation can be categorized as a piecemeal change within an existing organization. (Levine's type four). This type of change can lead to holistic changes that involve the entire faculty or lead to a major departmental reorganization.

Fullan and Stiegelbauer (1991), identified four phases of the change / innovation process:

1. initiation /mobilization /adoption: the phase of decision making as to whether to adopt the innovation or not
2. implementation / initial use: the first set of experiences with the innovation
3. continuation /routinization / incorporation / institutionalization: the stabilizing stage where the innovation becomes a legitimate part of the system
4. outcome: the result of the innovation

Fullan and Stiegelbauer (1991) stated that the outcome phase can refer to several different types of results and can be thought of generally as the degree of improvement in relation to given criteria. Results could include, for example, improved student learning and attitudes, new skills, attitudes, or satisfaction on the part of teachers and other school personnel, or improved problem-solving capacity of the school as an organization. This outcome phase is based on a process-product model in which innovation can be measured in terms of different variables. Looking at an innovation in terms of its outcome does not provide the understanding that is needed for a person that is considering embarking on innovation. For example, if a study that shows that the introduction of a particular type of technology improved student learning, one would want to know how, when and what aspect of student learning? Straight recall? In all students? In all contexts? What strategies did the teacher adopt to promote this? What things were avoided? What was the teacher's attitude towards this innovation? What feelings did the teacher go through during the different phases of the innovation process? What was the response of the students? Were they excited about the changes right away? The questions that arise are almost inexhaustible. The crucial point however is that all these issues affect students' learning so it is important to know how they were handled. Even though Fullan, (a respected author in the field of educational change), and his co-workers over a ten year span have constantly maintained that change is a process not an event and that evaluations can be misleading if they provide information on products only, the addition of this fourth category renders their stand contradictory. However, the outcome phase is still interesting and as educators, we are innovating our practices implicitly because of the intended outcome which we desire.

This study describes an innovation in the implementation phase. The instructor's first set of experiences with the innovation are described. His feelings and attitudes towards these experiences, fears, doubts and thrills are also documented. In addition, the study describes the sets of decisions that he made during this implementation stage and the factors that guided those decisions.

2.2 EDUCATIONAL TECHNOLOGY

Educational technology has been defined by 'The Association for Educational Communication and Technology's (AECT) Task Force' as

> ...a complex, integrated process, involving people, procedures, ideas, devices and organizations for analyzing problems and devising, implementing, evaluating, and managing solutions to those problems involved in all aspects of human learning. (p.164).

This was an appropriate definition given the applicability of educational technology across a variety of contexts. Educational technology includes all the approaches applied to educational problems such as educational psychology, media and systems approach, as well as terms such as instructional technology that implies the application of a specific technology in Education. This profusion of meanings was further evidenced by Grabowski's (1992) review of the literature on the multiple perspectives of educational technology in which he discussed four different research perspectives of educational technology. In his article, educational technology was defined from a philosophical, practical knowledge base, methodological, and a practical research perspective. The result was an "interesting mosaic of issues" (Grabowski, 1992).

2.2.1 Technological Innovation

Technological innovation in Education involves the adoption of a new technology in teaching/learning environments. Schools have always considered the use of new technologies. As Olson (1988) puts it "the slate was once a novelty". However in our time, teachers have had to consider the use of teaching machines, instructional television, videos, computers and, more recently, multimedia in their classrooms within a short period of time.

There is an increasing awareness that educational innovations are best initiated by the teachers themselves. Oakes & Schneider (1984), contend that even though ideas may be used from outside, the school should not be made a target for innovations developed outside the school. According to Fullan and Stiegelbauer (1991), innovation is not what is done on people but what people do, that is "bottom up changes" (Salisbury, 1992). For innovations to be successful they have to be owned by those who use them (Levine, 1980; Fullan, 1992). In this study, the decision to integrate multimedia technology into teaching was that of the professor who initiated the course and the instructor who taught it in the 1993/94 academic session. Fortunately, they were able to get funding from the Teaching and Learning Enhancement Fund at UBC to support and research the innovation.

Instructional innovation with technology is often classified as "piecemeal changes within existing organizations" (Levine, 1980). This type of change is usually initiated by those using it directly and tends to conform to the traditional ways of doing things within the organization. This could be why instructional technology, although introduced as a form of innovation, still tends to be used in a way that conforms to the traditional lecture mode in classrooms (Salisbury, 1992).

While technological innovations usually do not go outside the boundary of institutional values or norms (Duttweiler, 1983), piecemeal changes can sometimes lead to holistic ones within existing organizations as well as the establishment of innovative enclaves within existing colleges. Such major innovation-related changes generally involve some form of negotiation (Levine, 1980). For this negotiation to be effective, it must be shown that reasonable lessons have been learned from those piecemeal innovations. For such meaningful lessons to occur, a proper assessment of the innovation is vital.

Many scholars have expressed the need for technological innovation and its proper assessment in classroom settings. In the process-product approach, the most recent dominant paradigm, the success of the innovation is usually assessed in terms of improvement in achievement scores of the students. Hoyles (1992), Kinnick et al. (1990), and Olson (1985), suggest the need for a different approach in which technological innovation is assessed in terms of the interaction processes that go on in the classroom rather than a product or outcomes approach. This suggestion is based on the premise that, "Innovation is complex and subtle and we need to acknowledge the many years of practice it takes to acquire and integrate a new way of teaching." (Polin, 1991 p.7 cited in Hoyles, 1992 p. 40). This alternative approach can be appropriately studied by using the case study method of inquiry.

An interaction processes approach in which the innovation was studied within its context, was used in this study rather than treating those pertinent factors that make up the context as extraneous variables. Insights into the success of this technological innovation were gained by classroom observations, and interviews with the instructor and volunteer students.

Innovations, especially technological innovations, have been known to suffer from poor assessment (McClung, 1979). There has been a lack of understanding of how technological innovation takes place. Most of the research in this area uses a process-product framework with various scales and instruments that have produced mixed results. The quantitative approach in the evaluation of innovation does not reveal much about the day-to-day practices and the numerous contextual factors that are often hidden by statistical manipulations (Fullan & Stiegelbauer, 1991; McClung, 1979). Hence, there is a need to study innovation in a holistic context, to learn how innovation and everyday practices interact; to know what it is like to cope with new technologies; to find out how it affects the teachers and students interactions; and to know what changes to expect in the atmosphere of the classroom. As Fullan and Stiegelbauer (1991) note, "How change is put into practice determines to a large extent how well it fares." Studies that best capture a holistic, contextually rich picture of innovation are typically detailed case studies. These studies are usually done in the context of interaction processes within and beyond the classroom. They can also capture the reflexivity pattern of the teacher and indeed encourage this as the teacher makes day-to-day decisions on the use of technologies in class (Olson, 1991). This notion of "reflection on action" has been shown to be very valuable for effective teaching to take place in various contexts (Smith, 1993; Clarke, 1992).

2.3 MULTIMEDIA

"Multimedia refers to the ability to combine, within a given application, multiple channels of communication within a single distribution or delivery medium such as magnetic or optical disc." (Barker et al. 1993, p.33). Multimedia incorporates two or more of the following elements: text, graphics, animation, audio, and video. In multimedia, computer technology is used to integrate and control these elements. Using multimedia, information that has previously been presented in a lecture format and by the use of overheads and other visual aids can now be presented in a more dynamic, integrated and interactive manner. Multimedia packages can either be for a Macintosh or a DOS environment. The capabilities of multimedia include:

- The ability of multi-channel communication. This refers to the combination of data processing technology with sound and image technology.
- The ability to contain a large quantity of accessible material which can be integrated in a variety of ways. Since the amount of information available to educators has increased sharply, and this is a continuing trend, multimedia technology is increasingly required to handle such information.
- The flexibility of authoring and navigation. The user friendliness of the multimedia technology makes it accessible to people with minimal computer experience.
- The ability to be usable in various learning contexts such as the lecturing mode as well as in a hands-on mode.

The potential of multimedia technology is seemingly limitless. It is already widely used in the business sector. Many of today's computer applications could be improved with multimedia capabilities. According to IBM, "multimedia is limited only by the power of the user's imagination". (IBM international technical support centers, 1992. p.3). This may be an exaggeration especially bearing it in mind that IBM is a major stakeholder in the field of multimedia. Multimedia is new and still rapidly changing, and due to the infancy of its development, the technology still has many shortcomings. One shortcoming is that there is yet no unique way of defining a comprehensive set of multimedia application areas. New hardware and software product developments continue to affect the multimedia market and the growing number of multimedia network application areas. These new products make multimedia products expensive, especially considering that presently it is an emerging technology. Until things become fairly stabilized in the manufacturing sector, it is difficult for teachers to take full advantage of multimedia technology capabilities and think about ways in which they can use it and experiment with their various ideas.

2.3.1 Multimedia Technology in Education

Most states in the U.S now stipulate that K-12 teachers acquire knowledge and skills for using information technologies so that they can make effective use of this technology in the elementary and secondary school classrooms (Punt, 1994). As a result, there has been an increasing use of computers among teachers but mainly for word processing. Many teachers still lack the ability to incorporate this technology into the curriculum despite their genuine interest because many of them still lack a basic understanding of the pedagogical usage of multimedia or hypermedia packages (Reehm, & Kolloff, 1994). While the need for instructional technology in Education has been acknowledged by many within the last decade (Salisbury, 1992), the methodology of going about it still remains elusive. This study will provide a detailed account of a case of multimedia innovation in higher education.

The advantages of using instructional technology in Education has been well documented. Much has been written about the effective use of instructional television (Koontz, 1989; Rockman, 1985), videos, slides, computers (Duttweiler, 1983), and more recently, multimedia technology in Education (Falk, & Carlson, 1991; Faravelli, et al., 1991; Brandt, 1991).

A multimedia set-up is a combination of different components, for example, the computer, video player, laser disc player, and the liquid crystal display (LCD) panel. These components are also capable of being used individually in the classroom setting. There is the tendency, therefore, to see multimedia just in terms of these individual hardware components or as the new 'audio/visual' technology, but the concept of multimedia is integration of technologies that has a purpose beyond an amalgamation of the individual technologies. The effectiveness of the integration of the single media into multimedia technology means that the whole is greater than the sum of its individual parts. Because of this tendency of seeing multimedia just in terms of its individual hardware components, extrapolations from studies that have explored the effectiveness of single media usage in educational settings will have to be carefully examined. An example of such studies is Rockman's (1985) lessons from instructional television. Weingrad et al. (1993) also conducted a review of the literature on the effects of various single media on learning. The results of these studies may be useful pointers but are not necessarily generalizable to multimedia environments.

2.3.2 Multimedia Technology in Higher Education

As with many innovations, primary and secondary education continue to make more progress in the incorporation of multimedia technology in the curriculum than higher education (Sammons, 1993). In a study done with K-12 teachers, Huang (1994) found that there is a negative correlation between grade level taught and technology use. This can be extrapolated to higher education where it can be inferred that the level of technology use in the classroom is minimal. Notwithstanding, there is evidence that multimedia technology is being used in research laboratories, especially in the Natural Sciences. However, many instructors have yet to explore its pedagogical potential in the classroom. While many faculty members are of the opinion that multimedia instruction is valuable, in practice, they favor the traditional modes of instruction. Several universities have established Multimedia centers with adequate support for faculty members who are interested in the use of the technology in their classrooms. The major problem of such a centralized approach is that of getting instructors interested in using the technology. A centralized approach such as the mandate given by the Kentucky Education Reform Act (KERA) of 1990 stipulating that schools incorporate technology to change the way children are educated in their K-12 level schools will be difficult to implement in higher education because of the respect for diversity and academic freedom in such institutions.

Punt (1994), in her study with 163 student teachers who had completed a computer integrated course, found that hypermedia was their third option among eight possible ideas, tools, and teaching strategies which they were most anxious to use in the classroom. It was third only to the use of educational software and Word-processing. After about one and a half years of teaching, 35 of these 163 new teachers rated hypermedia third again in courses that they have been able to use in their classroom after their training. Interestingly though, many of these new teachers expressed the concern that they had difficulty implementing what they had learned because they could not visualize how to put in practice the concepts and skills learned in the course. Why could these new teachers not put those concepts and skills into practice? They were taught what they could do with the technology, but possibly had never been provided with exemplars.

The need for the use of exemplars in teaching student teachers was recognized by Woodrow (1994) in designing a practical, hands-on introductory course on the integration of computer technology into secondary Science instruction at the University of British Columbia. Some students in this introductory Science Education 412 course prepared elements of the software packages used in the Astronomy 101/102 tutorial sessions that constituted part of this study.

Many of the present generation of university professors were not taught with multimedia especially in higher education. Most of them teach in a strict transmissive manner-the way they were taught. How could they be convinced of the desirability of changing their 'tried and true good old methodology'? Technological innovation could be threatening to the instructor. Classroom norms may change due to the exploration of new ways of doing not just old tasks but the exploration of new ones. Such changes create an inertia that needs to be overcome if innovation is to take place.

Midoro (1993) noted, "In Education, multimedia systems should not be conceived as new systems for doing old tasks, but as a new class of systems which open up new possibilities." While agreeing with this notion, the starting point is probably doing old tasks differently as a springboard for the exploration of new ideas. The prospect of opening up new possibilities can be frightening though. Therefore the readiness of the instructors to deal with such new possibilities is crucial. It is interesting for instructors to know the kind of possibilities multimedia offers in contexts similar to their own. Hence this case study could be useful as personal resonance for any higher education instructor planning a similar kind of innovation.

The various capabilities of multimedia technology discussed previously contribute to making it attractive for Education. Some of the areas in which multimedia is currently being used in higher education include:

- The exploration of multiple classroom environments with the use of video within the context of multimedia (Edyburn et al. 1994; Goldman and Barron, 1990).

