

DOCUMENT RESUME

ED 167 184

IR 007 104

AUTHOR Andrews, Gordon C., Ed.; Knapper, Christopher K., Ed.
TITLE Computerized Multi-Media Instructional Television.
COMIT. Proceedings of a Symposium.
INSTITUTION Waterloo Univ. (Ontario).
PUB DATE 6 Apr 78
NOTE 119p.; Proceedings of a Symposium on COMIT (Waterloo, Ontario, Canada, April 6, 1978); For related documents see IR 007 186-193 and IR 007 285.

EDRS PRICE MF-\$0.83 HC-\$6.01 Plus Postage.
DESCRIPTORS Audiovisual Aids; *Computer Assisted Instruction;
*Educational Strategies; Educational Television;
Formative Evaluation; *Higher Education;
Individualized Instruction; *Instructional Aids;
*Instructional Design; Learning Modules; Program Evaluation
IDENTIFIERS *Computerized Multimedia Instructional Television.

ABSTRACT

A joint research project in educational techniques, which was conducted by the University of Waterloo and the IBM Corporation, explored the use of color television with random-access videotape under computer control. At the end of the three-year project, papers were solicited from all COMIT (Computerized Multi-Media Instructional Television) participants, and 12 of the 15 professors who had authored courses submitted papers. A representative sample of seven papers was presented at a one-day COMIT Symposium, some accompanied by videotaped demonstrations that illustrated the teaching techniques used. In order to provide as complete a record of the project as possible, all 12 of the papers from participants are included in this volume (grouped, where possible, by subject), as well as comments by the project director and the coordinator from IBM and a summary of the pedagogical lessons learned from COMIT. Courses described include environmental engineering, survey design, advanced calculus, organic synthesis, biology, human movement, ice hockey practice, football, leisure experience, history of art, and English. The appendix contains the schedule for the COMIT Symposium with the names of the speakers.
(Author/JEG)

* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *



U.S. DEPARTMENT OF HEALTH,
EDUCATION & WELFARE
NATIONAL INSTITUTE OF
EDUCATION

THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL NATIONAL INSTITUTE OF EDUCATION POSITION OR POLICY.

PROCEEDINGS OF A
SYMPOSIUM ON

COMMIT

COMPUTERIZED MULTI-MEDIA
INSTRUCTIONAL TELEVISION

THURSDAY, 6 APRIL, 1978

"PERMISSION TO REPRODUCE THIS
MATERIAL HAS BEEN GRANTED BY

Christopher K. Knapper

Symposium Editors:

Gordon C. Andrews
Chairman, Computers in Education Committee

Christopher K. Knapper
Teaching Resource Person

TO THE EDUCATIONAL RESOURCES
INFORMATION CENTER (ERIC) AND
USERS OF THE ERIC SYSTEM."

UNIVERSITY OF WATERLOO, WATERLOO, ONTARIO N2L-3G1, CANADA

PREFACE

In September 1974, the IBM Corporation approached the University of Waterloo with a proposal for a joint research project in educational techniques which would explore, in particular, the use of colour television with random - access video-tape under computer control. The proposal was referred by Dr. T.A. Brzustowski, Vice-President (Academic), to the Computers in Education Committee (CEC) for evaluation and comments. After some negotiation between UW and IBM, the project began officially in January 1975 with the name COMIT (for Computerized Multi-media Instructional Television), with Dr. J.B. Moore, Associate Professor of Management Science, as COMIT Project Director and with E.O. Elkeer representing IBM.

The Computers in Education Committee maintained an informal contact with COMIT during its three years of operation and, as the termination date (15 April 1978) approached, members of the Committee volunteered to assist in disseminating the knowledge obtained from the project. An editorial sub-committee was appointed and papers were solicited from all COMIT participants. Twelve of the fifteen professors who had participated in COMIT as "course authors" submitted papers and a representative sample of seven papers was selected for presentation at a one-day COMIT Symposium held on Thursday, 6 April, 1978. Some of the Symposium presentations were accompanied by video-taped demonstrations that illustrated, effectively, the teaching techniques used.

In reviewing the submitted papers for publication in this volume, the editors felt an obligation to produce as complete a record of the project as possible, while maintaining an acceptable standard of content and format. Not all of the papers submitted conformed to the specifications in the Call for Papers and, in some cases where it was not feasible to return papers to their authors for revision, the editors arranged for re-typing and made some minor modifications and condensations. The resulting volume is believed to be a fairly complete record of the COMIT Project as described by the participants. This volume should not, however, be mistaken for the formal report of the project which will be prepared by the COMIT Project Director and readers who want more information should contact the Director.

The papers which follow are arranged in a rather arbitrary order. The comments of the Director and the IBM Coordinator are first, followed by the papers from twelve of the course authors (grouped, where possible, by subject), followed by a concluding paper by Dr. C.K. Knapper, the University of Waterloo's Teaching Resource Person, summarizing the pedagogical lessons learned from COMIT. The appendix contains the schedule for the COMIT Symposium, showing the Symposium speakers.

Gordon C. Andrews
Christopher K. Knapper

6 July, 1978

TABLE OF CONTENTS

	<u>Preface</u>	
1.	<u>An Overview of the COMIT Project</u> J.B. Moore, COMIT Project Director	Page 1
2.	<u>COMIT: Experiences and Observations</u> E.O. Elkeer, IBM COMIT Project Coordinator	6
3.	<u>Computer-Aided Teaching in Environmental Engineering</u> E.A. McBean, Dep't of Civil Engineering	10
4.	<u>Armchair Survey Sampling: An Aid in Teaching Survey Design</u> M.E. Thompson, Dep't of Statistics	17
5.	<u>A COMIT Module on a Topic from Advanced Calculus</u> B.J. Marshman, Dep't. of Applied Mathematics	26
6.	<u>Computer-Assisted Instruction in Organic Synthesis</u> V.A. Snieckus, Dep't of Chemistry	36
7.	<u>An Application of COMIT in Biology</u> W.B. Kendrick, Dep't of Biology	47
8.	<u>The Potential Use of COMIT in the Study of Human Movement</u> D.A. Winter, Dep't of Kinesiology	53
9.	<u>COMIT Ice Hockey Practice</u> R.C. McKillop, Dep't of Athletics	55
10.	<u>COMIT Football Module</u> W.A. Delahey, Dep't of Athletics	63
11.	<u>COMIT: The Leisure Experience</u> E.M. Avedon and T.O. Stewart, Dep't of Recreation	68
12.	<u>COMIT as a Teaching Tool for the History of Art</u> E. Kliman, Dep't of Fine Arts	77
13.	<u>COMIT English Module</u> P.D. Beam, Dep't of English	79
14.	<u>Reflections on a COMIT Module</u> D.K. Erb, Dep't of Geography	92
15.	<u>Learning from COMIT: The Educational Implications</u> C.K. Knapper, Teaching Resource Person	102

Appendix: Program for COMIT Symposium 6 April 1978

AN OVERVIEW OF THE COMIT PROJECT

by

John B. Moore

Associate Professor of Management Science

COMIT Project Director

University of Waterloo

Abstract: This communication describes the prime objectives of the COMIT research project, highlights the major accomplishments, and provides a subjective evaluation of the benefits and costs of multi-media computer-aided-instruction.

Introduction:

The acronym COMIT, standing for Computerized Multi-media Instructional Television, was chosen to identify a major research project in computer-assisted learning (CAL) which was undertaken jointly by the University of Waterloo and IBM at the University of Waterloo. The project began in January 1975 and the research was completed in March 1978.

The main goal of the research was to integrate the educational technologies of television and CAL into a single delivery system. The objective was to determine whether the combined technologies would result in a learning vehicle which would have significant advantages over either educational television or conventional CAL.

The responsibility of IBM was to develop the unique hardware interfaces and software, that of the University to provide the application (courseware) to be used in the experiments.

It was decided at the outset to include as many audio-visual functions in the experimental system as was reasonably possible, subject to the requirements that the audio-visual hardware components should be commercially available and that existing CAL authoring languages should be used. (The languages necessarily were augmented with commands to control the audio-visual devices.) The following functional components were selected and synthesized into a working terminal system:

- a standard SONY colour television receiver
- a standard 3270 keyboard with upper/lower APL character set and a 5th programmable character set.
- a sonic pen with a dismountable pickup which provided a 220 by 330 grid of addressable (detectable) points on the screen surface and capability for off-screen detects
- a facsimile printer for obtaining hard copy output of screen displays
- direct access to video tape segments
- direct access to audio tape segments
- direct access to a video disk which could store 550 35mm slides
- colour graphics under pen, keyboard or program control.

All video output appeared on the television screen and audio output was presented through earphones.

The system consisted of four terminals with the above capabilities connected to a System 7 minicomputer which in turn was channel-connected to the University's System/370 Model 158. The courseware was resident on the 158 and the System 7-158 protocol was similar to that used for a 3270 control unit. The System 7 controlled all the audio-visual library devices and generated and stored the colour graphics.

Two major programming languages were used for authoring: a modified version of IIS and an enhanced form of APL.