- The use of cases in presenting different scenarios and asking students from different classes to comment on those scenarios. This is useful especially for student teachers (Abell et al., 1994).
- Computer-based Science Education instruction for student teachers (Woodrow, 1994).
- Multimedia supported data bases about the faculty and programs of a school. These data bases combine visual, audio, and textual data giving a profile for each faculty member. These data bases are useful for people who want to know the research areas of faculty members (Marcinkiewiczx, et al. 1994).
- Research tools for multimedia ethnographers as well as for students researching into various issues as school projects (Goldman-Segall, 1993).
- Multimedia enhanced distance education programs (Valmont, W. 1994).

Multimedia presentation software is now available to replace the use of slides and transparencies. Powerpoint is currently the most popular one and is available for the IBM and Macintosh computers. Murphy (1994) gave an overview of the capabilities of five software packages (see Appendix A), which are useful for the implementation of computers in instruction. In terms of the time investments required of the instructors and students, the advantages of using these programs over the regular curricula and the potential learning outcomes and benefits of the integration outweigh the time investment.

Like Freeouf and Flank (1994), this study took into consideration the notion that "successful change is contingent upon easy access, regular training, support, and opportunities to test and incorporate new skills and products in personally and contextually meaningful ways" (p.172). Hence the current study was a collaborative enterprise between researcher, technicians and the instructor. The Multimedia Instruction Laboratory (MILab) at UBC provided some of the training, support and opportunities needed for the instructors in the Department of Astronomy.

2.4 SUMMARY

In this chapter, three interrelated bodies of literature were reviewed and analyzed as they apply to this study. The first section started with an introduction to the concept of innovation. The various types and processes of educational innovation were then identified with a view of situating this study.

In the second section, a review of studies involving the assessment of technological innovation was presented. These studies presented the need for a holistic assessment of technological innovation thereby providing the rationale for using a case study research strategy for this study.

The final section started with an introduction into the concept of multimedia. Next was a review of evaluation studies done in the area of multimedia education within the last decade. Finally, the chapter ended with a review of studies on the use of multimedia in higher education. The need for increased multimedia innovation and its proper assessment in higher education was established. The next chapter describes the study's research methodology, that is, the procedures that were employed to implement this methodology and the rationale for selecting those procedures.

CHAPTER THREE

DESIGN AND METHOD OF ANALYSIS

3.0 INTRODUCTION

The purpose of this study was to investigate a professor's first attempt at incorporating multimedia technology as a teaching tool in a first year level Astronomy course. A qualitative case study research strategy was used for this investigation. According to Yin (1994), one of the over-riding principles important to any effort in doing case studies is the ability of the researcher to provide *explicit links* between the questions asked, the data collected and the conclusions drawn (emphasis mine). The purpose of this chapter is to describe and provide a rationale for the methods employed in the data collection and analysis. My trail as the researcher from the inception of the study to the conclusions drawn from the study is mapped out in this chapter. To assist the reader in situating this study, the context of the study is presented, a brief background of the participants is given, and the two courses under study are well laid out. Since research is a disciplined and systematic inquiry, the concerns of validity and reliability of the study must necessarily be addressed. These concerns are addressed in this chapter and in the final section, the limitations of the study are presented.

3.1 CONTEXT OF THE STUDY

My advisor, Dr. Janice Woodrow from the Department of Curriculum Studies, and Dr. Greg Fahlman from the Department of Geophysics and Astronomy are involved in a joint multimedia project between the two departments at U.B.C. The project is funded by UBC's Teaching and Learning

Enhancement Fund. The principal goal of the project is to initiate the implementation of multimedia technology into a university setting for instructional purposes. One aspect of the project involves the development of multimedia packages by students in the department of Curriculum Studies for use as instructional materials in the Astronomy classes. Drs. Woodrow and Fahlman are interested in making the best use of existing technology to maximize student learning. They argue that in order to keep pace with the technological advancement, especially in the area of computer technology, the mode of instruction at the university should incorporate the use of this technology in teaching. The study documented in this thesis, is a subset of the bigger collaborative project between the two Departments.

3.2 THE PARTICIPANTS

The participants in this study were:

- Dr. Greg Fahlman, *the initiator* of the Astronomy 101/102 course.
- Dr. Jaymie Matthews, *the instructor* for the Astronomy 101/102 course in 1993/94.
- Four male *student volunteers* from the class.

3.2.1 The Course Initiator

After twenty years of experience as a university instructor, Dr. Greg Fahlman was of the opinion that with the increasing use of technology in many subject areas, it was time the Geophysics and Astronomy department started an introductory course that made extensive use of computers. Hence, Astronomy 101 and 102 were introduced in 1990 by Dr. Fahlman. Prior to this study, the laboratory component of the course was the focus for microcomputer based instruction. Dr. Fahlman taught the two courses for two years after their inception. When the possibility of using multimedia technology in the lecture component of the course arose, Dr. Fahlman was interested in its implementation. However, in the fall of 1993, Dr. Fahlman went on a sabbatical leave, and Dr. Matthews was asked to teach the two courses.

3.2.2 The Instructor

Dr. Jaymie Matthews has about 13 years of teaching experience, most of it as a graduate student. He had redesigned the laboratory portion of Astronomy 101 and 102 with the assistance of Mr. Phil Hodder, a graduate student from the Department of Geophysics and Astronomy in 1991, and supervised the laboratory portion of the courses. When this study was conducted, Dr. Matthews was in his second year of teaching at UBC as an Assistant Professor. He was also the instructor of Astronomy 101 and 102 as well as supervisor for the laboratory sessions with the assistance of graduate students.

3.2.3 The Student Volunteers

The interview data were obtained from four male students in the course. At the beginning of the term, the instructor introduced me to the class. Subsequently, I addressed the entire class at the beginning of each term and at each of the tutorial sessions that took place during the term, told the students the purpose of the study, and asked them to volunteer for interviews. The condition of the interviews were defined as follows:

- participants would be anonymous.

- . participants were free to stop the interview at any time or decline to answer any questions if they were not comfortable with the questions.
- participants were free to choose the venue for interviews.

During the first tutorial session for the course which lasted for about one and a half hours, the instructor reviewed all the topics that had been covered so far in the course and asked for the students' feedback and questions. He also made extensive use of multimedia technology during this session. This tutorial took place a few days before the mid-term examination. At the end of this first tutorial session for the course, one male student walked up to me and said that he wanted to comment on the use of the multimedia technology. The other three students were asked if they would consent to an interview which they readily did. The students were interviewed at different times during the year. Only one male student refused an interview. Throughout this thesis, the following pseudonyms are used for the four male student volunteers, Alfred, Brad, Cal and Don.

Each of the four student volunteers were 'formally' interviewed once with each interview lasting for about an hour. These formal interviews were videotaped. In addition to these formal interviews were informal talks with these four students as well as other students throughout the year. These talks took place sometimes after classes, during laboratory sessions and after, as well as after tutorial sessions. The information obtained from such talks were considered part of the data for this study. Three interviews took place after the tutorial sessions that were held by the instructor at different times during the year, while the interview with Don was held after a laboratory session which was held towards the end of the second term, where the use of the multimedia was incorporated.

Female students constitute about 30% of the total number of students in the course. One female student consented to being interviewed for only five minutes she said, and declined to either being videotaped or audio taped. Unfortunately, she answered all the questions with a monosyllabic 'yes' or 'no'. However, I had 'informal talks' with about six female students throughout the year. even though they all refused being videotaped. Their opinions regarding the technology were similar to the views of the four volunteer male students.

Further discussions on the students' interviews are presented later in this chapter.

3.2.4 The Courses

Astronomy 101 and 102, are two introductory Astronomy courses at U.B.C. The University of British Columbia 1993/94 Calendar described Astronomy 101 as "Introductory Astronomy I–Basic astrophysical concepts and observational techniques; recent observations of the Solar System; the Sun and fundamental properties of the stars. Prerequisite: Physics 11, Mathematics 12." Astronomy 102 was described as "Introductory Astronomy II– An introduction to astronomy following on from Astronomy 101. Topics include stellar evolution; the structure of the Milky way: properties of Galaxies; the large scale structure of the Universe. Prerequisite; Astr. 101."

During the period of obtaining this data, Astronomy 101 was taught during the fall term while Astronomy 102 was taught during the winter term. The courses are three credits each with 101 being a prerequisite of 102. Many students from the Faculty of Arts are required by the university to pass at least one three-credit Science course in order to graduate. Many students from the Faculty of Arts choose Astronomy 101 to fulfill that requirement.

In the fall term of 1993, eighty-seven students registered for Astronomy 101 and thirty-one students for Astronomy 102 in the winter term. These students ranged in level from years one to four and were from different departments at U.B.C. The recommended text and laboratory manual was the same for the two courses. The lectures for the two courses were held in Room 1 at the Woodward building, and during the same time slots, 12:30-1:30 p.m. on Mondays, Wednesdays and Fridays. Each student was required to choose a two-hour laboratory time slot in the week. There were four laboratory groups for Astronomy 101 and three for Astronomy 102. The tutorial sessions were held on weeks when one of the laboratory sessions was lost to a public holiday. These sessions were held during the remaining laboratory times that week to ensure that none of the laboratory groups lagged behind in their laboratory work. Four tutorial sessions were held in the session, two each term. All the tutorial sessions were observed for this study.

3.3 DATA COLLECTION

The major sources of data for this study were interviews and observations. The course outline as well as the course evaluation forms were the other minor sources of data as outlined in chapter one. The data was collected from the summer of 1993 to the fall of 1994. A year was allowed for the data collection in order to:

- give a natural closure to the study by being on the research site for the duration of the two courses, thereby increasing the reliability of the study.

- minimize stress and inconvenience to the instructor by being aware of the instructor's busy schedule and other demands placed upon him.

The research design was strengthened by building a longitudinal component into the study through the following procedures:

- Eliciting from the instructor, his goals and aspirations for the course at the beginning of the term.
- Observing the instructor to see how he worked towards those goals and what obstacles he encountered.
- Allowing the instructor to talk about the process throughout the term.
- Eliciting from the instructor his reflections about the whole process towards the end of the term, especially with reference to his initial goals and aspirations.

3.3.1 Observations

The observation activities employed in this study were two-fold. First, the instructor's preparation activities for the use of the multimedia in the class were observed. Secondly, his teaching in the classroom with and without the technology was observed. The observations were used to cross reference the data. These field notes described the instructor's words and actions in those settings as well as some of the students' words and actions in the classroom setting.

My role as the researcher in this investigation was that of an observer as participant. This role definition was based on Merriam's (1991, p.92&93) distinction among four categories of observation.

1. Complete participant.

2. Participant as observer.

3. Observer as participant.

4. Complete observer.

As an "Observer-participant", the observer activities were known to the instructor and students and any participation in the group was secondary to the role of being an information gatherer. Taking on an observer as participant role is recommended by Yin (1994) and Marshall & Rossman (1989) who claim that a degree of participation is essential in order to conduct good observations. The participant activities were mainly restricted to sitting in the class with the students, attempting to understand the concepts being taught, and asking questions for clarification of the concepts during the class, like any student would. However, I was not under the same pressure to adequately understand the concepts being taught as the students since I did not have to do assignments, or write the examination. Hence this puts a limit on my participant's 'hat'.

Formal observations were done both when the instructor made use of the technology, and when he did not. Since this study was about a new technology, "observations of the technology at work are invaluable" (Yin, 1994). This variety of settings, roles and audiences allowed access to the instructor's ideas in different contexts, thereby increasing the credibility of the findings with respect to the instructor's ideas and actions. I attended all the four tutorial sessions that were held during the duration of the two courses. I documented and videotaped all the observations of the classroom interactions that related to multimedia as much as possible.

3.3.2 Interviews

The interviews were conducted using open-ended, semi-structured interview schedules that explored various themes. This procedure allowed the interviewees' perspectives to unfold during the interviews by letting them tell their story, rather than having their answers prescribed by my views. The interviews were allowed to flow more like a conversation, (albeit with a purpose) with the interviewees doing most of the talking. All interviews were conducted at a time and venue of the interviewees' choice and were videotaped with the interviewees' consent. The interviews took place in environments that were considered threatening neither to the interviewees nor to me.

3.3.2.1 Instructor's interviews

The interviews conducted with the instructor were in two broad categories. The *first* category focused on the preparations involved in using the technology, how he hoped to use it and what he intended to accomplish with the technology in class. The *second* category was reflective in nature. It gave him a chance to reflect on what he did in class and what he thought that he had accomplished, and what he would do differently in the future. I also had a chance to clarify with him some observations which were not understood, as well as to obtain insight into those things that could not be directly observed (i.e., his intentions, purpose and feelings).

There were four in-depth interview sessions with the instructor during the innovation process. The average time for the interviews was one hour. Interviews were held at the instructor's office. The focus of all the interviews was on the interpreted experiences of the instructor, and his explanations of what was happening to him regarding his exploration of the technology. In each interview there were themes to be explored, but the specific questions were allowed to flow with the course of the conversation. In many cases the instructor commented on questions which he anticipated that I would ask. The instructor appeared to be very enthusiastic and was always willing to talk about the innovation.

The first interview with him was the preliminary interview. This was held at the beginning of the fall term of 1993. The purpose of the interview was to elicit the instructor's background, his goals and aspirations with particular reference to the use of the multimedia technology for Astronomy 101/102 during the 1993/94 academic year. The second interview was aimed at obtaining insights into the instructors feelings at that time regarding the innovation in which he was involved, as well as find out how things were going for him, what changes he had to make or would make, what things were working well for him and those that were not. This interview was held towards the middle of the 1993 fall term after the first tutorial session. The third interview was held at the beginning of the winter term of 1994. Information regarding his reflections about how the fall term went for him regarding the innovation were collected as well as his goals for the winter term regarding the use of the technology. The fourth interview in which the instructor's overall impressions of the innovation were sought, took place in September, 1994. The study was debriefed with the instructor during this final interview, and the departmental instructor and course evaluation forms completed by the students were also collected at this time. This final interview was held in September because of the summer holidays.

In addition to the interviews with the instructor, I had informal conversations with him many times during the course of the year about the innovation. Much new information, and clarification of my understanding of the instructor's use of multimedia were obtained through those talks. These talks took place at various locations during his laboratory sessions with the students, after his Astronomy 101/102 classes, as well as during some of his sessions with Mr. Doug Bilesky, the graduate student in Curriculum Studies who helped design the multimedia packages that were used in the tutorials. Engaging in dialogue with the instructor throughout the year, enabled me to have an understanding on the instructor's critical thoughts about the innovation project. I was also able to observe shifts in his decisions regarding the use of the technology in various classroom situations.

3.3.2.2 Students' Interviews

Since the students' perspectives were an integral part of this study (research question 2), the interviews with them probed their general impressions about the use of the technology. They told their stories about what went on for them in different classes regarding the technology. These interviews took place immediately after the tutorial sessions and after classes in which the instructor made use of the multimedia technology. As each interview proceeded, I chose to follow closely the interviewees' pauses, and intonations and used them as clues to gather and authenticate data as they were collected.

3.4 MANAGING AND RECORDING DATA

Data records were in the form of field notes, interview transcripts and document analysis notes. Transcription of the videotaped interviews began immediately after each interview by me. Field notes were written immediately after each observation based to some extent upon data recorded during the observations. Pseudonyms were used for all the students in order to maintain their anonymity.

The data were annotated thus:

On the top right hand corner of each document were the date and code for the kind of information collected. The following letters were used to represent the corresponding kinds of information.

•J	Journal entries.
•I	Interviews
•OM	Observation of a multimedia lesson.
•OC	Observation of the class without multimedia.
•OT	Observation of the tutorial class.
•OL	Observation of the lab. session.

Below are examples of coding patterns used in data records:

•I931209 Alfred	Interview with Alfred on 9th Dec. 1993.
•OC931102	Observation of the class without multimedia set-up on 2nd Nov. 1993.

3.5 DATA ANALYSIS

Data analysis "involves working with data, organizing it, breaking it into manageable sized units, synthesizing it, searching for patterns, discovering what is important and what is to be learned..." (Bogdan & Biklen 1982, p. 146). Bogdan & Biklen (1982), refer to this process, when started during the data collection process, as "analysis-in-the-field mode" while Lincoln and Guba, (1985) called it the constant comparative method of analysis.

This constant comparative method of data analysis was used in this study. The formal or final analysis started at the end of the data collection. The use of the constant comparative method of analysis allowed the hypotheses to emerge from the data, rather than testing hypotheses arising from *a priori* theory. To avoid the danger of pouring the data into pre-designated boxes, the categories were allowed to emerge. In addition, given that this study was an exploratory study of an innovation process, it was best to select the appropriate data and analyze for emergent categories. Emerging hypotheses were tested for all negative cases by searching through the data, challenging the hypotheses and looking for larger or alternative constructs where necessary (Marshall & Rossman 1989, p.118).

The data analysis process consisted of four levels of 'transformations', (Novak and Gowin, 1984):

1. Transcription of all the videotaped interviews and observations.
2. Identification of responses related to the same subjects to form categories.
3. Identification of similar categories from the different sources of data.
4. Development of themes from similar categories to form trends and patterns.

3.5.1 Transformations

The *first* level of transformation was the transcription of all the interviews. Each interview was transcribed verbatim from the videotapes. The transcription started the day after each interview. This procedure was adopted in case the interview was not well recorded or, if there was a technical fault with the equipment, my memory from the interview was still fresh and I could recall highlights of the interviews. Fortunately there were no technical glitches, and all interviews were well recorded. The observation field notes were also written immediately after each observation was conducted.

The *second* level of transformation involved the identification of similar components, especially those that occurred longitudinally from the instructor's interview transcripts. The data was searched for responses that were related to the same subject or similar responses. For example the instructor talked about the use of software at the beginning, middle and end of the term. Hence, issues related to the use of software during the innovation became a category.

The *third* level of transformation involved the identification of similar categories from all the different sources of data. For example, what did the students say about software, and what did I observe about the use of software during the innovation? Evidences from all these sources were then used to juxtapose the data from the instructor.

The *fourth* and final level of transformation was the identification of similar categories to form themes. These themes were categorized according to dominant trends and patterns. Claims emerging from the study were based on the analysis at the second, third and fourth levels.

3.6 RECIPROCITY AND ETHICS

Marshall & Rossman (1989 p. 63) suggest that "in negotiating access, researchers might need to offer rewards or benefits to motivate participants' cooperation". Hence, the final report of the study was made available to the Department of Curriculum Studies and Department of Geophysics and Astronomy. I have also offered that some of the findings from this study could be used as supporting documents in the application for future grants for the two departments. On the part of the student volunteers, they have finished the course and some of them have left the university, but they were all invited to contact me through the Department of Curriculum Studies to obtain a copy of the thesis.

In all interactions with the participants in this study, guidelines promoted by the UBC Ethical Review Committee were followed. In order to ensure that a good collegial relationship was maintained with the instructor, a debriefing session was held with him. During this session, the instructor was asked to comment on his feelings about how the study was conducted, especially with regards to my role as the researcher. The instructor expressed his satisfaction with the conduct of the study. Hence, there was an amicable closure to the interviews with the instructor.

3.7 CRITERIA OF SOUNDNESS

In any research work there is concern for internal and external validity, reliability and objectivity. However, in qualitative research work, these concerns are often defined differently than they are in quantitative research Guba 1981 (cited in Lincoln & Guba, 1985). Guba suggests the term "credibility" for construct validity, "transferability" for external validity or generalizability, "dependability" for reliability and "confirmability" for objectivity or internal validity. Yin, (1994) however, keeps the terminologies of internal, and external validity, reliability and construct validity. Both sets of terms will be used in addressing the criteria established for ensuring the soundness, i.e., the trustworthiness, of this study.

3.7.1 Credibility/Construct Validity

In establishing credibility, the goal is to demonstrate that the participants and events were accurately identified and described (Marshall & Rossman, 1989 p. 145). In accomplishing this, Lincoln & Guba (1985) recommended "prolonged engagement", "persistent observation", "triangulation", "peer debriefing" and "member checks" as important criteria.

Prolonged engagement is deemed necessary in order to be able to sufficiently understand the context and recognize "distortions which might creep into the data" (Lincoln & Guba 1985, p. 302). These distortions may stem from misunderstandings of the actions that were observed. By being on the research site for a long period and possibly observing the reoccurrence of various actions, the researcher may gain more accurate understandings of the different phenomena. I was on the research site for the duration of the two courses (September 1993 to April 1994). This prolonged interaction helped in collecting credible data as well as in building trust with the participants.

Persistent observation requires that the researcher be attentive to all relevant aspects of a situation. While prolonged engagement provides scope, persistent observation provides depth (Lincoln & Guba, 1985). This was established by my presence in all the tutorial sessions that were held during the year, about three quarters of the class sessions, and about a third of the laboratory sessions of the two courses. In addition to the interviews, there were many informal talks with the instructor and the students during the period of data collection. In some of those talks, issues were clarified and better insights were gained into some of the actions that were observed.

Triangulation involves the collection of data from different sources in order to verify the findings. It involves "the use of multiple sources of evidence, in a manner encouraging convergent lines of inquiry" (Yin 1994, p.

35). The use of multiple sources of evidence enhances the scope and clarity of the study. Thus, any finding or conclusion based on such study is more convincing and accurate because multiple sources of evidence essentially provide multiple measures of the same phenomenon. According to Goetz and LeCompte (1984), triangulation assists in correcting bias that may occur when the researcher is the only observer of the phenomenon being investigated. In this study, data were collected through my interviews with the instructor and students, observations, and document analysis concurrently. *(See page 5 of Chapter One.)* The interviews with the instructor were spread throughout the session. This enabled me to obtain insights into the reasons for some of the instructor's actions which I observed especially as they related to the decisions that he made regarding the use of the technology before and after he took those actions in the class.

Member checks involves the reasonable and accurate representation of the participants' views. In this study, it was important to accurately and reasonably represent the participants' views. Hence a number of informal checks were undertaken during the study through informal talks with the instructor and the students. In addition to this, the final draft of the thesis was read by the instructor and the professor who initiated the course before the thesis was defended. They both commented that they were not misrepresented in any way.

3.7.2 Dependability and Confirmability

The aim of dependability or reliability is to minimize the errors and biases in a study. How reliable was the instrument? In a qualitative study, the researcher is the instrument. This question was partly answered during the debriefing interview with the instructor, in which the instructor was asked to comment on my role as the researcher during the study especially during the interviews. The instructor's only negative comment, according to him, was that I allowed him to talk too much about the innovation process. He felt he could have been cut short. I do not consider this comment as being negative since the goal of a qualitative researcher is to allow the interviewees perceptions to unfold without bias. It would have been difficult to ensure this 'non-bias' if the instructor had been cut short during the interviews.

Another method of enhancing the reliability of the qualitative researcher as the research instrument is by the use of a reflexive journal. Lincoln and Guba (1985) described a reflexive journal as:

> ...a kind of diary in which the investigator on a daily basis, or as needed, records a variety of information about self (hence the term "reflexive") and method. With respect to the self, the reflexive journal might be thought of as providing the same kind of data about the human instrument that is often provided about the paper-and-pencil or brass instruments used in conventional studies. With respect to method, the journal provides information about methodological decisions made and the reasons for making them -- information also of great import to the auditor. (p. 327).

Hence the use of a reflexive journal was made an integral part of this study.

Reliability is also concerned with the extent to which a study can be repeated and result in the same findings. To the extent that replication is possible, it can be claimed that the instrument of experimentation was indeed reliable. According to Yin (1994), if two or more case studies are shown to support the same theory, replication may be claimed. Since this study is an exploratory case study, one suggestion for further work is to try replicating this study with the aim of generalizing it to a theory. To ensure the possibility of replication of the study, Yin (1994) and Merriam (1991) suggested a detailed documentation of the research work. The detail presented in this thesis was predicated upon these recommendations.

Furthermore, Lincoln and Guba (1985) suggest the use of an audit trail which Yin (1994) called "a case study database" to ensure reliability of qualitative studies. This audit trail is a formal assembly of evidence distinct from the final case study report that provides explicit links between the questions asked, the data collected, and the conclusions drawn. Yin (1994) suggests that this should be kept with utmost care and attention as one would give a financial audit and should be available for review at all times. This procedure is recommended to ensure that all possible constructs were considered, and care was taken in the generation of the sub-categories, categories and themes during the analysis of the data. For this study there were four levels of the audit trail. The *first level* consisted of all the video master tapes for all the interviews as well as for the observations. The *second level* of audit trail consisted of the verbatim transcriptions of all the interviews. The *third level* was the identification of similar responses by the use of different colors of highlighters. Different quotes were then extracted to form sub-categories, categories and, subsequently, themes at the *fourth* level. These different categories were pulled out from the transcripts to form another word processing document, which were revised and re-revised.

All aspects of this case study data base were shared by my peers and the thesis committee, and there was a consensus that the links made between the questions asked, the data collected and the inferences drawn were acceptable.

3.7.3 Transferability/Generalizability

Transferability or generalizability is concerned with establishing the domain to which a study can be generalized. Case studies, like experiments, are generalizable to theoretical propositions. Yin (1994) refers to this kind of generalizability as "analytic generalization". Quantitative research work on the other hand, relies on statistical generalization in which generalizations are made to populations and universes. These are two different yet valid kinds of generalizability. While scientists hesitate to generalize to a scientific theory from a single experiment, case studies researchers face a similar kind of hesitancy in generalizing to a theory from a single case study. Unlike the use of samples for statistical generalizations, cases are not sampling units. Hence the use of multiple case study research method and replication of single case studies for analytic generalizations were highly recommended by Yin (1994).

In a qualitative case study, the *first level* of generalizability or external validity is for the researcher to provide an index of transferability, i.e., a data base that makes transferability judgments possible on the part of potential appliers (Lincoln & Guba 1985). Teachers construct their own meanings, and these meanings vary from context to context. The goal in qualitative research is to understand the particular in depth, not what is generally true of the many (Merriam, 1991). This study, therefore, reports the activities of an instructor in attempting innovation using multimedia technology. In order to provide a useful framework for the readers who may be interested in seeking applications to their own circumstances, enough detail regarding the method used and the circumstances involved are included.

A *second* level of generalizability is "Case to Case" generalization (Yin, 1994). At this level, claims are made to support the notion that for a context similar to that in which a case study was performed, the researcher would claim that the same findings or knowledge claims would hold.

In the context of this study, the first two levels of generalization by Yin (1994), that is, transferability and case to case generalizations are claimed. The previous discussions and details regarding the manner of the conduct of this study in a contextually rich fashion, especially with regards to construct validity, reliability and internal validity of the study serve to support this claim.

The *third* level, is the generalization to theory as already discussed earlier in the first part of this section.

3.8 LIMITATIONS OF THE STUDY

The most significant limitation to the study was that the processes involved in technological innovation cannot be limited to the interviews and my observations as a researcher. For example, if the professor makes decisions about the innovation and discusses its effects with other colleagues within and outside his department, or at conferences etc., such information would be difficult to access and assess. Therefore, the study was delimited by collecting information only on campus activities specifically through interviews, observations and document analysis. The categories documented herein were the ones that emerged from this data and were deemed to be the most pertinent to the study.