The Experiments:

Initially, thirty professors were contacted and given the opportunity to participate voluntarily in the project. From this group fifteen authors became involved and entered the process of topic selection, construction of learning objectives, detailed presentation design, and implementation. The content in most cases covered approximately three to four hours of lecture material. The selection of the pedagogy (drill and practice, tutorial, simulation, information retrieval, etc.) was left to the author. Each author (professor) worked closely with one of the project analysts and coding was done by twelve students hired on a full-time

3.

basis. The subject matter varied immensely. Subject areas included biology, English, poetry, water pollution, calculus, football, statistics, volleyball, organic chemistry, geography, leisure studies, theory of interest, accounting, hockey, biomechanics, and fine arts. Approximately half used a tutorial presentation; the others were mixtures of simulation, drill and practice and information retrieval. The resulting models took students anywhere from one hour to nine hours to complete. Over 570 students participated in the experiments and this usage involved upwards of 2000 hours of terminal time spread over 15 months.

Evaluation:

In four experiments, the class was divided into two groups - a control group was taught the material in the usual lecture fashion - and an experimental group took the same material using the COMIT system. In the other experiments, either the whole class (or team in the case of the volleyball, football and hockey modules) or a selected subset of the class used the research system. Six of the experiments were run more than once.

Results:

The University had three questions to which it was hoped the research would provide the answers:

First - Do students learn better with multi-media CAL? In all four experiments where direct comparisons were made, the students using the system had slightly higher average scores on post-tests than the students in the lecture group. The differences in each case were not statistically significant. No rigorous attempt was made to measure changes in affective behaviour of the COMIT students. However, a questionnaire given to students after completing the computer session showed generally positive attitudes to this form of learning.

Second - Can resources be saved using a multi-media terminal? The pre-project conjecture was that the richness of the terminal environment would allow realistic simulations of laboratory experiments to be conducted, thus providing potential savings in lab equipment. No firm conclusion was reached because no well-controlled experiments were done.

Nonetheless, students participated willingly in the laboratory simulations, and the information retrieval program used with the art history slides had a high utility. In three instances (theory of interest, history of leisure and statistics) significant amounts of professor time were saved once the respective modules were operational. Against the potential savings must be weighed the increased costs required for computer and audio-visual specialists, computer time and author development time.

Third - What is the potential of multi-media CAL for extramural education? It is in this area that perhaps the greatest potential benefits lie. With the advent of microcomputers, low cost terminals, video disks and cheap mass storage, the use of multi-media CAL becomes definitely feasible for home education, correspondence programs, remedial learning and special education. Such uses make it possible to spread the high capital cost of courseware development over many independent users. Without such uses the problem of justifying a multi-media CAL system for in-house use only is much more difficult.

Some Lessons Learned:

In terms of ability to enhance conventional CAL with multi-media attributes, the following list is arranged in order of decreasing priority of function: graphics, colour, slides, tapes (audio and video). This ranking represents a consensus of the views of the project personnel. Experience taught us also that good response time was vital for modules in which all student input was done with the pen. Pen resolution and calibration is extremely important when two or more detectable areas are close together. Also, production of audio-visual materials was and is a very time-consuming process relative to coding. In some instances we chose to omit a potentially valuable tape segment because of the production factors involved.

Conclusions:

The COMIT project must be considered an overall success in that almost without exception, the original objectives of the research were achieved. Aside from the observations made previously, the truth of

the following three statements was substantiated by the experiences in the project:

1. CAL can use multi-media effectively but it is not essential for good CAL.
2. Good CAL requires a team effort. The author is the most important team member.
3. Technology is not the limiting factor in CAL development.

The papers which follow provide the individual viewpoints of most of the fifteen participating professors. They are well worth reading.

COMIT: EXPERIENCES AND OBSERVATIONS

by

Eileen O. Elkeer

Advisory Education Representative

IBM COMIT Project Coordinator

IBM Canada Limited

Abstract: This paper was prepared from the activities of a Joint Study undertaken by IBM Canada Limited and the University of Waterloo. The study was given the Acronym COMIT (for Computerized Multi-media, Instructional Television) and the objective of the study was to determine the value of an interactive, computer-driven multi-media teaching terminal based upon television technology. A few of the experiences and observations are recorded in this paper.

Introduction:

COMIT was a truly unique and leading-edge system based on TV technology. It was the first known system with a standard colour TV set used as the basis of a terminal with the range of multi-media that was available to the teacher and student. The multi-media included randomly-accessible motion sequences, randomly-accessible audio segments, still images, a pen with tablet for pointing or digitizing, programmable colour and line graphics.

Fifteen modules or course segments were implemented utilizing a cross-section of the media. They represented all six UW faculties and employed a variety of teaching and learning techniques. The students' comments about their experiences and reactions, as well as their learning achievements, indicate that this type of terminal is a workable learning tool. The professors' experiences indicate that this type of system is a valuable teaching resource. COMIT posed no constraints on subject matter, teaching style or learning mode. In fact, tutorial mode was more readily implementable than in traditional CAI.

Over 550 students used the system for over 1900 student hours studying one of the fifteen modules. All classes that ran pre-tests and post-tests found a slight positive advantage in favour of the COMIT students. The increment is not statistically significant, but the trend is encouraging and rewarding for unique research hardware and first time authors of CAI.

The use of multi-media expands the range of topics that can readily be implemented via CAI. Some of the modules would never have been tried without media. No significant increase in computer resource was required to accommodate the multi-media.

More people, vis-a-vis conventional CAI, are required to obtain effective utilization of the audio and video functions. Assistance from Audio/Visual, Graphic Services and the Language Laboratory were required and greatly appreciated.

Authoring Approach

A team approach was used. As professors' time was voluntary, we attempted to use them as subject matter experts only. Co-op students were given training in authoring, coding, and making calls. Their function was to interact with the professors in documenting the objectives and the flow of the presentation. From the professor's script or lesson notes, they prepared a storyboard which showed the detailed content on the screen and on the audio tape. As well, it included pictures and graphics. Once the level of documentation was satisfactory to the team members, the student coded it. Only one professor did his own coding. By using the team approach, we feel we best utilized the time and talent of the subject matter expert. The co-op students were challenged with new content and utilization of time. Their innovativeness produced some beneficial by-products such as code and improved techniques.

The ability to use still images under computer control and the digitizing aspect of the pen were great time savers for the team. Still images saved a large amount of verbalizing, and digitizing allowed those blackboard kinds of sketches and diagrams to be easily included.

Professors' Reactions

Quality of teaching was enhanced by allowing some of the course material to be removed from the lecture load. Pre-requisite or supplemental material was put on the terminal system. Also, the COMIT module could include more learning alternatives than could be used in a class. An example is the Economics module. The computer module would greatly assist in detecting the problems of students in a particular topic, so that they could spend the tutorial on a discussion of a specific problem.



1. The first part of the document is a list of the names of the authors of the papers presented at the conference. The names are listed in alphabetical order.

2. The second part of the document is a list of the titles of the papers presented at the conference. The titles are listed in alphabetical order.

3. The third part of the document is a list of the abstracts of the papers presented at the conference. The abstracts are listed in alphabetical order.

4. The fourth part of the document is a list of the full texts of the papers presented at the conference. The full texts are listed in alphabetical order.

5. The fifth part of the document is a list of the conclusions of the papers presented at the conference. The conclusions are listed in alphabetical order.

6. The sixth part of the document is a list of the recommendations of the papers presented at the conference. The recommendations are listed in alphabetical order.

7. The seventh part of the document is a list of the references of the papers presented at the conference. The references are listed in alphabetical order.

8. The eighth part of the document is a list of the acknowledgments of the papers presented at the conference. The acknowledgments are listed in alphabetical order.

9. The ninth part of the document is a list of the appendices of the papers presented at the conference. The appendices are listed in alphabetical order.

10. The tenth part of the document is a list of the index of the papers presented at the conference. The index is listed in alphabetical order.

11. The eleventh part of the document is a list of the glossary of the papers presented at the conference. The glossary is listed in alphabetical order.

12. The twelfth part of the document is a list of the bibliography of the papers presented at the conference. The bibliography is listed in alphabetical order.

13. The thirteenth part of the document is a list of the list of the papers presented at the conference. The list is listed in alphabetical order.

14. The fourteenth part of the document is a list of the list of the papers presented at the conference. The list is listed in alphabetical order.

15. The fifteenth part of the document is a list of the list of the papers presented at the conference. The list is listed in alphabetical order.

16. The sixteenth part of the document is a list of the list of the papers presented at the conference. The list is listed in alphabetical order.

17. The seventeenth part of the document is a list of the list of the papers presented at the conference. The list is listed in alphabetical order.

18. The eighteenth part of the document is a list of the list of the papers presented at the conference. The list is listed in alphabetical order.

19. The nineteenth part of the document is a list of the list of the papers presented at the conference. The list is listed in alphabetical order.

20. The twentieth part of the document is a list of the list of the papers presented at the conference. The list is listed in alphabetical order.

21. The twenty-first part of the document is a list of the list of the papers presented at the conference. The list is listed in alphabetical order.

22. The twenty-second part of the document is a list of the list of the papers presented at the conference. The list is listed in alphabetical order.

23. The twenty-third part of the document is a list of the list of the papers presented at the conference. The list is listed in alphabetical order.

24. The twenty-fourth part of the document is a list of the list of the papers presented at the conference. The list is listed in alphabetical order.

25. The twenty-fifth part of the document is a list of the list of the papers presented at the conference. The list is listed in alphabetical order.

26. The twenty-sixth part of the document is a list of the list of the papers presented at the conference. The list is listed in alphabetical order.

27. The twenty-seventh part of the document is a list of the list of the papers presented at the conference. The list is listed in alphabetical order.

28. The twenty-eighth part of the document is a list of the list of the papers presented at the conference. The list is listed in alphabetical order.