The second limitation of this study was that of my presence in the classroom as an observer. Being an observer in any classroom is interventionist in nature. No longer was the classroom the 'normal' Astronomy 101/102 classroom. To reduce the distortion in the atmosphere of the class, I sat with the students and not just in a corner taking notes. Being a participant-observer improved trust and the building of a collegial relationship between the instructor and me, as well as with the students. I sat in the class and asked questions from the instructor during the classes for clarification of certain concepts that he was talking about, just like any student would. Sometimes during laboratory sessions, I sat in groups with the students to discuss the tasks. This helped in easing the tension created by my presence in the classroom and enhanced both the participation and observation processes desired for this study.

The third limitation is related to the second one. This limitation arose from the use of a video camera during classes, laboratory and tutorials. The use of a video camera also altered the setting. To ameliorate the situation, I attended the classes and tutorials for a couple of weeks before bringing the camera in. This procedure was adopted to ensure that the instructor and students did not have to adjust to too many things at the same time. Furthermore, I did not take the video camera to all the classes.

3.9 SUMMARY

In this chapter, the processes of data collection and analysis in this study have been explained. Attention was paid to details regarding the context in which the innovation was conducted so that insights could be gained into innovation practices involving the use of multimedia technology in a first-year level university course. Concerns regarding the quality of the study were also addressed and finally the limitations of the study were discussed.

CHAPTER FOUR

DATA PRESENTATION

4.0 INTRODUCTION

In this chapter, the story of the exploratory innovation is presented. To assist the reader in understanding the context of the study, a brief background of the instructor's views on teaching and learning are presented in the first section. In the second section, the issues that emerged from this study involving innovation with the use of multimedia technology in Astronomy 101/102, are discussed under two major themes. Both themes encompass a longitudinal component because the data was collected over a considerable period of time, i.e., from the beginning of the session in September to the end of the session in April.

4.1 INSTRUCTOR'S VIEWS

Like many teachers, Dr. Matthews has his own conceptions of good and bad teaching. During an interview in September, at the beginning of the term when this innovation process was about to start, Dr. Matthews' metaphor for teaching/learning was that teaching was like *"a two-way street."* According to Dr. Matthews, he does not want to spoon feed the students, rather he sees his role as that of a facilitator, entering into partnership with the students. He sees himself as one who gives the students the tools and expects them to build certain basic things with those tools:

> *For example, on assignments often they [students] are not asked to regurgitate things in class, [rather] they are asked to combine various pieces of information -of principles- that they've learned*

in class and apply them... it turns Astronomy into a detective game for them [the students].

To Dr. Matthews, Astronomy is an example of how Science works, and fortunately, a discipline in which the students are inherently interested.

...Astronomy has an appeal to students, and it's something that they can share in. They can go out at night and look up at the stars... and so rather than showing some reaction in a test tube or talking about some physical principle by itself, we can relate it and show them how Science works, [that is] how we go from observation to theory to confirmation in things that are likely to take their interest and at the same time give them a sense of the philosophical and social importance of Astronomy.

This view of Astronomy is probably why he gives the students "*...some incentives either through rewards of marks or humor or entertainment value, or relating what they are doing to things of topical interest or to last week's episode of 'StarTrek: The Next Generation'.*" During classes, stories connected with Astronomy were very frequent. The students that were interviewed commented on the instructor's use of humor and storytelling, and how these make his classes interesting. In the students' course evaluation forms, about 90% of the students commented on the instructor's interesting ways of presenting the course material.

From the beginning of the innovation, Dr. Matthews' interest in the technology was obvious. He was willing to talk about it anytime with me. In conjunction with Dr. Greg Fahlman and Dr. Janice Woodrow, he decided to embrace this innovation:

...over the years in my conversations with Greg about Astronomy education here at UBC in particular we've always

bemoaned the lack of facilities and the fact that we're stuck ...with the chalkboard age and we'd like to incorporate all this technology. This was an opportunity for us to do it in our own backyard."

At the beginning of the session when this innovation started, Dr. Matthews' four goals regarding the technology were:

1. To incorporate multimedia technology as a regular component of Astronomy 101/102.
2. To expand the use of multimedia technology into other courses like Geophysics and Astronomy 310.
3. To use multimedia technology in departmental seminars. According to Dr. Matthews,*"...if we have guest speakers we can now tell them that if they have some stuff on computers that they'll like to show, they can bring along the diskette and they will be able to show it in their talks."*
4. To provide an example to the Department and the University of the possibility of using multimedia technology in other courses.

By the end of the course, most of these goals were realized. The use of multimedia technology became a regular component of Astronomy 101/102 classes and their associated tutorial sessions as an instructional tool. Instructors for the different sections of the Geophysics & Astronomy 310 course incorporated multimedia technology into their courses, in the winter term, with some input from Dr. Matthews. One of the instructors for the 310 course was Dr. Fahlman. Finally, attempts made by some faculty members to use the multimedia technology for the departmental seminars were initially impeded by some glitches in the hardware. The use of the technology for departmental seminars has since been successfully achieved. In addition Dr.

Matthews has since used the technology for public lectures at the planetarium and various other venues.

4.2 EMERGENT ISSUES

Two broad sets of issues or themes emerged from this study of the use of multimedia technology in teaching:

- *Practical issues*
- *Pedagogical issues*

Both themes were further subdivided into categories and subcategories. These sub-categories, categories and themes were constructed from the data in order to make reasonable and persuasive interpretations of the data. Figure 1, on the next page, shows a summary of the categories and subcategories that are discussed with respect to each theme. However, these emergent categories are interrelated and are not exclusive of one another.

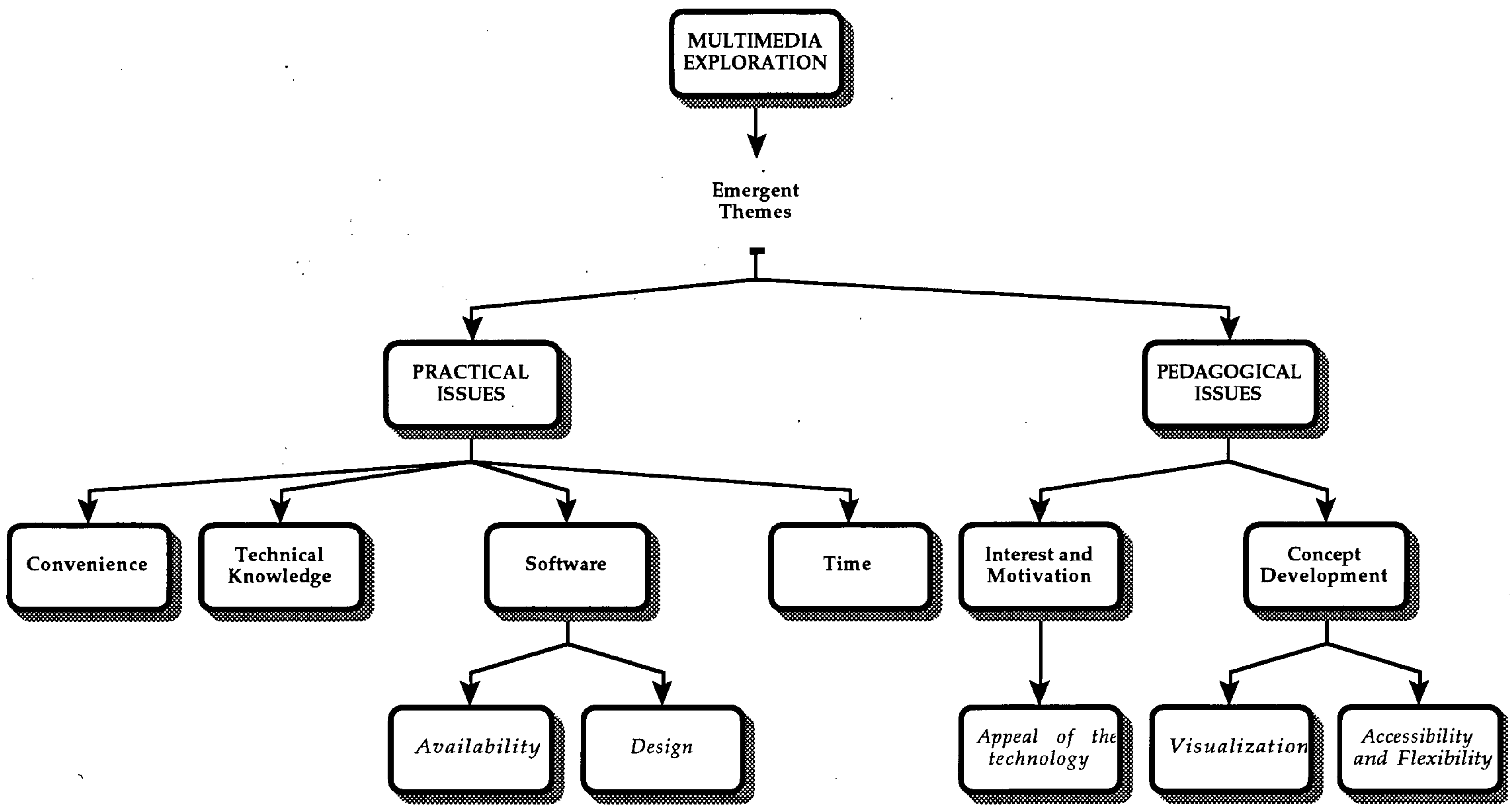

Figure 1: A Summary of the emergent categories of description

4.2.1 Practical Issues

Practical issues were related to the practicality of using the technology in Astronomy 101/102. These issues relate to the planning, organization and implementation procedures that were undertaken to incorporate multimedia during the innovation. Four categories involving the practical use of the technology were identified in this study:

1. **Convenience**: This category refers to the ease of utility of the multimedia hardware. This ease of use is discussed in terms of the location and infrastructure of the building in which the multimedia set-up was used.
2. **Technical knowledge**: This category is discussed in terms of the instructor's knowledge of how the hardware and software components of the multimedia set-up work.
3. **Software:** This category recounts the availability and design issues relating to the different programs and software packages that were used in the innovation process.
4. **Time:** This category addresses the time required by the instructor for the exploration of multimedia technology.

4.2.1.1 Convenience

Convenience was a major practical issue that came up in all the interviews with the instructor. The lecture theater where the classes were held is about a five to ten minute walk from the Astronomy building where the instructor's office is located and the equipment is stored. The necessity of carrying the equipment back and forth created a major problem, hence there was a limit to how much hardware could be safely transported. Furthermore, the Astronomy classes were held in one-hour slots three times a week. There were other classes before and immediately after the Astronomy 101/102 classes, hence, there was not much time for the instructor to set up and pack the equipment before and after classes.

These inconveniences had been anticipated by the instructor which was why the decision was made to use a laptop computer in the lectures. The inconvenience of transporting even the laptop computer and LCD panel was evident the first time the instructor used the technology in the classroom. He had asked the students to submit their laboratory notebooks that same day at the end of the class. What he did not anticipate was that he had to carry about eighty notebooks in addition to the lap-top computer, LCD panel and his own course notes back to his office. He did survive that ordeal, but, needless to mention, he did not ask the students to submit their laboratory notebooks after the class sessions again.

At the very beginning of this study, the instructor remarked that

> *...most of the lecture halls at U.B.C are not really very conducive to using the technology. There are only a few places on campus like the I.R.C building that seem relatively well suited to it. We may have some difficulty setting up and having the right kind of projection facilities, so it's a disadvantage for us because we are lecturers, hired gun lecturers. We go to other buildings, we don't get to stay here and so we have to carry all this stuff around...I don't see any immediate disadvantages other than just the mechanics of carrying things, setting them up and finding the room which is suitable for them where you can bring the lights down to the proper level and that sort of thing.*

As a result of this inconvenience, the instructor decided to limit the use of the laser disc player (which was much less portable than the laptop) to the laboratory and tutorial sessions which were held in the Astronomy building whereas the laptop computer and the LCD panel were used to display simulations and digitized material in the lectures. The following steps summarize the procedures taken by the instructor in order to minimize the level of inconvenience caused by the necessity of transporting the multimedia equipment.

1. Purchasing portable multimedia equipment.
2. Using only the laptop and LCD panel in the lectures to show simulations and digitized material.
3. Limiting the use of the laserdisc technology to the tutorial and laboratory sessions.
4. Digitizing some images from the laserdiscs to present in lectures.

These actions taken by the instructor were successful in reducing the inconvenience of transportation.

After a few occasions of using the technology in the classroom, the instructor commented,

> *...the laptop technology and the projection panel are clearly easy to use in a lecture environment as long as you are in a lecture hall which has good lighting control. You can bring the lights down to a reasonable quality [darkness]... so I think that's encouraging because many of the venues on campus where we might have to teach courses should present no problem [in] using the technology.*

At the beginning of the innovation, the instructor said that the issue of convenience was a major impeding factor to his teaching with the use of the multimedia technology. However, he overcame the inconveniences as much as he could as the innovation proceeded. Finally at the end of the innovation, the instructor felt that the issue of convenience was no longer a major impediment to the innovation process.

Once the instructor got the multimedia equipment to the lecture hall where he could use it, the next issue was setting up the equipment and getting it to work.