29. The twenty-ninth part of the document is a list of the list of the papers presented at the conference. The list is listed in alphabetical order.

30. The thirtieth part of the document is a list of the list of the papers presented at the conference. The list is listed in alphabetical order.

31. The thirty-first part of the document is a list of the list of the papers presented at the conference. The list is listed in alphabetical order.

32. The thirty-second part of the document is a list of the list of the papers presented at the conference. The list is listed in alphabetical order.

33. The thirty-third part of the document is a list of the list of the papers presented at the conference. The list is listed in alphabetical order.

34. The thirty-fourth part of the document is a list of the list of the papers presented at the conference. The list is listed in alphabetical order.

35. The thirty-fifth part of the document is a list of the list of the papers presented at the conference. The list is listed in alphabetical order.

36. The thirty-sixth part of the document is a list of the list of the papers presented at the conference. The list is listed in alphabetical order.

37. The thirty-seventh part of the document is a list of the list of the papers presented at the conference. The list is listed in alphabetical order.

38. The thirty-eighth part of the document is a list of the list of the papers presented at the conference. The list is listed in alphabetical order.

COMPUTER AIDED TEACHING IN ENVIRONMENTAL ENGINEERING

The computer is a powerful tool for the environmental engineer. It can be used to model the behavior of complex systems, to analyze data, and to design systems. The computer can also be used to teach environmental engineering. This paper discusses the use of the computer in environmental engineering education. It describes the advantages of computer-aided teaching and presents a number of examples of its use. The examples include the use of the computer to model the behavior of a wastewater treatment plant, to analyze data from a water quality monitoring system, and to design a water supply system. The paper concludes by discussing the future of computer-aided teaching in environmental engineering.

the availability of micro organisms, the availability of nutrients, and the temperature of the material. Because of the difficulties involved in the conditions for a satisfactory culture, it is often necessary to use a special method of cultivation, such as the use of a special medium, or the use of a special incubator.

A special method of cultivation is the use of a special medium. A special medium is a mixture of nutrients and other substances which are necessary for the growth of the micro organism. The special medium is usually a liquid, and it is usually contained in a special container, such as a test tube or a flask. The special medium is usually prepared by a special method, and it is usually used in a special way. The special medium is usually used to cultivate the micro organism in a special way, such as the use of a special incubator, or the use of a special method of cultivation.

1. The use of a special medium.

2. The use of a special incubator.

3. The use of a special method of cultivation.

on that might result from an awareness of the experiences of the

as

in the case of the first group, the results of the study
 in the case of the second group, the results of the study
 in the case of the third group, the results of the study

the

the

the

the

the

the

the

the

the

the

the

the

the

the

the

the

the

the

the

the

the

the

the

the

the

the

the

the

the

the

the

the

the

the

the

the

is no significant statistical difference between the apparent learned experiences of the control and the 16 hour mode participants.

A pool of 6 mm (2.4 in) water was the only water

1 1 1 1 1

[illegible]

Conclusion

As a large number of the students in the sample were from the same school, the results of the study may not be generalizable to other schools. The study was limited by the small sample size and the lack of a control group. The study was also limited by the lack of a long-term follow-up. The study was limited by the lack of a control group. The study was limited by the lack of a long-term follow-up.

The study was limited by the lack of a control group.

The study was limited by the lack of a long-term follow-up.

The study was limited by the lack of a control group.

The study was limited by the lack of a long-term follow-up.

The study was limited by the lack of a control group.

The study was limited by the lack of a long-term follow-up.

The study was limited by the lack of a control group.

The study was limited by the lack of a long-term follow-up.

THE UNIVERSITY OF CHICAGO

THE ARCHIVES OF THE UNIVERSITY OF CHICAGO

1

2

3

4

TABLE 2: Results from Quota Sampling Experiment

Student:	Sample Totals						Sample Percentages	True Population Percentages
	JY	PH	FY	MW	JD	All		
<u>Occupation Class of Household Head</u>								
Managerial	3	4	4	1	4	16	21.9	22.7
Professional	3	4	2	1	0	10	13.7	16.3
Clerical	1	1	0	3	2	7	9.6	10.9
Sales	0	2	1	1	2	6	8.2	8.2
Service	0	0	0	0	0	0	0	3.2
Craftsman	5	3	5	6	6	25	23.2	26.8
Labourer	0	0	0	0	0	0	0	4.0
Other	<u>3</u>	<u>1</u>	<u>1</u>	<u>3</u>	<u>1</u>	<u>9</u>	<u>12.4</u>	<u>7.9</u>
	15	15	13	15	15	73	100.0	100.0
<u>Answer to Q1</u>								
Yes	10	9	10	10	10	49	68.0	74.3
No	3	4	1	4	5	17	23.6	20.5
Don't Know	<u>2</u>	<u>2</u>	<u>1</u>	<u>1</u>	<u>0</u>	<u>6</u>	<u>8.4</u>	<u>5.2</u>
	15	15	12	15	15	72	100.0	100.0
<u>Answer to Q2</u>								
Yes, strongly	2	3	2	1	2	10	13.9	17.0
Yes	6	5	3	2	3	19	26.4	34.9
No opinion	2	0	2	5	3	12	16.7	11.2
No	4	6	4	5	6	25	34.7	26.0
No, strongly	<u>1</u>	<u>1</u>	<u>1</u>	<u>2</u>	<u>1</u>	<u>6</u>	<u>8.3</u>	<u>10.9</u>
	15	15	12	15	15	72	100.0	100.0
<u>Location</u>								
Zone 1	5	1	1	-	1	8	13.8	18.9
Zone 2	3	3	3	-	4	13	22.4	19.2
Zone 3	7	6	2	-	7	22	37.9	31.6
Zone 4	<u>0</u>	<u>5</u>	<u>7</u>	-	<u>3</u>	<u>15</u>	<u>25.9</u>	<u>30.3</u>
	15	15	13	-	15	58	100.0	100.0
<u>Building Type</u>								
Townhouse	0	0	0	-	0	0	0.0	8.2
Apartment	1	0	0	-	1	2	3.4	16.5
Other	<u>14</u>	<u>15</u>	<u>13</u>	-	<u>14</u>	<u>56</u>	<u>96.6</u>	<u>75.3</u>
	15	15	13	-	15	58	100.0	100.0

they ought to do something about all the dirty soap operas" (no, strongly). They found the exercise itself reasonably enjoyable and not difficult (according to one student, not difficult enough). They seemed to be quite interested in the results of the combined sample.

The Probability Sampling Exercise:

The exercise called STRATA SAMPLING is more technical in nature. Here the student is not to "interview" occupants of the households, but is required to "design" a probability sample for gathering household characteristics and to "test" the design.

The first thing that the student is asked to do is to "stratify" the blocks of the town into non-overlapping "strata". He or she may designate the town as one large stratum, or may stratify the town into the four zones, or may assign blocks to strata in any other way. The sample of households will then be the union of subsamples, one from each stratum. The student is asked to specify the number of households to be selected in each of the subsamples. He or she must then specify the sampling design to be used for the subsamples, and has four options (see [1] for definitions of the terminology):

- A: simple random sampling of households
- B: systematic sampling of households
- C: two stage sampling, in which a simple random sample of blocks is selected first, and the households to be sampled are selected from these blocks
- D: further stratification by building type, followed by simple random sampling within strata.

If C or D is chosen, there are more detailed sample size specifications to be made.

Once the design is completely specified, the program implements the design once, and displays estimates of quantities like the proportion of households with head having a specified occupation, or the average number of children aged 0-4 per household; together with these are shown estimated standard errors of estimation. It also prints out the true population value

for each quantity and the theoretical standard error of estimation under the design.

In the associated laboratory assignment in the Winter of 1978 the students were asked to try out the various options, with design parameters given to them, for a sample of total size 75. They were then asked to examine the results to see if they were in accordance with theory. For example, theoretically a dispersed sample (systematic or stratified by zone and allocated to the zones proportionally) should be relatively efficient, and tend to have lower theoretical standard errors than a clustered sample (two stage with several households chosen from each sampled block). The students were asked to compare the performance of these samples with that of the quota sample in estimating the distribution of occupation of household head. Finally, they were asked to design a sample which would be more "efficient" than any of the prescribed ones for estimating the average number of preschool children per household.

An unexpected feature of this exercise was the finding that as in real life, there were results for some of the prescribed designs which did not apparently agree with theory! Apart from some confusion, the effects of this were largely beneficial, since the author was forced to spend a good deal of time and effort trying to convince the students that the theory could be relied upon in general.

Conclusions:

Because of the small size of the class on which the module was tested, and because of difficulties encountered with the operation and scheduling of the second exercise, conclusions about the effectiveness of the module as a teaching tool must be tentative. Continued use of the module in future terms is planned, however, and more definite conclusions should be available at a later date.

Happily it appeared by the end of the second exercise that the notions (i), (iii) and (iv) mentioned in the Introduction had been conveyed to most of the students (more could have been done with (ii), in a classroom Monte Carlo study, if more time had been available). In addition, the impression gained was that this sort of simulation of survey situations could

for each quantity and the theoretical standard error of estimation under the design.

In the associated laboratory assignment in the Winter of 1978 the students were asked to try out the various options, with design parameters given to them, for a sample of total size 75. They were then asked to examine the results to see if they were in accordance with theory. For example, theoretically a dispersed sample (systematic or stratified by zone and allocated to the zones proportionally) should be relatively efficient, and tend to have lower theoretical standard errors than a clustered sample (two stage with several households chosen from each sampled block). The students were asked to compare the performance of these samples with that of the quota sample in estimating the distribution of occupation of household head. Finally, they were asked to design a sample which would be more "efficient" than any of the prescribed ones for estimating the average number of preschool children per household.