4.2.1.2 Technical Knowledge

Technical knowledge issues relate to the operation of the multimedia equipment. A few technical glitches were expected due to the instructor's minimal familiarity with the multimedia set-up. One of the technical glitches occurred during the first class in which the instructor used the multimedia set-up in Astronomy 101. Reflecting on this class about three days after the class during an interview, the instructor said,

> *Well, on Friday's class I used the projection panel. That's the one day in which I normally have only one lecture, and had time before and after, so I thought if I was going to do a test of this, this was the best day to do it. Because if things didn't work, I'd have time to try to fix it before or afterwards. ... As it turned out, the setup of the computer and the projection panel was very simple. I arrived 10 minutes before the class and everything was plugged in and running in about five minutes. A minor glitch is that there is an option: you can either see everything projected just on the monitor screen of the laptop or on the projection panel projected on the main screen or both. Unfortunately the 'both' option wasn't working, I had to configure to allow it to do both, and that didn't work and it turns out that the minor problem is that if the battery dies, It runs on the power from the*

outlet. But if the internal battery runs down, then when you start up the computer again it resets to its basic configuration, and the basic configuration doesn't allow you to project both at one time. So now I know: one, it's useful to try and keep the battery charged; two, now I have investigated how I can go into the setup and change that, so I can see on the monitor with the keyboard what's going on in the screen so that I don't have to type and look over my shoulders, especially in the dark.

After the instructor's first use of the technology in the class, he became more confident with handling some of the problems associated with the technology. Since the instructor was fairly comfortable with using computers, and only made use of the laptop computer and LCD panel in the lectures, he did not encounter any major technical difficulties in that environment. However, for the tutorial sessions, the laserdisc player was integrated with the rest of the equipment and it was the laserdisc player and controlling software that were new to him. Once, during the first term, the instructor commented that he was just using the set up like "a black box". The instructor's confidence with adjusting the various controls of the technology to suit his needs grew during the term as he explored the technology. Finally towards the end of the term, when the instructor needed to make adjustments in the settings he consulted the manual and tinkered with the various settings with increasing confidence.

At the beginning of this innovation, the tutorial packages were developed on the Macintosh platform. The instructor, however was most familiar with IBM computers, and the Astronomy PC laboratory for 101/102 was already based on such machines. Towards the middle of the term, the packages were converted from Hypercard on the Macintosh into Toolbook on the IBM, thereafter the instructor became more comfortable with using the packages. Finally, in the second term, the software development was done using an IBM computer. The instructor's knowledge of software development using Toolbook was limited, so, if he desired changes in the way the software was set-up, he had to talk with the developer, who then made the adjustments.

Before each tutorial session, the instructor had at least three meetings with Mr. Doug Bilesky, the graduate student from the Faculty of Education who developed most of the software packages which interfaced the computer and the laserdisc player. Some packages were custom-made by some students in the Science Education 412 summer 1993 class.

In the first meeting, the instructor met with Mr. Bilesky to discuss the kinds of things he would like to accomplish with the package, as well as the features that he would like to see included. The second meeting consisted of checking to see how much of the instructor's ideas were implementable in the package and to discuss necessary revisions that needed to be made. The final meeting was to show the instructor how the package worked, and to work through the package together on the computer which the instructor would use in the tutorial sessions. The packages were developed on Mr. Bilesky's computer. Since the packages were developed on one computer and used on another, Mr. Bilesky also used this meeting to adjust software settings to make the program run smoothly on the instructor's computer.

4.2.1.3 Software

Availability and software design features, were the two subcategories of issues relating to software use that emerged from this study.

Software Availability

During the class sessions, the instructor used the software that had been accumulated by the department for use in the Astronomy 101/102 laboratory. Some of the software packages could be adapted for 'lecture-style' teaching, while some were not deemed suitable for use outside the laboratory.

One major problem in the field of computer technology in Education is locating suitable software. This instructor was of the opinion that there exists ample suitable software, but"*...most of the simulation software that we have doesn't really seem to illustrate anything in any different way than I would do it in class to make it worth taking the projection panel...*" Despite this handicap, during the first term, the instructor did not actively search for appropriate software for the class, because, according to him, "*...I considered that part, last term in the lectures to be more of the test of the technology and its practical aspects ... than really exploring the full power of the educational potential.*"

During the second term, however, the instructor ordered some software which he thought was more suitable to the lecture environment and useful for illustrating different Astronomy concepts. Unfortunately, the software did not arrive in time for the instructor to be able to use during the second term.

For the tutorial sessions, the instructor used the software packages that Mr. Bilesky developed. The final tutorial package developed was on galactic morphology. When the instructor met with Mr. Bilesky after the package was developed, Dr. Fahlman, Mr. Phil Hodder, a graduate student from the Department of Geophysics and Astronomy who assisted in the development of the laboratory manual for Astronomy 101/102, and I were also in attendance. Everyone present at that meeting brainstormed on the different ways in which the package could be used. Everyone was pleased with the package on galactic morphology.

Towards the end of the second term, there was the possibility of using CD-ROM technology. A graduate student from the Faculty of Education developed and pressed a CD-ROM of Astronomical images. This graduate student was given a list of images that would be put on the CD-ROM. Because it was close to the end of the term, and most of the topics where the CD-ROM would have been useful were already covered, the CD-ROM technology was not used. The instructor's reaction to the CD-ROM technology was:

> *I'm really pleased that we are making inroads into the CD-ROM technology so soon in this project. Eventually, that will be of most use as opposed to the laser disc which is a little bit fixed to the building here or to the Education building. But with this now, the ability of having a CD-ROM unit, we'll be able to put laser disc images and presumably digitized slide images and some other media to a CD-ROM which can then be hooked up with the same kind of presentation package. Then we have the possibility of adding images as things are updated for making different CD-ROM and so on.*

Traditionally, slides have been used in Astronomy education as a major visual aid. There have been some problems with the maintenance as reflected by the instructor thus:

> *The slide collection in our department...is difficult to maintain and keep up to date. There is very little control over people who can go in and take the slides and never return them and don't sort them when they do return them. Many of the faculty have just given up on the departmental slide collection, and put*

together their own personal slide collections for their lectures. So this kind of system [CD-ROM technology] really will avoid most of the problems associated with that and once it's set-up will have fairly minimal maintenance to keep it up-to-date. Well this is the sort of direction that Dr. Fahlman and I are going. Our vision, a sort of 'pie in the sky' picture, is to have a kind of audiovisual educational workstation with CD-ROM unit, small computer and possibly a laser disc unit and slide digitizer. All of this in a location with a library of images in store, with some kind of software catalogue that makes it easy to find what you're looking for. Then the instructor can just go in there with the diskette, plug it in and basically pick and choose from the library which images he/she will like to use for this particular lecture, download them on the diskette. With the laptop computer and the projection panel, ... they also have the ability to show films and the still images. One can update the library because it's all digital and you can add things at will rather than having to get a new drawer as you get another stack of slides and resort all the numbers and re-label them.

Hence, for this exploration with multimedia technology, the instructor preferred the customized software he used to achieve a few but specific course objectives in the tutorial sessions, than using the commercially available software designed to achieve many but less specific objectives.

Closely related to the discussion on software availability, is the consideration of the design features of the software.

Software Design Features

Many design features of the software and presentation packages, such as the size and position of the text and images, as well as the speed of the simulations were beyond the instructor's control. These features were inherent in the packages and could not be adjusted by the instructor. One example occurred at a class he taught with the use of the multimedia

> *...when I brought the lights down, the images I think were quite visible. Some of the text is not easily seen from the back of the room, but I wasn't relying heavily on text in some of these things, and these programs weren't designed, custom-designed, for lecture purposes.*

To ameliorate this situation, the instructor's strategy was to be less dependent on the text in the program, and also in the future his intention was to be able *"...to set up some simulations that we intend specifically for projections in the classroom, so we can make extra large text or labels. "*

Another situation occurred during a tutorial session, when the instructor was caught a little bit off-guard because,

> *...when I got to the planets, Uranus and Neptune, I was accustomed to showing slides of the Voyager flybys and close-ups of these planets and of course the laser disc was made before those flybys occurred. ...the first time that I ran it, of course, I had forgotten that. So I was preparing to show these, then I realized that they weren't there. The second time I knew this so I adjusted the presentation accordingly. But that's always going to be a restriction with the laser disc.*

The instructor's strategy in dealing with the situation of an outdated laser disc was to inform the students of the restriction. When I asked the students that were interviewed for their comments on those glitches in the software, the students all felt that they could live with it.

During the innovation, the instructor moved from relying on software packages that were not very suitable for classroom purposes to using custom made packages. Towards the end of the term, even when the instructor had to use pre-made software packages, he was able to adapt them to suit his classes. However, for the design features which he could not adjust, the instructor supplemented the information given in the software and hoped for a time when all the software packages for the lectures could be custom made.

4.2.1.4 Time

At the beginning of the first term when this exploration started, it was necessary for the instructor to take extra time planning what to do, and when and how to incorporate the technology in the class. He also needed time to decide the appropriate software for use in the class. The first time he used the technology in class,*"...it was an hasty choice of what I did have on hand to try this [the technology] out..."* Three weeks into the first term he commented *"It's been a shame, I would have been able to use some things earlier in the course, but I was just too busy and it was too hectic to get everything set-up. "* The instructor's initial decision to limit the use of the technology to his Friday classes was related to the issues of time, and the added attraction of showing something different and colorful at the end of the week. This was one day which he did not have another lecture immediately before and after the Astronomy 101 class.

Commenting on his time input towards this exploration during the second term, the instructor said, *I guess when you are first trying it out, it takes a lot of time. You would go down some blind alley, so it probably took a little more effort and time than it would have if I had presented the course in a more conventional way. So you just have to be prepared for it. I'd say using the panel and the laptop doesn't really take any additional time. The additional time now is going out to look for new software and trying to keep in mind as you prepare the course. "Where can I use the technology?" We're not used to thinking in these terms ...It's taking less and less time.*

So, the initial time input required by the instructor decreased over the term as he became more familiar with the technology, therefore, time became less of a limiting factor.

Summary

In the preceding discussions on the categories that pertain to the practical theme of the use of multimedia technology, four categories were identified. These categories, for the most part, were outside the control of the instructor even though the instructor was able to do things that reduced the negative effects of these categories on the innovation process.

The next theme discussed relates to pedagogical issues.

4.2.2 Pedagogical Issues

While practical issues can often be considered to be a given, pedagogical issues are not. Pedagogical issues are mostly within the control of the instructor and relate to how the instructor uses the technology as an instructional tool by taking advantage of some of the attributes that are inherent in the technology, such as accessibility and flexibility and the appeal of the technology, in order to achieve the desired learning effects.

The issues of pedagogy and concept development (which are examined later in this section) reflect the teacher/student duality. While the instructor strives towards pedagogy in the class by adopting different modes of presentation of the instructional materials in part to motivate the students, and stimulate their interest in the subject matter, the primary goal is concept development on the part of the students. From the beginning of this innovation process, pedagogy was important to the instructor. Astronomy is an appealing course choice for many students. Enrollment figures are clear evidence of this appeal. According to the instructor, enrollment was restricted by the Department because of the limited numbers of computers they have for the laboratory activities, not by the number of students wanting to take the course. Both Arts and Science students enroll in this course. The instructor was interested in presenting the course content in different ways, such that all the students could benefit from the course. Two broad categories related to pedagogy as they pertain to teaching and learning identified in this study were:

- Interest and Motivation
- Concept development

1. **Interest and Motivation:** This category relates to the inherent appeal of, and students' fascination with the instructional materials presented with the aid of the technology as they affect the students' interest and motivation in the course.

Appeal of the technology relates to the uniqueness the technology offers as it affects interest and motivation. Also discussed in this sub-category is the appeal with the technology, i.e. the appeal of what pedagogically one can do with the technology, i.e. run simulations, access stored images, and highlight features with the technology. Using the technology gave the instructor an opportunity to present the subject matter in a non-traditional way. Therefore, for the students, technology provided another platform for the representation of Astronomy concepts.

This section will seek to answer the following questions:

- In what ways did the instructor strive to exploit the appeal of the technology in order to promote the interests of the students as well as motivate them?
- Did the students feel that they were motivated?
- Do I have any evidence to show that the students were motivated and interested in the instructional materials?

2. **Concept development:** The category of Concept development will be discussed in terms of the two subcategories, visualization, and accessibility and flexibility.

Visualization relates to the intention of the instructor to promote concept development by presenting the material in a visual format wherever possible. The instructor's use of different images to predict, observe and explain Astronomy concepts and phenomena, to the students are discussed. The resulting implicational factors are also considered.

Accessibility and Flexibility aspects relate to access to the technology, access to information via the technology, and flexibility in terms of random access to information as opposed to sequential access as it affects concept development.

4.2.2.1 Interest and Motivation

Paramount to the theme of pedagogical issues was the instructor's intention of motivating and keeping the students' interest. One way of sustaining the students' interest in the subject, according to the instructor, is maintaining his own interest too. The use of technology was perceived as one means of maintaining that interest.

> *Anything that allows you to try to teach something in a different way... keeps it interesting for you. After one teaches a subject essentially year after year after year, then one of the challenges isn't just keeping it interesting for the students, it is keeping it interesting for yourself, because if you're bored up there then that's going to be transmitted to the audience.*

The instructor was concerned about appealing to the varied interests of all the students in the course, as diverse as they were. To obtain this result, he felt that it was important to use as many varied ways of teaching as he could. The multimedia technology was another teaching tool for the instructor. At the beginning of the first term the instructor said,

> *...I think from the point of view of keeping the students' interests ... this [the technology] certainly helps. I noticed that [in comparison to] last year with the labs, (having had to teach the celestial sphere with the traditional old plastic and cardboard models and then seeing how the students reacted to the full-color SkyGlobe software) it's fun for them. It's exciting and that helps make it easier for them to learn. So I think that's a big factor...*

The course was an elective not a requirement for all of the students. The instructor described Astronomy as an inherently interesting subject, one in which many people are interested. The four students that were interviewed shared this view. All four of them related Astronomy to outdoor activities and real life, and were curious about Astronomy. At the end of the course, after asking some students if their sense of curiosity was now satisfied, they all felt that they were now even more curious about other aspects of Astronomy.