An unexpected feature of this exercise was the finding that as in real life, there were results for some of the prescribed designs which did not apparently agree with theory! Apart from some confusion, the effects of this were largely beneficial, since the author was forced to spend a good deal of time and effort trying to convince the students that the theory could be relied upon in general.

Conclusions:

Because of the small size of the class on which the module was tested, and because of difficulties encountered with the operation and scheduling of the second exercise, conclusions about the effectiveness of the module as a teaching tool must be tentative. Continued use of the module in future terms is planned, however, and more definite conclusions should be available at a later date.

Happily it appeared by the end of the second exercise that the notions (i), (iii) and (iv) mentioned in the Introduction had been conveyed to most of the students (more could have been done with (ii), in a classroom Monte Carlo study, if more time had been available). In addition, the impression gained was that this sort of simulation of real situations could

A COMIT MODULE ON A TOPIC FROM ADVANCED CALCULUS

by

Bev Marshman

Department of Applied Mathematics

Abstract: This is a report on an experiment conducted with three successive second year calculus classes, in which part of each class was taught the concept of uniform convergence of a sequence of functions by an interactive COMIT module, while the remainder were given lectures in the traditional manner. An outline of the teaching techniques used in the module is followed by a comparison of the performances of the two groups on a pre-test, post-test, mid-term, and final exam. Finally, an attempt is made to evaluate the significance of any differences in the above results, and to assess the assets and liabilities of computer-aided teaching in general.

Introduction:

This project was very much a joint effort of myself and L. J. Makela, then a graduate student in the Department of Computer Science. Basically, I developed the course content, while he took charge of the programming, although there was much interaction at all stages. Since details of the software are included in his master's thesis [1], I would refer anyone interested in the computing aspects of the module's development to that source. In this report, I'll generally stick to a discussion of the teaching techniques we utilized.

Our principal aims were threefold. First, we wanted to see if the graphics capabilities and interactive nature of the COMIT facilities could be used effectively to convey the concept of uniform convergence of a sequence of functions to second year calculus students (irrespective of the effort and cost involved). Secondly, we wanted to compare the performance, both short-term and long-term, of the students who learned the topic through the COMIT module (approximately one-third of each group) with that of the remainder, to see if there were any detectable differences. Finally, we wished to assess, as far as possible, the advantages and disadvantages of this medium in general.

The Module:

The subject material of the module, uniform convergence of a sequence of functions, was chosen for a variety of reasons: it is most easily interpreted geometrically, and would thus utilize the graphics capabilities of COMIT; it is a concept which frequently gives students difficulty, and would, we hoped, truly test the system as a teaching device; finally, it is about the right length. The first stage was development of a set of behavioural objectives, which break the topic down into distinct steps, each building on the previous ones until the 'terminal objectives' are reached. These steps were then further dissected, examples selected, and a flow chart designed for each. Several months of programming followed, and the module was ready for use early in 1977. (For more details on all aspects of the structure of the module, see [1].)

The main teaching technique used was a combination of allowing the students to display for themselves the graphical behaviour of the functions involved while at the same time continuously soliciting answers to pertinent questions. In the following, one of the principal ideas contained in the module is presented (although not verbatim), along with explanations of what the student might have done and seen in that portion of the module; hopefully, this will clarify how the above-mentioned technique was utilized. (Anyone not interested in the actual content of the module can ignore the balance of this section, as it is not essential to the remainder of the report.)

A sequence of functions, denoted $f_n(x)$, is just a set of functions of a variable x ; one for each value $n = 1, 2, 3, \dots$. For example, consider the sequence $f_n(x) = x^n$, several terms of which are shown in Figure 1. Note that each term of the sequence is a single function of x .

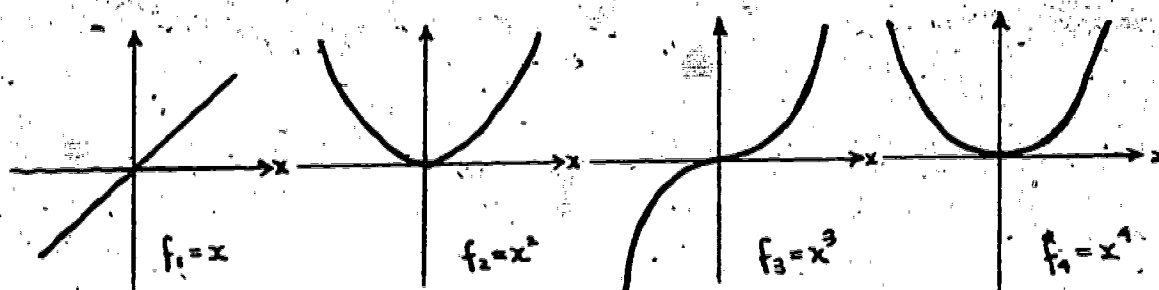


Figure 1

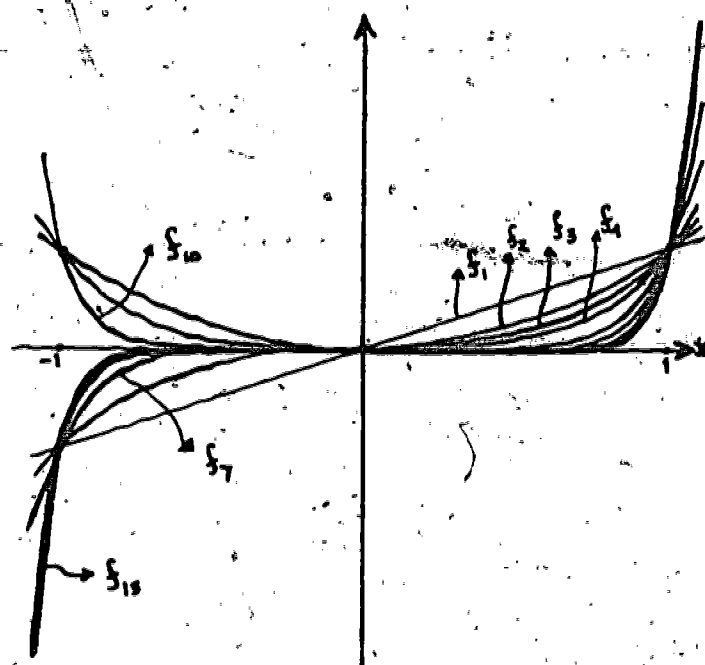


Figure 2

In the COMIT module, the student could choose to see any terms desired, but each was superimposed on the previous graphs, with the latest displayed in bright white and the former choices dimmed to a pale green. Thus a student who had asked, in turn, for terms $n = 1, 2, 3, 4, 7, 10$ and 13 on the interval $[-1.1, 1.1]$ would, in the end, see Figure 2 displayed on the screen, with the graph of $f_{13}(x)$ displayed most brightly. (Note: To facilitate the fit, the vertical scale in this figure has been compressed)

This example was then re-used to illustrate the notion of pointwise convergence: the sequence $f_n(x)$ converges pointwise at $x = x_0$ if the sequence of real numbers $f_1(x_0), f_2(x_0), f_3(x_0), \dots$ approaches a certain value as n gets larger. For example, if $f_n(x) = x^n$, and $x_0 = \frac{1}{2}$, we get the sequence $\frac{1}{2}, (\frac{1}{2})^2, (\frac{1}{2})^3, \dots$ or $\frac{1}{2}, \frac{1}{4}, \frac{1}{8}, \dots, \frac{1}{2^n}$ which obviously approaches zero as n gets

large. (When this happens, we say the sequence has a limit and write, for example, $\lim_{n \rightarrow \infty} \frac{1}{2^n} = 0$.) On the other hand, if we choose $x_0 = -1$, we get $(-1), (-1)^2, (-1)^3, \dots$, or $-1, 1, -1, 1, -1, \dots$ which does not approach any particular value as n gets larger. A moment's thought will convince you that the sequence x^n will only have a limit for values of x such that $-1 < x < 1$; i.e. either x is a fraction, so that x^n approaches 0 as n gets large, or $x = 1$, which gives the sequence $1, 1, 1, \dots$. We say, then, that the sequence $f_n(x) = x^n$ has limit function

$$f(x) = \begin{cases} 0 & \text{if } |x| < 1, \\ 1 & \text{if } x = 1. \end{cases}$$

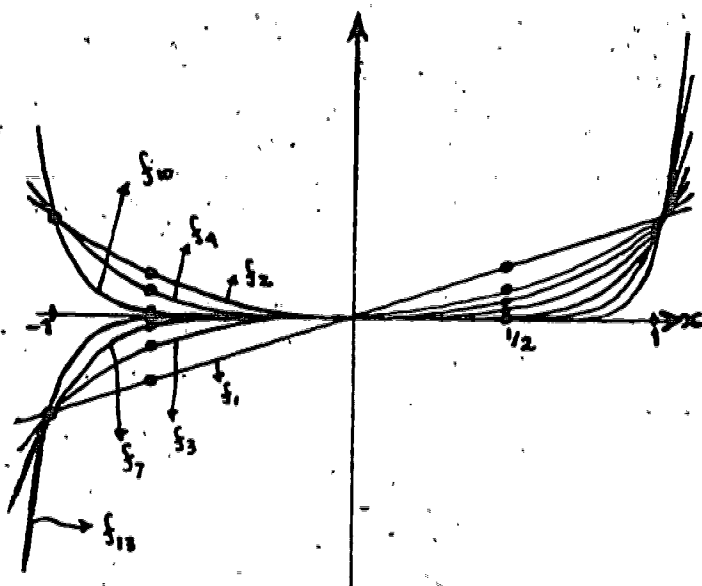


Figure 3

We again utilized graphics to illustrate this in the COMIT module; the convergent sequences for $x = \frac{1}{2}$, and $x = -\frac{2}{3}$, for example, are displayed as the vertical rows of dots in Figure 3. It is clear that they approach zero, while $x = -1$, say, oscillates between 1 and -1. (Here, 'approach zero' means the dots get arbitrarily close to the x-axis as $n \rightarrow \infty$.)