All the students that were interviewed spoke about motivation. This is best typified by an excerpt from the interview with Alfred, a second-year student in the Department of Forestry. Alfred was spending a year at U.B.C as part of an exchange program that his university has with U.B.C. English is not his first language. During the interview, Alfred used a lot of gestures and facial expressions while he was speaking which cannot be textualized in this thesis. Alfred was interviewed after the first tutorial session held in middle of the first term. For Astronomy 101 and 102, the instructor used teaching aids like slides, transparencies, multimedia displays and video. Alfred considered those teaching aids to be very important, because they helped him to be motivated. In courses where the instructors do not use teaching aids, Alfred thinks that the students lose their motivation.

Alfred: *Teachers have to be careful so that we don't lose our motivation. In many courses which are not interesting to us, we are losing our motivation. So we just sit in class and try to pass exams, but what kind of Bachelors' [degree] do we get? (Pause.)*

Ajibola: *Yes, what kind of Bachelors' does one get? That's a major concern isn't it?" (In a rather low voice, thoughtfully)*

Alfred: *Yes it is. Teachers have to do a lot of work so that we don't lose our motivation. If we don't understand the stuff, we lose our motivation. So the use of audio-visual materials can help our motivation in the material that we are learning.*

So, instructors must ensure that motivation is maintained amongst the students. During the term, the instructor was able to verify that the students were indeed being motivated by the use of the technology.

It [the technology] certainly heightened their [the students'] interest in that they are seeing something different. All the new kind of technology up front. [in class] A number of students came down [to the front of the class], and were intrigued by the software itself. They thought it was interesting and they wanted to know whether it was available commercially, and could they buy it or could they get a copy? It was also an opportunity to let everybody know that this particular package was available in the laboratory on their menu. We don't use it in the lab, [for a project] but it is there as a possible tutorial aid, and so this was a good chance to show them, that this is the kind of thing that exists if you're curious or if you want to reinforce some concepts from the lectures and lab... And this week, I noticed a marked increase in the number of people who were actually calling up Orbits [a solar system tutorial program] in the lab after they finished their measurements on the regular project. I've noticed about four or five people this week, who started Orbits and were looking through the different menus on planets and so on. So I think, just from the point of view of stimulating curiosity and *also making students aware, its better than just telling them, well we have this tutorial package on the computer, which sounds kind of intimidating, "Oh! We have to use the computer again. It's probably some dry boring lines of text..."*

I also observed that the students were interested in the technology. After classes in which the instructor had made use of the technology, students were often seen gathering around him and asking questions and talking about the concepts that had been presented via the technology. This was in contrast to the normal behavior of the students after classes in which no technology was used, even though the instructor thinks that whether there was an after- class response would depend on what was discussed in class.

The students' interest in the technology was also evident during the laboratory sessions. An example was Don, a fourth-year Physics student in his last semester at the university. Don is no newcomer to the use of multimedia technology, having worked with different types at Science World in Vancouver. Don showed a lot of excitement in the laboratory sessions. He is quite comfortable with the technology. During the laboratory sessions, I observed that he frequently offered help to classmates and sometimes called them to come and see the *"neat stuff"* that he was doing on the computer. Many of those things were outside the scope of the lab requirements.

Appeal of the technology

One of the reasons why the students were motivated by the technology was the appeal of the technology itself. The use of multimedia technology was a unique instructional medium for the instructor to use. Students were motivated and showed greater interest in the subject matter when it was presented with the use of a computer and computer-related technologies in the classroom. So, pedagogically, the appeal the technology offers in terms of its uniqueness is important in stimulating the interest of the students as well as motivating them. At the beginning of the term, to describe one of the advantages of using multimedia technology as an instructional tool, the instructor said:

> *I think that there is an appeal to it [the technology] and especially in [Astronomy] 101 where the students are in first year, from secondary schools. Often there is a bit of a let down; they are coming into the University for the first time and then they ... see inadequate lecture halls, people using chalkboards and clunky old overheads and so on. I think students would like to have the impression that they are coming to a place where they are seeing some of the latest techniques in studying current Science and so be able to use technology, you know current technology. To be able to show them computer simulation in real time, to make use of videos and laser discs and so on, gives them the impression that, yes, they are at a first-class institution ...*

All the students that were interviewed expressed preference for seeing images on the computer or television monitor rather than from the slide projector or photocopies even when the computer images did not necessarily show more details than the transparencies. For the most part though, the instructor used transparencies as a replacement for chalkboard notes. From my observations too, many images were more visually pleasing using the multimedia set-up than using slides and transparencies even when colored transparencies were used. However, the instructor claims that the resolution of the LCD panel is still inferior to slides although not by much in some instances.

Throughout the term, when the technology was used, the instructor was able to motivate the students by the use of the technology. Over the course of the term, I observed that the students maintained a constant interest in the technology.

4.2.2.2 Concept Development

Pedagogy and Concept development reflect the teaching and learning situation. They are so closely related that the boundary between the two terms is not easily defined as reflected in the literature on teaching and learning.

The term, concept, is defined by the Webster's Seventh New Collegiate Dictionary as "something conceived in the mind," a "thought" or a "notion" as well as "an abstract idea generalized from particular instances". Novak and Gowin (1984, p.4) cited in Hansby (1991, p. 11) define concept as "a regularity in events or objects designated by some label". Novak and Gowin (1984), also cited in Hansby (1991), established that observation is the first step in the construction of knowledge and that "objects" are things while "events" are happenings. According to Hansby (1991), "the notion of regularity seems to indicate repeated observation and again the building up of an idea".

There exists a wide range of sometimes conflicting ideas in the literature on conceptual change and concept development. In the context of this study, the term, concept development, refers to that process of repeated observation, analysis and synthesis that leads to the construction and increasing sophistication of an idea. In this study, the focus is on the students' construction of meaning as they attempt to grapple with different Astronomy concepts. Since personal meanings are not constructed in isolation (Von Glasersfeld, 1989), it would be interesting to know if the use of multimedia technology helped the students of Astronomy 101/102 individually and collectively in understanding or making sense of Astronomy concepts. However, since this study was about the innovation process and not the evaluation of that process, there were no specific measures of outcome built into the study. Therefore this section will examine certain evidences from the data collected in this study of what might count as multimedia technology influencing concept development.

Visualization

While visualization was claimed by the instructor and students as being important for concept development, visualization is also closely related to interest and motivation, hence this aspect of the study is also categorized as a pedagogical issue. One major reason why the students were motivated by the technology was because they could see many of the astronomical images and relate these images to the description and characteristics associated with the images. This ability to visualize many of the things being talked about in the class, on the other hand, helped concept development.

At the beginning of the term, one of the instructor's aspirations was to be able to use multimedia to show students in real time what happens with the motions of the Celestial spheres. *"...to actually have it there when I'm talking about, say, the gradual motion of the [sun along the] ecliptic over the year. I can actually illustrate it."* I noticed that the instructor used the multimedia set-up in talking about the motions of the Celestial sphere in the class during the year.

The instructor's view of some Astronomy concepts like the appearance and motions of the celestial sphere was that, *"...these concepts are hard even for advanced students to grasp because it's more of a perception problem, and to be able to show them [students] things moving as opposed to just static* *diagrams would be very valuable."* In the above quote, the instructor identified certain Astronomy concepts as difficult because of the students difficulty in perceiving or visualizing the concepts as being real. For example, planets are not bodies that can be observed like one would a tree, hence the need for a sophisticated yet accessible medium of observation. In this study, the multimedia technology served as this medium of observation. Strike and Posner (1985) suggest that the use of exemplars and images help in establishing the intelligibility and plausibility of a new conception by influencing a person's intuitive sense of what is reasonable. In this study, the instructor felt that it was important to be able to show images to the students in order to aid their understanding of the concepts. On how he would know if the technology was aiding conceptual development, the instructor said, *"... I think I'll get some feedback during the course itself. You can see how students react to things, especially in the labs, and you get an immediate response in many cases. Hopefully there will be some feedback in the course evaluations."* The instructor did receive some feedback from the students regarding their understanding of some of the concepts during the course. The students alluded to visualization as a major step towards their understanding of the concepts. At the end of the term, commenting on the performance, of the students, the instructor said, " *I also can gauge performance on particular test questions compared to previous years. I have noticed improved performance on celestial sphere questions."* While the instructor's response may not be considered to be an effective measure of concept development, it is at least a subtle mix of checking for students' understanding as well as concept development.

The course evaluation forms that were completed by the students were positive. While they were few specific comments about the use of multimedia in teaching, most of the students mentioned that they appreciated the instructor's use of various methods of teaching. During the term, the instructor was able to use some of the software available in the laboratory sessions to visually reinforce some concepts that were taught in the class. According to the instructor,

> *..the educational potential was clear...If the software had been tailored a little bit better to the topic, I would see many cases where you would want to use this...Although there were...four or five different simulation packages, I think the two or three of them that we used...were effective, [and] brought across the concept more clearly than I would have if I just had slides or if I just had [the] blackboard or the overhead projector with normal transparencies.*

Students also cited instances where visualization helped their understanding of the concepts. Consider the case of Alfred who described himself as a very visual person as opposed to being verbal so, for him, he is able to understand concepts better when he sees them represented in one visual form or the other. He found the use of audio-visual devices, with all the motion and animation of the images very helpful. When comparing this Astronomy course with his other courses in which the instructors do not make use of visual aids he said, *"I sit in some courses and the teacher goes 'blah blah blah,' all the class long. It's a bit boring, and I wonder, 'what is this?'"* indicating that lectures often go straight 'over his head'.

While Alfred does not mind the use of transparencies, he is of the opinion that the use of multimedia technology and video is better suited for a course like Astronomy. *"For Astronomy, for this type of course, definitely you need a video. Because for many people, it's easy to see planets in their* *head, but for others, it's harder: it's tilted and it's moving around the Sun which way? So, it's easier with video for this particular course... to see the surface of Mars and I go 'Oh ,Wow!'"*

Alfred showed some excitement at some of the things that he learned: *"Just in class this morning, we were talking about Saturn. Saturn is a planet but it's only gas, but you can't actually pass through this planet..."* When I expressed surprise about the fact that the planet Saturn is gaseous, Alfred spoke excitedly about the computer images they had seen in the class earlier that day in which the multimedia set-up was used to show the features of the planet Saturn.

Brad, a second-year arts student, considers the use of transparencies as being elementary and unclear since the images appear only in black and white. On the other hand, images appear in color on the computer. Brad gave an example of an image of stars that they saw in one of the tutorial classes using multimedia technology thus:

> *...the colors of stars comes out on the color pictures ... I guess the different temperatures would come out as different colors, it does not come out in black and white. So you get a grasp of what it looks like rather than elementary grasp using an overhead projector.*

Don, another student, said,

> *...I enjoyed it, like it [the multimedia] helped me visualize what we've been taught in the lab with the CD-ROM set-up hooked on with the laser disc. That helps because it gives me actual pictures to have in my mind when I'm going through my notes later on so that I can remember seeing what they actually look like. And last week, when we did the flying over planet Mars*

and stuff like this, that really helped too when I can find the stuff that I can picture not only in my mind. I thought it [the multimedia] was an asset too in addition to the lecture notes.

Another interesting theme that came across from the students regarding the visual representation phenomena was the distinction between what is real and what is theory. For example, Brad stated that seeing the images helped to prove that what the instructor said was true, and that helped the students' understanding of the concepts. For Brad, since he had nothing in his imagination with which to compare the concepts, he considered it beneficial to be able to see the images. He used the examples of Hydrogen II regions and star clusters in the following conversation:

Brad: *Unless you can actually see it, you have absolutely no idea of what the professor is talking about, so it [the technology] certainly makes it a lot clearer to the students.*

Ajibola: *For you?*

Brad: *Certainly yes. Otherwise I would have no idea of what HII regions are about, I would go out of the lecture and then go home and wonder about it at night: what in the world was it because we've never seen one so we have no idea what HII was except what we are told in class. But to actually see one is more or less the application side in the course whereas the lecture is the theory and actually seeing it is applying it to everyday life. If you wonder at the sky and have a telescope you can actually understand because you've seen it before.*

Don also made this distinction between theory and reality. For Don, when the instructor shows images using the multimedia set-up, or overheads, that is real, but when he lectures, that is theory.

> *...It was nice because he [the instructor] could talk a little bit about the theory, show us some of the actual stuff that is in outer space, give us some concrete pictures of it and then explain how each relates to each part. I thought it was really good. Okay this is the theory and that's what it looks like in real life].*

According to the four students that were interviewed, the technology aided their understanding of certain concepts. They also felt that there would have been no other way through which they could have been able to comprehend some of these concepts but for the technology.

Brad, a student, described the case of a class session where the instructor described the features of hydrogen regions and star clusters in the class. According to Brad, many of the students found it difficult to understand the concept but when the computer images were later shown, the students understood what the instructor meant.

Cal, a first-year Arts student, thinks that using the multimedia to teach helps his understanding of the concepts. According to him, many of the concepts being taught in Astronomy are difficult to understand without seeing pictures. For Cal, ideally, he wants to be able to see the images while the instructor is introducing the concepts. When asked if photocopied images on transparencies would suffice, he said no, and explained further:

> *Because for something like the demonstration of the circles that he showed, where he can actually show you the flash as it rotated, and the sound as it vibrated. You know it got the point across better rather than just saying it pulses and it vibrates blah*

blah blah. So by actually showing it instead of just telling it, it's easier to process.

Commenting on the significance of seeing the moving images, he said,

> *Because when I see a question on the exam, I see the word posted on there. I remember, oh yeah, that flashing thing; otherwise it's just all jumbled together. So I think if you can sort of isolate it and have a visual picture of it then it's much more effective than just the Prof. spurting out words because that just loses the point altogether.*

For Cal, having a demonstration with the multimedia is better than a lecture alone which he described as *"...just an explanation."* Furthermore, he said,

> *As a rule I think just the ideas are easier to follow than the technical Mumbo Jumbo. [For] something like Astronomy, which is very scientific, if you just have the professor spurting off all this technical Mumbo Jumbo, then I find it sort of confusing. But if I can see what he means when he talks about supernovae or any of these other things then I get a much clearer picture, because for a lot of these things, I mean, I'm a first-year student in Astronomy and all of these things I've never even heard about before. So if you're just giving me words and I don't have pictures, then I just get lost.*

Don, who as previously mentioned, is no newcomer to the multimedia set-up, *"...would have done okay..."* without the multimedia in terms of understanding the concepts but he thought *"...it was a definite help..."*

Evidently from the students' interviews, the ability to visualize many of the things being talked about in the class, helped the students' understanding of the concepts. This made the concepts real for some of the students. As a participant observer in this study, I paid attention to the classroom instruction with the aim of understanding the concepts being taught, and occasionally asked questions for clarification. The use of the multimedia set-up in displaying many images and simulations helped my understanding of the concepts.

A second feature that emerged from the analysis that was also significant in terms of concept development was accessibility and flexibility of the technology.

Accessibility and Flexibility

A very useful feature of multimedia technology is the accessibility to multiple forms of representation which it offers and the flexibility of its possible usage in different learning settings. In the Astronomy 101/102 course, the instructor was able to use the multimedia set-up in classroom settings and tutorials, as well as in the laboratory sessions. The instructor was also able to teach in a different way. The multimedia,

> *... gives some flexibility. We can do things that we always just dismissed before. We'd say, well it would really be nice to...and now we are starting to get to the stage where we can do that. There were certain things that I wouldn't have been able to do any other way like the simulations, [which] I would never have been able to show. When we are discussing the collision of galaxies, we can actually show a computer simulation of two galaxies interacting before, [and after] rather than just talking about it or ...photocopying a set of still images and showing it in sequence, like those old flip-card movies. I think it was a great success having the ability of this menu-driven software in front*

[of the class]. You could see that there were a lot of [natural] pauses, one could move the mouse fairly easily, bring up images, adapt the tool to the situation, and change things at will. I really appreciated that flexibility... I could have presented the tutorial in a conventional slide show fashion but I wouldn't have had the same amount of flexibility as within the software...

Don preferred the accessibility and flexibility of the multimedia technology to the use of slide projector particularly because, as a student, he could go to the multimedia set-up and choose what he was interested in seeing and in whatever order he wanted. Using the slide projector on the other hand, according to him,"*... is a lot more tedious and cumbersome... to try to go back and forth through all the slides.*" In summing up, Don noted:

What I find most helpful was, like last week when I was up there myself choosing what I wanted to see and stuff like that. It was available for us to come in and look at it like that, studying it on our own time and stuff like this. I was able to choose and then go back and forth to compare many different things, if I wanted to, and that's what I found most helpful. So I think if it was available for student use or for small groups to use, maybe to come in and sign up for a time allotment, to use it for a certain time. it might be a good idea."

In the above discussion, two different, yet valuable types of accessibility and flexibility were discussed with regards to multimedia. First was the accessibility and flexibility that made the technology to be useful in different settings. Second, was the accessibility to various forms of representation of information using the technology. Both were found to be useful for concept development.

Summary

Reflecting on the use of the technology, teaching/learning goals and the students' overall performance in the course, the instructor said

> *I got no sense that the use of this technology confused anybody, that it gave the wrong impression. I got a sense that anytime we used it effectively, that a concept was made a little clearer to people as opposed to people getting blinded by all the bright colorful technology. It wasn't so flashy as to obscure the message...People, [the students] came up individually and they said they would like to see more of that. They found it very useful to better understand the concepts.*

The concept development category discussed in this section support Novak and Gowin's (1984) notion that observation is an important step in the construction of knowledge. All the four students interviewed described visualization as a major factor that aided their understanding of the Astronomy concepts. Finally, while the practical issues discussed in the previous section seemed to have relatively clear boundaries, the pedagogical issues were interwoven.

4.3 SUMMARY

In this chapter, the analysis of data has been presented. Furthermore, the data is presented along with quotes as evidence to support the two emergent themes: Practical and Pedagogical issues. These themes portrayed different pertinent aspects of the innovation with multimedia. There were different categories discussed under each of these themes. (See Figure 1). These themes and categories were delimited for analytic purposes only, and were not mutually exclusive of one another but are interrelated. A summary of the salient points in each category is presented in Table 1 on the next page.

Finally, at the end of the term when I debriefed the study with the instructor, the instructor referred to the innovation process as virtually an unqualified success from the technical standpoint. From the educational standpoint, the instructor admitted to it as not having been fully exploited. The testimony of the success of the innovation for the instructor is that he is teaching the two courses again and is making increasing use of the multimedia technology. Given the instructor's increased familiarity with the technology, and the availability of new software which is better suited for the lecture environment, the instructor hopes to be able to take more advantage of the educational potential of the technology.

THEME	COMMENT
1. Practical Issues	
i. Convenience: Transportation of the equipment	For convenience, the instructor used a lap-top and LCD panel in the classes and, the laser disc player only during tutorial sessions.
ii. Technical Knowledge: Use of the technology.	By the end of the term, the instructor was able to change the settings of the equipment with increased confidence.
iii. Software:	
a. Availability of the software packages.	The instructor used available software for the classes and custom-made packages for the tutorials.
b. Design features of the software packages.	The instructor used his text to compensate for the text and speed of the simulations which were design features inherent in the software, that he found to be inadequate.
iv. Time: Instructor's time input.	The additional time required by the instructor to familiarize himself with, and structure his lecture around, multimedia technology decreased over the term as his familiarity with the technology increased.
2. Pedagogical Issues	
i. Interest and Motivation: Motivation and arousing the interests of students.	The use of multimedia technology motivated the students and promoted their interest in the subject.
a. Appeal of technology: The uniqueness of the technology.	The uniqueness of the technology motivated and stimulated the interest of the students.
ii. Concept development: The construction of an idea or concept.	The instructor made use of the technology in teaching some concepts in a way which he otherwise would not have been able to do.
a. Visualization: Showing images and simulation programs with the technology.	Visualization was important for the understanding of the concepts by the students.
b. Accessibility and Flexibility: Access to the technology and information via the technology.	The access to multiple representation of information that the use of the technology offered was important in the construction of knowledge. The flexibility with which the instructor and the students were able to randomly explore and choose the information they wanted in a software package also helped concept development.

Table 1: A summary of the emergent themes and related issues in the exploration with the use of multimedia technology in Astronomy 101/102.

CHAPTER FIVE

DISCUSSION, CONCLUSIONS AND IMPLICATIONS

5.0 INTRODUCTION

This chapter begins with a brief overview of the study. In the second section the findings based on the answers to the research questions are presented. Recommendations for the successful implementation of multimedia technology as an instructional tool are presented in the third section, while the fourth section concludes with suggestions for further research.

5.1 OVERVIEW OF THE STUDY

The purpose of the study was to gain insights into a professor's first attempt at incorporating multimedia technology as a teaching tool in an introductory Astronomy course. Olson (1988), calls for a need for "...research to be a part of a process of teacher education, rather than manipulation" (p. 13). In order to achieve this, he mentioned the need for the researcher to work closely with the teacher during the process of the innovation. This advice was closely followed during the process of this innovation. I worked closely with the instructor such that the process of the innovation was allowed to unfold in the presence of both instructor and researcher. In this research, attempts were made to examine and document the innovation within the everyday practice in Astronomy 101/102.

The data in this study consisted of field notes on classroom observations, observations of some of the instructor's preparatory activities before the class, and transcripts of interviews with the instructor and four students in the course. Analysis of the course outline and the course evaluation forms completed by the students, were used to corroborate the claims from the interviews and observations. Relying on multiple sources of data helped to triangulate the data interpretation.

Another aspect of the research design built into this study was the longitudinal aspect of data collection. Since this study explores the innovation process, the different planning, organization and implementations during the innovation process were documented over time.

The analysis of the data was informed by a holistic world view of Education (Roberts, 1982). Hence, the day-to-day practices and the numerous contextual factors of innovation were sought and not masked by the series of statistical manipulations that are representative of studies that are based upon a sampling logic approach.

5.2 RESEARCH FINDINGS

The two interrelated research questions served as a focus for the study toward gaining insights into an innovation involving the use of multimedia technology in a first year level Astronomy course. In the next two subsections, the research questions are stated and discussed.

5.2.1 Research Question 1

What planning, organization and implementation was undertaken to incorporate multimedia during the innovation?

The planning, organization and implementation involved in the innovation emerged as a series of practical issues and have been grouped into the following categories:

Convenience

Technical knowledge

Availability and design of appropriate software

Time

A brief treatment of these issues in each of these four categories is addressed in the section discussing the practical aspects of the multimedia innovation.

Convenience

The ease of utility of the multimedia technology was important for the Astronomy 101/102 instructor. For him, it was important that the technology be portable since his classes were some distance from the Astronomy offices and there were no means of storing the equipment at the class location. Indeed, at the beginning of the course, the issue of convenience was the instructor's greatest challenge to the workability of the innovation. For example, limiting the use of the laser disc player to the tutorial sessions within the Astronomy building and making use of only the laptop and LCD panel as an alternative in the classes greatly facilitated the ease of using the technology. *For this innovation to be successful, steps were implemented to minimize the inconveniences experienced by the instructor.*

Technical knowledge

Once the equipment was at the location where it was to be used, the next concern was getting it to work. In this study, it was found that although the expertise required of the instructor was minimal in getting the hardware to work, the instructor's expertise in multimedia applications required on-going support and assistance particularly during the start-up phase. *Therefore, a technical knowledge of multimedia applications was required by course instructor and a technical assistant who was familiar with the technology was required to help ensure the successful implementation of the technology.*

Software

Two sub-categories or aspects, availability and software design, were discussed under the software category. For this innovation, the instructor made use of the software that was already available in the Department, obtained for use in the laboratories. He considered the first year of the innovation to be a test of the technology itself, not of the software. Towards the end of the term, however, he was able to locate and order more suitable software for the class.

The design of the software was also important to the instructor. Some of the design features used in the software were not suitable for use in the classes. The screen text was too small and some of the simulations ran too quickly. The instructor's strategy to overcome design deficiencies was to use some of the software as demonstration only, rather than allowing the lesson content to be driven by the software.

For the tutorials, the instructor used custom-made software packages, hence the design features were more tailored to suit the needs of the Astronomy 101/102 tutorials. *Thus, tailored software packages, although expensive in terms of time and funding, were a critical feature of successful and substantive multimedia innovation.*

Time

University professors considering any kind of innovation are usually interested in knowing about the amount of time required of them. Between getting lectures ready, marking, conducting research, supervising students, keeping abreast of recent developments in their respective fields and publishing, little time is left to invest in explorations of which the outcome is uncertain. For the instructor of Astronomy 101 and 102, the extra time input required decreased over the term as he became more familiar with the technology and, although he did spend extra time on exploring the technology, he felt the time spent was quite worthwhile. *Therefore, successful multimedia innovation required sufficient time investment that is above and beyond regular course planning and teaching, especially during the initial stages of the innovation.*

Hence in answer to the first research question, the planning, organization and implementation issues that arose have been grouped under the theme of practical issues and subgrouped into four categories related to the technology most of which were transparent to the students but were clearly apparent to both the instructor and myself through our observations and our conversations. The instructor was able to work through many of these planning and organizational details during the year and made adjustments as his exploration of the technology progressed.

5.2.2 Research Question 2

What aspects of multimedia technology were salient to its implementation, and how did they affect teaching and learning in the Astronomy 101 /102 class?

This question relates to the issues of multimedia technology and the pedagogical implications of this technology. Two distinct but interrelated categories of pedagogical issues were generated from the analysis of the data:

- Interest and Motivation
- Concept development

In order to clarify the data analysis, sub categories or aspects were developed for each of these two categories. Appeal of the technology is a sub-category related to interest and motivation, while visualization, and accessibility and flexibility of the technology are the sub-categories related to concept development. These categories and sub-categories were constructed for analytic purposes only and are not representative of individual entities in and of themselves. Finally, teaching and learning within each of the three subcategories were examined from the students' and the instructor's perspectives.

Interest and Motivation

The students considered it important that the instructor's presentation, knowledge, and interest in the course motivated them to learn. In this study, the appeal of the technology, in terms of its uniqueness was an element of the instructor's teaching that was cited as an important motivational factor for the students. The use of the technology enabled the instructor to employ varied ways of teaching which served to keep the instructor and students interested in the course. *Thus, motivation was an important attribute of multimedia use that contributed to student learning.*

Concept development

The accessibility to the technology, and to information with the technology, coupled with the flexibility of authoring and navigation of multimedia programs was greatly valued by the instructor and students. All four of the students who were interviewed spoke significantly on visualization, accessibility and flexibility as contributing to their development of Astronomy concepts. Clearly, the findings of this study concur with Novak and Gowin (1984), who state that observation is an important step in the construction of knowledge. In this study, the four students that were interviewed said that the phenomena described by the teacher made more sense to them after they were able to visualize it through the use of multimedia technology. When the instructor taught the concepts, the students said, that was theory, but when the students were able to visualize the phenomena with the aid of the multimedia technology, then they said that the concepts became real. So, to the students, visualization is reality, while teaching or talking about a concept is theory. This meant that for the students, lecture was not real and the concepts explained to them in the lecture may not be considered real or true unless they could visualize.