Once the concept of pointwise convergence had been presented, the student was allowed to 'play' with several other examples of sequences, using the graphics capabilities of the system to assist in finding for which values of x each sequence converged, and to what limit function $f(x)$. The student's grasp of the material was constantly monitored by a variety of types of questions (including some multiple choice), with immediate feedback giving the proper reasoning when errors

were made.

It should be pointed out that the above is a simplification of the actual material presented (mathematical rigour not being the object here); the aim was simply to demonstrate that the ideas could be handled graphically, and to give a hint of how this was done. (Complete flow charts of actual material are contained in [1].)

Structure of the Experiment:

From each of three different classes of students in Math 230B (Advanced Calculus), we selected ten students to use the module by first ranking them according to their Math 230A grades, then selecting every third student; the remainder of each group attended the usual two lectures on this topic, all being given basically the same two lectures by the author. All the students were given, unannounced, a pre-test just prior to the experiment (to measure their background in the relevant area), and a post-test, immediately following, to measure their grasp of the topic at that point. In addition, grades on the relevant questions on mid-term (except for group 2, where no mid-term was given) and final examination were recorded for each student, to serve as a measure of long-term retention of the material, although it should be noted that they are probably not very reliable indicators of any effect of the module or lectures encountered initially, since by that time many other factors will have come into play.

The students who used the module were given a set of notes which roughly paralleled the material in the module, except the interactive portions. These same notes were used as a basis for the lectures given to the remainder of each group, in hopes that all students would be exposed to more or less the same material.

Statistical Analysis:

I wish to thank G. W. Bennett of the Department of Statistics for the summary which comprises the balance of this section: further details

31

analysis may be obtained from him. Data used are the scores on the above-mentioned tests and exams, converted to percentages. Throughout the following, PRE and POST refer to pre-test and post-test grades, respectively, COMIT and NON-COMIT refer to the portions of each group using the module and attending lectures, respectively, and T1, T2, T3, and T4 refer to pre-test, post-test, mid-term, and final examination grades, respectively.

Table 1 illustrates the performances of COMIT and NON-COMIT on the pre-test and post-test for each of the three groups. The figures in brackets indicate the number expected in that cell under the hypothesis that there is no relationship between COMIT and $POST > PRE$. In all three groups, the figures are consistent with this hypothesis; that is, any differences are well within the allowable error.

An analysis of variance on $-\ln(\text{grade})$ was done as a nested factorial with main factors COMIT, NON-COMIT, T1, T2, T3, T4, and students as a factor nested within the COMIT factor. This analysis shows a significant time effect for Groups 1 and 3, but with no significant differences between COMIT and NON-COMIT insofar as their patterns go. In Group 2, there were no significant effects, although the error terms were large enough to make differences difficult to detect.

Table 2 gives the means of grades on the various tests for each group.

In summary: (i) there is no evidence that COMIT versus NON-COMIT is related to the fraction of students with $POST > PRE$; (ii) there is some evidence that over time, the students learn, in that T3 is greater than T1 and T2, although again, there is no evidence that COMIT students behave any differently from NON-COMIT students in this respect.

It is important to note that the various marks measured performance under different conditions in that T1 and T2 are local to the

	GROUP 1			GROUP 2			GROUP 3		
TYPE OF STUDENT	NO. WITH POST > PRE	NO. WITH POST < PRE	TOTAL (30)	NO. WITH POST > PRE	NO. WITH POST < PRE	TOTAL (32)	NO. WITH POST > PRE	NO. WITH POST < PRE	TOTAL (27)
COMIT	7 (6.7)	3 (3.3)	10	6 (5)	4 (5)	10	7 (6.7)	3 (3.3)	10
NON-COMIT	7 (10.3)	13 (9.7)	20	10 (11)	12 (11)	22	11 (11.3)	6 (5.7)	17
TOTALS	14	16	20	16	16	32	18	9	27

Table 1: Comparison of COMIT and NON-COMIT Students Results on Pre-test and Post-test. Three separate groups of students were involved.

	GROUP 1				GROUP 2			GROUP 3			
	T1	T2	T3	T4	T1	T2	T4	T1	T2	T3	T4
COMIT	.729	.821	.821	.780	.494	.594	.630	.538	.713	.787	.480
NON-COMIT	.607	.655	.869	.663	.632	.639	.564	.479	.686	.719	.414
COMMENT	This difference is mostly T3 improvement over T1 and T2.				No significant time pattern.			The bulk is due to the steady rise T1 → T2 → T3 and the sudden fall T3 → T4, although a significant T2-T1 component does not exist.			

Table 2: Comparison of Mean Grades for COMIT and NON-COMIT Students on Pre-test (T1), Post-test (T2), Mid-term Test (T3) and Final Exam (T4).

material, whereas T3 is only as a component of about half the course, while T4 is as a component of the whole course. Study preferences may influence T3 and T4.

Conclusions:

Our primary aim, that of testing the capabilities of COMIT as a teaching device for mathematical material, was fully achieved, and with great success. Aside from some complaints about the response time of the computer, over which we had no control, student reaction to the module was very favourable. The following is a selection of more or less typical quotes from the written comments handed in on completion of the module:

"I feel that seeing the graphs and being able to experiment with various n 's and x 's greatly helped me understand the concept of uniform convergence..... Another advantage of this teaching method is that it requires active participation of the student, where in a class, full attention is not always given."

"... I was forced to respond to questions all the time and thus take part in what was going on...."

"The graphical aspect certainly added to the comprehension..."

"Being able to go at your own pace and having things repeated when you didn't catch a concept was helpful. The use of examples with immediate feedback and explanations of how to do the questions was good also."

"The advantage was that I had to be on the alert all the time and thus I learned more about the topic. In class I normally feel sleepy sometimes The idea of asking questions after each section was a good one. It tested the student's ability to retain the work."

Some of the students thought even more examples should have been included; some would have preferred two one-hour sessions rather than one two-hour, as their attention flagged towards the end. It should also be pointed out that the novelty of the situation probably contributed somewhat to their enthusiasm. I feel quite strongly, however, that the immediacy of the feedback is a really valuable asset of computer-aided instruction; we don't ever learn much by listening to someone talk about something; we learn by trying things out, making errors, correcting for them, and trying again. It is in this aspect that an interactive system excels.

Regarding our second aim, that of comparing the performances of COMIT versus NON-COMIT students, the statistical results speak for themselves: any differences are well within allowable error. The post-test grades, which are certainly the measures most closely related to the material presented in the module, were obtained on a ten-minute quiz, and it could be questioned whether such a quiz could test anything in depth. Nevertheless, it was designed to test whether their knowledge was at a level acceptable for that topic in that particular course, and as such represents as extensive a performance test as would ever be required. Keeping this in mind, we conclude that using COMIT did not produce perceptibly better performance (at least as we measure it) from the COMIT students over the NON-COMIT students. Whether that means they did or did not understand the concepts any better is quite another question!

Our third and final aim was to assess some of the advantages and disadvantages of the medium in general. The obvious ones have already been mentioned: the student sets the pace at which the material is covered; the constant stimulus provided by the interaction with the terminal keeps interest up, and accelerates assimilation of the concepts; the explanations given after each error provide a degree of 'personal' attention impossible in a lecture where there are more than half a dozen students. It is true that attempts to go to an interactive system like COMIT do not get the benefit

of the other end of the spectrum, and I think it is a very important
 in a lecture situation, but I think it is a case where I think it is
 very important, particularly, since we are in a very important
 large lecture hall, and I think it is a very important

of the other end of the spectrum, and I think it is a very important
 in a lecture situation, but I think it is a case where I think it is
 very important, particularly, since we are in a very important
 large lecture hall, and I think it is a very important
 of the other end of the spectrum, and I think it is a very important
 in a lecture situation, but I think it is a case where I think it is
 very important, particularly, since we are in a very important
 large lecture hall, and I think it is a very important
 of the other end of the spectrum, and I think it is a very important
 in a lecture situation, but I think it is a case where I think it is
 very important, particularly, since we are in a very important
 large lecture hall, and I think it is a very important

AN O'GADIN DE THES IS

by

JOHN

DE THES

JOHN DE THES

JOHN DE THES

JOHN DE THES

JOHN DE THES

JOHN DE THES
 had agreed to do so. A great many of the
 pointed out to you that the blame for the
 practical result of the war was the same as
 the fact that the war was the same as the
 serve to enhance our standing and our skill in
 the way of our own interests.

ORGAN
CLASSROOM CIRCA 19 8

CLASSROOM M CIRCA 19 8

- Fig. 1. Schematic diagram of the experimental setup.
1. The subject is seated in a chair.
 2. The subject is wearing a head-mounted display (HMD).
 3. The subject is viewing a virtual environment (VE) through the HMD.
 4. The subject is interacting with the VE using a controller.
 5. The subject is receiving feedback from the VE.
 6. The subject is performing a task in the VE.

The experimental setup is designed to study the effects of the HMD on the user's performance in the VE. The HMD is used to provide the user with a sense of presence in the VE. The controller is used to allow the user to interact with the VE. The feedback is used to provide the user with information about their performance in the VE. The task is used to measure the user's performance in the VE.

The first of these is the fact that the first of these three
 subjected to a very high level of analysis. These were 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100, 101, 102, 103, 104, 105, 106, 107, 108, 109, 110, 111, 112, 113, 114, 115, 116, 117, 118, 119, 120, 121, 122, 123, 124, 125, 126, 127, 128, 129, 130, 131, 132, 133, 134, 135, 136, 137, 138, 139, 140, 141, 142, 143, 144, 145, 146, 147, 148, 149, 150, 151, 152, 153, 154, 155, 156, 157, 158, 159, 160, 161, 162, 163, 164, 165, 166, 167, 168, 169, 170, 171, 172, 173, 174, 175, 176, 177, 178, 179, 180, 181, 182, 183, 184, 185, 186, 187, 188, 189, 190, 191, 192, 193, 194, 195, 196, 197, 198, 199, 200, 201, 202, 203, 204, 205, 206, 207, 208, 209, 210, 211, 212, 213, 214, 215, 216, 217, 218, 219, 220, 221, 222, 223, 224, 225, 226, 227, 228, 229, 230, 231, 232, 233, 234, 235, 236, 237, 238, 239, 240, 241, 242, 243, 244, 245, 246, 247, 248, 249, 250, 251, 252, 253, 254, 255, 256, 257, 258, 259, 260, 261, 262, 263, 264, 265, 266, 267, 268, 269, 270, 271, 272, 273, 274, 275, 276, 277, 278, 279, 280, 281, 282, 283, 284, 285, 286, 287, 288, 289, 290, 291, 292, 293, 294, 295, 296, 297, 298, 299, 300, 301, 302, 303, 304, 305, 306, 307, 308, 309, 310, 311, 312, 313, 314, 315, 316, 317, 318, 319, 320, 321, 322, 323, 324, 325, 326, 327, 328, 329, 330, 331, 332, 333, 334, 335, 336, 337, 338, 339, 340, 341, 342, 343, 344, 345, 346, 347, 348, 349, 350, 351, 352, 353, 354, 355, 356, 357, 358, 359, 360, 361, 362, 363, 364, 365, 366, 367, 368, 369, 370, 371, 372, 373, 374, 375, 376, 377, 378, 379, 380, 381, 382, 383, 384, 385, 386, 387, 388, 389, 390, 391, 392, 393, 394, 395, 396, 397, 398, 399, 400, 401, 402, 403, 404, 405, 406, 407, 408, 409, 410, 411, 412, 413, 414, 415, 416, 417, 418, 419, 420, 421, 422, 423, 424, 425, 426, 427, 428, 429, 430, 431, 432, 433, 434, 435, 436, 437, 438, 439, 440, 441, 442, 443, 444, 445, 446, 447, 448, 449, 450, 451, 452, 453, 454, 455, 456, 457, 458, 459, 460, 461, 462, 463, 464, 465, 466, 467, 468, 469, 470, 471, 472, 473, 474, 475, 476, 477, 478, 479, 480, 481, 482, 483, 484, 485, 486, 487, 488, 489, 490, 491, 492, 493, 494, 495, 496, 497, 498, 499, 500, 501, 502, 503, 504, 505, 506, 507, 508, 509, 510, 511, 512, 513, 514, 515, 516, 517, 518, 519, 520, 521, 522, 523, 524, 525, 526, 527, 528, 529, 530, 531, 532, 533, 534, 535, 536, 537, 538, 539, 540, 541, 542, 543, 544, 545, 546, 547, 548, 549, 550, 551, 552, 553, 554, 555, 556, 557, 558, 559, 560, 561, 562, 563, 564, 565, 566, 567, 568, 569, 570, 571, 572, 573, 574, 575, 576, 577, 578, 579, 580, 581, 582, 583, 584, 585, 586, 587, 588, 589, 590, 591, 592, 593, 594, 595, 596, 597, 598, 599, 600, 601, 602, 603, 604, 605, 606, 607, 608, 609, 610, 611, 612, 613, 614, 615, 616, 617, 618, 619, 620, 621, 622, 623, 624, 625, 626, 627, 628, 629, 630, 631, 632, 633, 634, 635, 636, 637, 638, 639, 640, 641, 642, 643, 644, 645, 646, 647, 648, 649, 650, 651, 652, 653, 654, 655, 656, 657, 658, 659, 660, 661, 662, 663, 664, 665, 666, 667, 668, 669, 670, 671, 672, 673, 674, 675, 676, 677, 678, 679, 680, 681, 682, 683, 684, 685, 686, 687, 688, 689, 690, 691, 692, 693, 694, 695, 696, 697, 698, 699, 700, 701, 702, 703, 704, 705, 706, 707, 708, 709, 710, 711, 712, 713, 714, 715, 716, 717, 718, 719, 720, 721, 722, 723, 724, 725, 726, 727, 728, 729, 730, 731, 732, 733, 734, 735, 736, 737, 738, 739, 740, 741, 742, 743, 744, 745, 746, 747, 748, 749, 750, 751, 752, 753, 754, 755, 756, 757, 758, 759, 760, 761, 762, 763, 764, 765, 766, 767, 768, 769, 770, 771, 772, 773, 774, 775, 776, 777, 778, 779, 780, 781, 782, 783, 784, 785, 786, 787, 788, 789, 790, 791, 792, 793, 794, 795, 796, 797, 798, 799, 800, 801, 802, 803, 804, 805, 806, 807, 808, 809, 810, 811, 812, 813, 814, 815, 816, 817, 818, 819, 820, 821, 822, 823, 824, 825, 826, 827, 828, 829, 830, 831, 832, 833, 834, 835, 836, 837, 838, 839, 840, 841, 842, 843, 844, 845, 846, 847, 848, 849, 850, 851, 852, 853, 854, 855, 856, 857, 858, 859, 860, 861, 862, 863, 864, 865, 866, 867, 868, 869, 870, 871, 872, 873, 874, 875, 876, 877, 878, 879, 880, 881, 882, 883, 884, 885, 886, 887, 888, 889, 890, 891, 892, 893, 894, 895, 896, 897, 898, 899, 900, 901, 902, 903, 904, 905, 906, 907, 908, 909, 910, 911, 912, 913, 914, 915, 916, 917, 918, 919, 920, 921, 922, 923, 924, 925, 926, 927, 928, 929, 930, 931, 932, 933, 934, 935, 936, 937, 938, 939, 940, 941, 942, 943, 944, 945, 946, 947, 948, 949, 950, 951, 952, 953, 954, 955, 956, 957, 958, 959, 960, 961, 962, 963, 964, 965, 966, 967, 968, 969, 970, 971, 972, 973, 974, 975, 976, 977, 978, 979, 980, 981, 982, 983, 984, 985, 986, 987, 988, 989, 990, 991, 992, 993, 994, 995, 996, 997, 998, 999, 1000.

Fig. 2. (continued)

Fig. 2. (continued)

Fig. 2. (continued)

Fig. 2. (continued)

Fig. 2. (continued)

Fig. 2. (continued)

Fig. 2. (continued)

Fig. 2. (continued)

Fig. 2. (continued)

Fig. 2. (continued)

Fig. 2. (continued)

Fig. 2. (continued)

Fig. 2. (continued)

Fig. 2. (continued)

Fig. 2. (continued)

Fig. 2. (continued)

Fig. 2. (continued)

Fig. 2. (continued)

Fig. 2. (continued)

Fig. 2. (continued)

Fig. 2. (continued)

Fig. 2. (continued)

Fig. 2. (continued)

Fig. 2. (continued)

Fig. 2. (continued)

Fig. 2. (continued)

Fig. 2. (continued)

Fig. 2. (continued)

Fig. 2. (continued)

Fig. 2. (continued)

Fig. 2. (continued)

Fig. 2. (continued)

Fig. 2. (continued)

Fig. 2. (continued)

Fig. 2. (continued)

Fig. 2. (continued)