This accessibility to multiple representation of concepts, and flexibility offered by the technology allowed the students to be actively involved in the construction and refinement of concepts in astronomy in ways that are not possible in traditional classroom setting. *In short, visualization and the flexibility and accessibility of the technology enhanced student observation through multiple representations of the phenomena under study, which in turn contributed to concept development.*

5.3 Recommendations for the successful implementation of multimedia technology

The following are recommendations, arising from this study, for enhancing successful innovation with multimedia technology in an instructional environment:

1. Ownership

This study was clearly the story of a successful innovation. According to the instructor, his use of multimedia technology in Astronomy 101/102 will continue because he was convinced that this study demonstrated the efficacy of the technology for enhancing student learning. The results of this study support the notion made by many notable scholars on innovation (e.g. Fullan, (1993); Olson, (1985); and Levine (1980) that for an innovation to be successful, it is important that the innovation is owned by those who implement it. The different instructional approaches that this instructor took during the process of this innovation may have been curtailed if he had not been in control of the innovation process.

2. Pedagogical Considerations

While Salisbury (1992) claims that the need for technological innovation has been acknowledged by many within the last decade, Reehm and Kolloff (1994) state that many teachers still lack the ability to incorporate this technology into the curriculum despite their genuine interest because many of them still lack a basic understanding of the pedagogical use of multimedia or hypermedia packages. This study highlighted several pedagogical issues that emerged from the use of the multimedia.

Visualization aided the students' understanding of the various Astronomy concepts. When the students were able to visualize the phenomena with the aid of the multimedia technology, then, the concepts became real to them.

The **accessibility** to multiple representation of concepts, and **flexibility** offered by the technology allowed the students to be actively involved in the construction and refinement of concepts in Astronomy in ways that are not possible in traditional classroom setting.

In short, this study claims that the use of multimedia technology in the teaching of Astronomy 101/102 aided **concept development** on the part of the students. Based on these findings, this study proposes that the use multimedia technology be regarded as an important pedagogical element of instruction in Astronomy.

3. Construction of a technically rich learning environment.

McClung (1979) claimed that there has been a lack of understanding of how technological innovations take place, and that most studies done in this area do not reveal much about the day-to-day practices that took place during the innovation. Furthermore, Fullan and Stiegelbauer (1991) note that "how change is put into practice determines to a large extent how well it fares". In this study, therefore, the process of change has been carefully documented and several important aspects of how the innovation with multimedia in Astronomy 101/102 was implemented have been highlighted. In light of the results, it is useful for anyone planning on a similar kind of innovation to know how a technically rich environment can be constructed in order to enhance learning. The following practical suggestions are useful guidelines for any university instructor embarking on innovation using multimedia technology as an instructional tool.

i. The technology should be conveniently located in order to avoid major transportation of the equipment. In this study it was inconvenient for the instructor to have to be transporting the technology to and from the classroom each time it was to be used. Each time the computer was unplugged, some adjustments in the settings had to be made before it could be usable in the classroom. Transporting the equipment also potentially decreases the life span of the equipment.

ii. The equipment should be accessible to the instructor so that the instructor is able to tinker with the technology outside of class time. This accessibility is important so that the instructor can increase his or her familiarity with the technology and think through the best way of using the technology in the class.

iii. The technology should also be available to the students outside class time or for use in small group settings such as tutorial groups. Accessible technology will enable the students to be able to explore the accessibility and flexibility potential of the multimedia technology.

iv. Technical support personnel should be provided for the instructor especially at the beginning of the innovation. The process of the innovation would be easier if the instructor does not have to worry about not being able to get the technology to work in front of the students! There could also be a potential negative backlash from the students if the introduction to technology is poorly implemented. The students may see it as a joke since they tend to laugh when something goes wrong with the technology hence their attention may tend to be diverted to the technology rather than on what is being taught with the aid of the technology. In this study, the assistance provided by graduate students from the Department of Curriculum Studies and the Department of Geophysics and Astronomy were invaluable. Inter-faculty liaison of this nature should be encouraged and utilized whenever possible.

v. Appropriate software should be located or developed. For this study, it was found that "off-the-shelf" software was not always appropriate for the instructor. There were always some features of the software that the instructor wished he could change. This study proposes that custom-made software, which is more tailored to the instructor's needs, is important for the use of multimedia technology in university classrooms. In this study, the instructor found it more useful to use customized software to achieve a few but specific course objectives rather than using commercially available software designed to achieve many but less specific objectives. With the emerging use of CD-ROM technology, it is becoming easier and cheaper to have custom made software packages. Efforts should also be made to keep the multimedia data up-to-date.

vi. The university should provide time for instructors embarking on innovation with multimedia technology to experiment with the technology. According to Woodrow et al. (1994, p.697),

...while the introduction of such technology [multimedia technology] affords the possibility of producing change and educational benefits, none of them can be assumed to become automatically realized only because of the technology's presence. The implementation of technology requires major adjustments in the traditional roles and instructional procedures of teachers. It takes careful preparation and planning to realize the educational benefits of technology and to make innovative things happen.

Time is needed for the instructor to experiment with different ideas with the technology and alternative pedagogical approaches.

5.4 RECOMMENDATIONS FOR FURTHER RESEARCH

In this study, the major focus was on the instructor's activities, and rightly so, since, being the implementer of the new technology, his activities were quite central to the innovation. A further study that focuses on the students experiencing innovation with a new technology and their reactions to it would further inform both the practical and pedagogical aspects of multimedia innovation.

Finally, a similar study using a multiple case study research strategy that would enable the investigation of a variety of contexts would further contribute to our understanding of the process (and potentially the products) of multimedia innovation for tertiary education.

REFERENCES

Abell, K.S., Cennamo, K.S., Campbell, L.M. & Hug. W. (1994). Designing interactive video case studies for reflection on Science teaching. Paper presented at the annual meeting of the National Association for Research in Science Teaching. Anaheim, CA.

AECT: Association for Educational Communications and Technology (1977). Educational Technology: Definition and Glossary of terms. Washington: AECT.

Barker, P., Giller, S., Richards, S., King, T. (1993). The evaluation of interactive multimedia courseware. Educational Multimedia and Hypermedia Annual, Proceedings of ED-MEDIA, 32-38.

Bogdan, R.C & Biklen S.K. (1982). Qualitative research for Education. Massachusetts: Allyn and Bacon Inc.

Brandt, R. (1991). Multimedia and reality. Multimedia Review, 2(3), 28-32.

Clarke, A. (1992). Student-Teacher reflection in the practicum setting. Unpublished doctoral dissertation, University of British Columbia.

Duttweiler, P.C. (1983). Barriers to optimum use of educational technology. Educational Technology, 23(11), 37-40.

Edyburn, D.L., Rieth, H.L., & Bishop L.J. (1994). A technology enhanced approach to special education personnel preparation. Technology and Teacher Education Annual, Proceedings of STATE 94, p. 135-137.

Falk, D.R. & Carlson, H.L. (1991). Evaluating the effectiveness of multimedia applications in human service and teacher education. Multimedia Review, 2(3), 12-17.

Faravelli, G., Ghislandi, P., & Zullini, A. (1991). Discovering unfamiliar animals with multimedia: Rethinking higher education through the new technologies. Multimedia Review, 2(4), 28-32.

Freeouf, B. C. & Flank, S. (1994). Preparing teacher educators to integrate technology into required courses; Technology and Teacher Education Annual, Proceedings of STATE 94, p. 172-177.

Fullan, M.G & Stiegelbauer S. (1991). The new meaning of educational change. Teachers College Press, New York.

Fullan, M. (1992). Teacher development and educational change. Falmer Press. New York.

Fullan, M. (1993). Change forces: Probing the depths of educational reform. Falmer Press. New York.

Goetz, J.P. & LeCompte M. (1984). Ethnography and qualitative design in Educational Research. Academic Press.

Goldman, E., & Barron, L. (1990). Using hypermedia to improve the preparation of elementary teachers. Journal of Teacher Education, 41(3), 12-20.

Goldman-Segall, R. (1993). Layering tools for analyzing video data. Educational Multimedia and Hypermedia, Proceedings of ED-MEDIA 93, p.215-223.

Grabowski, B. (1992). Multiple perspectives of educational technology. Tech Trends, 37(3), 41-43.

Hansby, R. (1991). Conceptual change in a context of collegial consultation. Unpublished M.A thesis, University of British Columbia.

Hoyles, C. (1992). Mathematics teaching and mathematics teachers: A meta-case study. For the Learning of Mathematics, 12(3), 32-44.

Huang, L. (1994). Prospective teachers' use and perception of the value of technology. Technology and Teacher Education Annual, Proceedings of STATE 94, p. 61-65.

International technical support centre. IBM personal system/2. (1992). Multimedia fundamentals. Document number GG24-3653-01. Boca Raton.

Kinnick, M.K.,Driscoll, A., & Strouse, J.H. (1990). Evaluating computer technology innovation in the schools: The need for a new framework. Journal of Evaluation and Program Planning, 13 (4). 335-341.

Koontz, F.R. (1989). Critical barriers to the adoption of instructional television in higher education. Educational Technology, 29(4), 45-48.

Levine, A. (1980). Why innovation fails. State University of New York Press. Albany.

Lincoln, Y.S & Guba E.G. (1985). Naturalistic Inquiry. Newbury Park, CA: Sage Publications.

Marcinkiewicz, H.R.; Hoadley, M.; Farland, D.S.; Jenson, R. & Bruning, W. (1994). Building faculty: Reflective decision-making and developing a faculty kiosk. Technology and Teacher Education Annual, Proceedings of STATE 94, p. 156-158

Marshall, C. & Rossman, G.B. (1989). Designing qualitative research. Newbury Park, California: Sage Publications.

McClung, L.A. (1979). On the dread of innovation in Universities. Humanist, 39(2), 5-8.

Merriam, S.B. (1991). Case Study Research in Education. San Francisco: Josey-Bass.

Midoro, V. (1993). What makes multimedia systems interesting for education? Educational Multimedia and Hypermedia Annual, Proceedings of ED-MEDIA 93, p. 377-381.

Murphy, C.A., (1994). Five practical examples of software integration in university level courses. Technology and Teacher Education Annual, Proceedings of STATE 94, p. 138-40.

Novak J.D & Gowin B., (1984) Learning how to learn. Cambridge University press.

Oakes J & Schneider M., (1984). Computers and schools: Another case of "... the more they stay the same"? Educational Leadership. 42(3), 73-79.

Olson, J.K. (1985). Changing our ideas about change. Canadian Journal of Education, 10, 294-307.

Olson, J. (1988). Schoolworlds/microworlds: Computers and the culture of the classroom. Pergamon Press. Toronto.

Olson, J. (1991). Understanding teaching. Open University Press, Milton Keynes. Philadelphia.

Punt, N.P. (1994). Intentions and Implementations: The impact of technology coursework in elementary classrooms. Technology and Teacher Education Annual, Proceedings of STATE 94, p. 38-41.

Reehm, S.P. & Kolloff, M. (1994). Integration of hypermedia into teacher education: A beginning. Technology and Teacher Education Annual, Proceedings of STATE 94, p. 35-37.

Roberts, D.A (1982). The place of qualitative research in Science Education. Journal of Research in Science teaching. 19(4). 277-292.

Rockman, S. (1985). Success or failure for computers in schools? Some lessons from instructional television. Educational Technology. 25(1), 48-50.

Salisbury, D.F. (1992). Some conclusions about technology and improving schools. Tech Trends, 37(3), 55-56.

Sammons, M.C. (1993). Issues in using multimedia in the classroom. Journal of Hypermedia and Multimedia studies, 3(3), 3-5.

Sarason, S. (1990). The predictable failure of educational reform. San Francisco: Jossey-Bass.

Smith, M. (1993). Professional development in elementary Science teaching using video technology. Unpublished PhD Thesis. University of British Columbia.

Strike, K.A., & Posner, G.J. (1985). A conceptual change view of learning and understanding, In L.H.T. West and A.L. Pines (Eds.), Cognitive Structure and Conceptual Change. p. 211-231. Academic Press.

Valmont, W. (1994). Helping teachers become distance learning teachers. Technology and Teacher Education Annual, Proceedings of STATE 94, p. 208-211.

Von Glasersfeld, E., (1989). Cognition, construction of knowledge, and teaching. Synthese, 80, 121-140.

Webster's Seventh New Collegiate Dictionary. Thomas Allen & Son.

Weingrad, P., Hay, K., Jackson, S., Boyle, R., Guzdial, M., Soloway, E. (1993). Student Composition of multimedia documents. Educational Multimedia and Hypermedia, Proceedings of ED-MEDIA 93, p. 541-548.

Woodrow, E., Farenholtz, A., Spann, G. (1994). Developing a framework for delivering technology-enhanced physics instruction. Educational Multimedia and Hypermedia, Proceedings of ED-MEDIA 94, p. 697.

Woodrow, E.J., (1994). A Computer-based multimedia Science education course. Technology and Teacher Education Annual, Proceedings of STATE 94. p. 579-584.

Wunsch, M.A. (1992). Positioning an instructional technology center for a new era in higher education. Tech Trends, 37(6), 17-21.

Yin, R.K. (1994). Case Study Research. Newbury Park, California: Sage Publications.

APPENDIX A

Five Software integration packages for university level courses.

1. Authorware Professional: An authoring program that allows users to create their own programs and instruction on the computer without learning a computer language.

2. Action: A presentation package capable of incorporating text, graphics, motion, interactivity and audio with minimal effort.

3. Inspiration.

4. SemNet.

5. Learning Tool.

The last three are conceptual mapping programs of similar capabilities.