•

•

•

•

•

•

•

1

2

3

4

5

6

1

•

•

•

•

•

•

•

•

•

•

•

•

•

•

•

•

•

•

•

•

•

•

•

•

•

•

•

•

•

•

•

•

•

•

•

•

•

•

•

•

•

•

•

•

•

•

•

•

•

•

•

•

•

•

•

•

•

•

•

•

•

•

•

•

•

•

•

•

•

•

•

•

•

•

•

•

•

•

•

•

•

•

•

•

•

•

•

•

•

•

•

•

•

•

•

•

•

•

$\frac{1}{2}$ $\frac{1}{4}$ $\frac{1}{8}$ $\frac{1}{16}$ $\frac{1}{32}$ $\frac{1}{64}$ $\frac{1}{128}$ $\frac{1}{256}$ $\frac{1}{512}$ $\frac{1}{1024}$ $\frac{1}{2048}$ $\frac{1}{4096}$ $\frac{1}{8192}$ $\frac{1}{16384}$ $\frac{1}{32768}$ $\frac{1}{65536}$ $\frac{1}{131072}$ $\frac{1}{262144}$ $\frac{1}{524288}$ $\frac{1}{1048576}$ $\frac{1}{2097152}$ $\frac{1}{4194304}$ $\frac{1}{8388608}$ $\frac{1}{16777216}$ $\frac{1}{33554432}$ $\frac{1}{67108864}$ $\frac{1}{134217728}$ $\frac{1}{268435456}$ $\frac{1}{536870912}$ $\frac{1}{1073741824}$ $\frac{1}{2147483648}$ $\frac{1}{4294967296}$ $\frac{1}{8589934592}$ $\frac{1}{17179869184}$ $\frac{1}{34359738368}$ $\frac{1}{68719476736}$ $\frac{1}{137438953472}$ $\frac{1}{274877906944}$ $\frac{1}{549755813888}$ $\frac{1}{1099511627776}$ $\frac{1}{2199023255552}$ $\frac{1}{4398046511104}$ $\frac{1}{8796093022208}$ $\frac{1}{17592186044416}$ $\frac{1}{35184372088832}$ $\frac{1}{70368744177664}$ $\frac{1}{140737488355328}$ $\frac{1}{281474976710656}$ $\frac{1}{562949953421312}$ $\frac{1}{1125899906842624}$ $\frac{1}{2251799813685248}$ $\frac{1}{4503599627370496}$ $\frac{1}{9007199254740992}$ $\frac{1}{18014398509481984}$ $\frac{1}{36028797018963968}$ $\frac{1}{72057594037927936}$ $\frac{1}{144115188075855872}$ $\frac{1}{288230376151711744}$ $\frac{1}{576460752303423488}$ $\frac{1}{1152921504606846976}$ $\frac{1}{2305843009213693952}$ $\frac{1}{4611686018427387904}$ $\frac{1}{9223372036854775808}$ $\frac{1}{18446744073709551616}$ $\frac{1}{36893488147419103232}$ $\frac{1}{73786976294838206464}$ $\frac{1}{147573952589676412928}$ $\frac{1}{295147905179352825856}$ $\frac{1}{590295810358705651712}$ $\frac{1}{1180591620717411303424}$ $\frac{1}{2361183241434822606848}$ $\frac{1}{4722366482869645213696}$ $\frac{1}{9444732965739290427392}$ $\frac{1}{18889465931478580854784}$ $\frac{1}{37778931862957161709568}$ $\frac{1}{75557863725914323419136}$ $\frac{1}{151115727451828646838272}$ $\frac{1}{302231454903657293676544}$ $\frac{1}{604462909807314587353088}$ $\frac{1}{1208925819614629174706176}$ $\frac{1}{2417851639229258349412352}$ $\frac{1}{4835703278458516698824704}$ $\frac{1}{9671406556917033397649408}$ $\frac{1}{19342813113834066795298816}$ $\frac{1}{38685626227668133590597632}$ $\frac{1}{77371252455336267181195264}$ $\frac{1}{154742504910672534362390528}$ $\frac{1}{309485009821345068724781056}$ $\frac{1}{618970019642690137449562112}$ $\frac{1}{1237940039285380274899124224}$ $\frac{1}{2475880078570760549798248448}$ $\frac{1}{4951760157141521099596496896}$ $\frac{1}{9903520314283042199192993792}$ $\frac{1}{19807040628566084398385987584}$ $\frac{1}{39614081257132168796771975168}$ $\frac{1}{79228162514264337593543950336}$ $\frac{1}{158456325028528675187087900672}$ $\frac{1}{316912650057057350374175801344}$ $\frac{1}{633825300114114700748351602688}$ $\frac{1}{1267650600228229401496703205376}$ $\frac{1}{2535301200456458802993406410752}$ $\frac{1}{5070602400912917605986812821504}$ $\frac{1}{10141204801825835211973625643008}$ $\frac{1}{20282409603651670423947251286016}$ $\frac{1}{40564819207303340847894502572032}$ $\frac{1}{81129638414606681695789005144064}$ $\frac{1}{162259276829213363391578010288128}$ $\frac{1}{324518553658426726783156020576256}$ $\frac{1}{649037107316853453566312041152512}$ $\frac{1}{1298074214633706907132624082305024}$ $\frac{1}{2596148429267413814265248164610048}$ $\frac{1}{5192296858534827628530496329220096}$ $\frac{1}{10384593717069655257060992658440192}$ $\frac{1}{20769187434139310514121985316880384}$ $\frac{1}{41538374868278621028243970633760768}$ $\frac{1}{83076749736557242056487941267521536}$ $\frac{1}{166153499473114484112975882535043072}$ $\frac{1}{332306998946228968225951765070086144}$ $\frac{1}{664613997892457936451903530140172288}$ $\frac{1}{1329227995784915872903807060280344576}$ $\frac{1}{2658455991569831745807614120560689152}$ $\frac{1}{5316911983139663491615228241121378304}$ $\frac{1}{10633823966279326983230456482242756608}$ $\frac{1}{21267647932558653966460912964485513216}$ $\frac{1}{42535295865117307932921825928971026432}$ $\frac{1}{85070591730234615865843651857942052864}$ $\frac{1}{170141183460469231731687303715884105728}$ $\frac{1}{340282366920938463463374607431768211456}$ $\frac{1}{$

The following general:

1. The first step is to identify the problem. This involves understanding the situation and the goals that need to be achieved.

2. The second step is to gather information. This involves collecting data and resources that will be needed to solve the problem.

3. The third step is to develop a plan. This involves creating a strategy and a timeline for solving the problem.

4. The fourth step is to implement the plan. This involves putting the strategy into action and monitoring progress.

5. The fifth step is to evaluate the results. This involves assessing the effectiveness of the solution and making adjustments as needed.

... ..

[illegible]

Journal of Management Inquiry 18(6) 709–724

1. *Journal of the American Medical Association*, 1997; 277: 1039-1043.

[illegible][illegible]

1 ...
 2 ...
 ...
 "All these years I have ...
 ...
 "It gave me time to ...
 ...
 "A ...

1. The first step in the process is to identify the problem. This involves gathering information about the situation and determining what needs to be solved.

2. Once the problem is identified, the next step is to develop a plan. This involves deciding on the best way to solve the problem and setting out the steps that need to be taken.

3. The third step is to implement the plan. This involves putting the plan into action and carrying out the steps that have been decided on.

4. Finally, the fourth step is to evaluate the results. This involves checking to see if the problem has been solved and if the solution is the best one possible.

with the following information: **DATE OF BIRTH** **DATE OF DEATH** **DATE OF BURIAL**

1.

2.

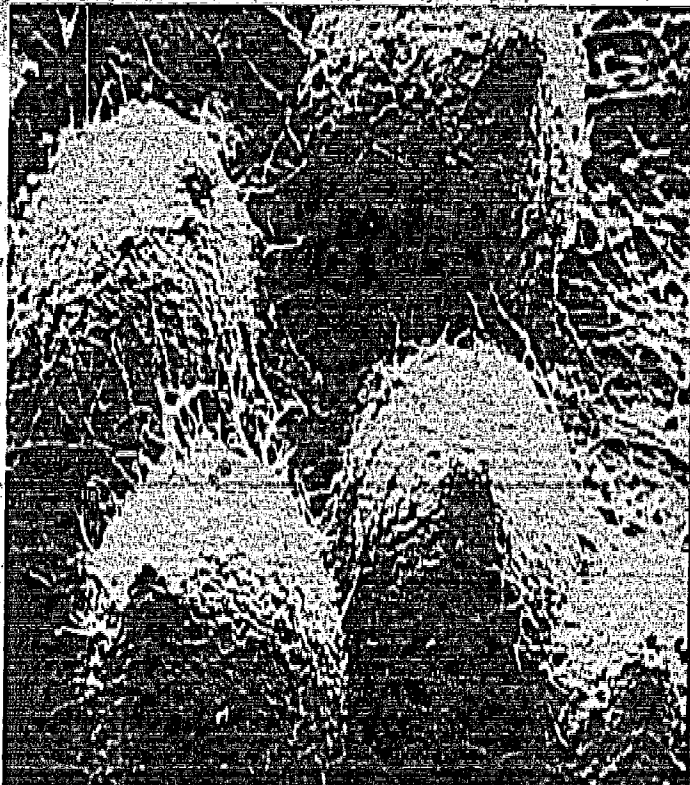
3.

4. **DATE OF BIRTH**

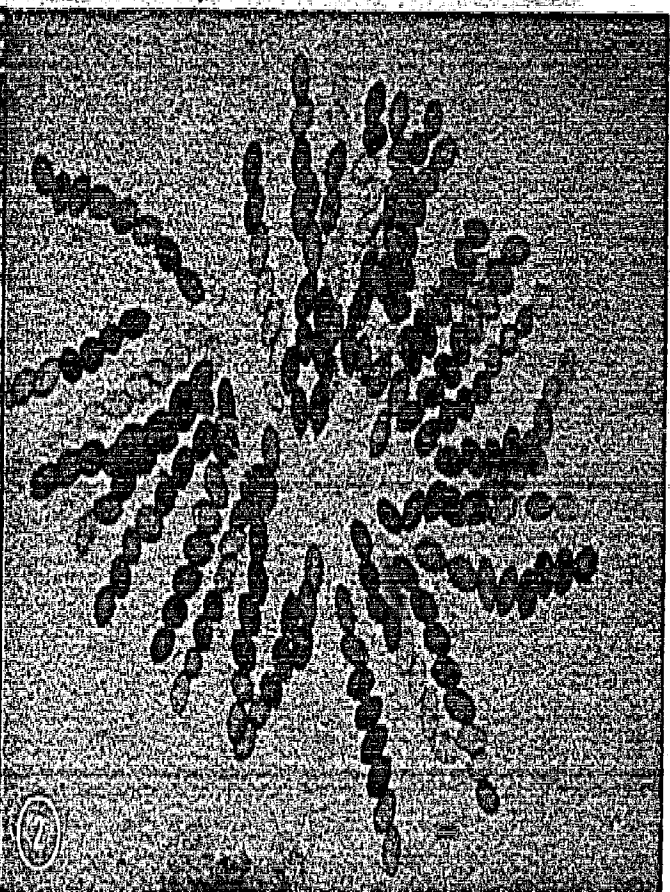
DATE OF BIRTH

1. **DATE OF BIRTH** **DATE OF DEATH** **DATE OF BURIAL**
 2. **DATE OF BIRTH** **DATE OF DEATH** **DATE OF BURIAL**
 3. **DATE OF BIRTH** **DATE OF DEATH** **DATE OF BURIAL**
 4. **DATE OF BIRTH** **DATE OF DEATH** **DATE OF BURIAL**
 5. **DATE OF BIRTH** **DATE OF DEATH** **DATE OF BURIAL**
 6. **DATE OF BIRTH** **DATE OF DEATH** **DATE OF BURIAL**
 7. **DATE OF BIRTH** **DATE OF DEATH** **DATE OF BURIAL**
 8. **DATE OF BIRTH** **DATE OF DEATH** **DATE OF BURIAL**
 9. **DATE OF BIRTH** **DATE OF DEATH** **DATE OF BURIAL**
 10. **DATE OF BIRTH** **DATE OF DEATH** **DATE OF BURIAL**

44 25



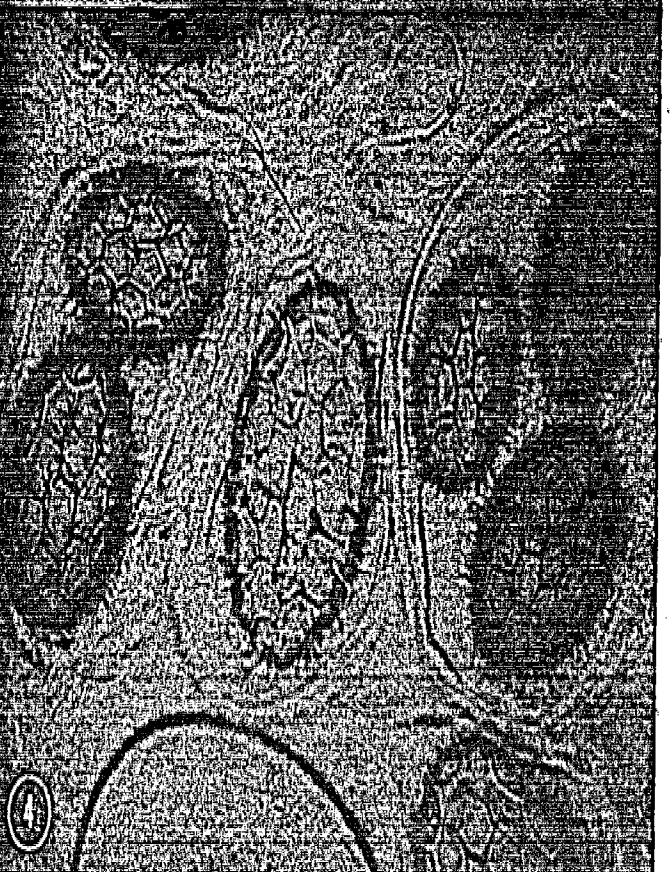
①



②



③



④

I hope these few examples have convinced you of the great importance of visual aids to the teaching of mycology. COMIT promised to make this material available in an automated, interactive system.

After some initial planning sessions, during which the aims of my segment were enunciated, we began to build the framework. I found that many diagrams I usually draw on the blackboard had to be produced as colour transparencies for COMIT. This was a plus, because I was subsequently able to use some of these diagrams in a correspondence version of Biology 232. But I soon became horrified by the massive investment of time which the production of this segment was obviously going to entail. I did not keep a record of the hours I spent on it, but I know their number was excessive. The parallel investment of time on the part of the COMIT programmer was, I know, larger by an order of magnitude than my own. After a protracted period of development during which innumerable changes and corrections had to be made, the system became operational, at least in theory. Another problem surfaced at this point. The computer had to be programmed to cope with all possible incorrect answers, as well as with essentially correct answers which had been misspelled. This called for additional hours of programming and consultations. After a further extended period of fine-tuning, it became possible to sit at the console and run through the module.

I had originally requested that a sound-track be incorporated in the module. I didn't press the matter too hard, and in the event, the sound track did not materialize.

I regretted this omission, because I believe that the information I try to present is better accepted when received by more than one of the senses. The mycology module in its final form was entirely visual. The students have to stare at a T/V screen, at very close range, for an hour or more. This probably bothered them far less than it did me, since they have been exposed to T/V from birth.

Because of certain unavoidable delays in putting the final touches to the COMIT module, the topic had already been covered in the regular lecture format when the time came for 20 volunteers from among the one hundred second year students to do the modules. I announced that there would be a class test on the topic the following week. This gave non-COMIT students a chance to revise the topic from their regular text and other material.

The test showed that although scores of the students taking the COMIT module were, on average, slightly higher than those of the rest of the class, the difference was not significant.

I asked for written comments from the COMIT students. Since the COMIT module was a new toy, I was not quite sure how these comments would reflect on my regular presentations. I need not have worried. Their general tenor was reassuring. Many students claimed to have enjoyed the module, and to have found it a good method of revising material, but most of them also insisted that it could not replace the normal lectures.

But perhaps I should let the students speak for themselves. Here are some representative comments:

"... an excellent attempt at using sophisticated technology as a teaching aid ..." "... it was very well organized ..." "I look forward to using teaching aids of this sort (and this quality) in the future ..." "... you were able to go at your own speed ..." "... served as an excellent review ..." "... I intend to use the computer as a way to review for the exam ..." "... it was very effective in reinforcing the basic characteristics of the Ascomycetes due to the immediacy of interacting with the computer, and the thoughtful manner in which the segment was organized and illustrated..." "As a supplement to lectures it was worthwhile. It helped to clarify and condense the lecture material.... It was a good idea to involve the students in answering questions: since I was receiving immediate feedback, I felt like I was getting personal attention .. but if there was something I didn't understand, I couldn't ask the computer to explain. The slides were good, although not as clear as when projected..." "... You were unable to return to a previous part of the module if you found you had not grasped the concept fully..." "Even with the questions the computer is much like reading a text-book..." "... Perhaps if a sound track had been provided, it would have helped..." "... the lack of an audio stimulus made it perhaps a little boring..." "... Though the computer method was interesting enough, I felt I preferred the lectures and slides..." "... The programme was very impersonal ... the colours on the screen were often very bright, and after reading it for two hours your eyes became very tired ... lectures are preferable..." "... A good professor brings a lot more to a course than this pro

gramme did. He brings interesting anecdotes, vitality, living proof that somebody really studies all this stuff, as well as a lot of humanism that the computer didn't have...."

My own feelings after the experiment can be expressed as follows:

- (1) I now realize very clearly that it would be enormously expensive in hardware, software and labour, for computer instruction to replace even one professor for one course.
- (2) Perhaps even more importantly, there is still no substitute for the human element in teaching. A good professor can communicate enthusiasm in a way that any computer would find difficult to emulate. In addition, the professor can immediately handle all kinds of red herrings, offbeat but interesting questions and backtrackings, and he can respond to the mood of a class or individual in a more flexible way than is possible even for the most elaborately programmed machine. (This is not to say that he always does!)

My general conclusion is that computer assisted instruction can be a useful additional resource, but that it is not yet time for the professor to quit the classroom forever. Only internal motivation can make a student learn and retain information and ideas. I believe he is still most likely to contract that motivation from another human being.

THE POTENTIAL USE OF COMIT IN THE STUDY OF HUMAN MOVEMENT

by

David A. Winter

Professor

Department of Kinesiology

Abstract: Two undergraduate student projects were undertaken on COMIT aimed at presenting many variables associated with human gait. The goals were to display the outline of the leg along with other diagnostic variables such as muscle activity (EMG), kinematic, kinetic and energy calculations. The projects were partially successful in demonstrating possible potential of the COMIT system as a teaching and diagnostic tool.

Introduction:

A complete analytical description of one stride of gait requires twenty or more time domain plots. These would include time histories of kinematics (trajectories of mass centres, angular velocities of limb segments, accelerations of joints, etc.), kinetics (reaction forces at the ground and between the joints, muscle moments, gravitational forces, etc.), energetics (potential and kinetic energies of segments, energy generation and absorption by muscles, etc.) and muscle activity (as indicated by its electromyogram). It is an extremely difficult problem to assess the interaction of a fraction of these variables in normal gait, and even more complex to integrate them to assess pathological locomotion. It therefore appeared that COMIT had the potential of presenting an integrated picture of many of these variables and of seeing their influence in time.

Student Projects

Two senior undergraduate research projects were directed to the development of user programs for the assessment of human gait. Data routinely obtained from the Gait Analysis Laboratory in the Department of Kinesiology were used. The aim of the two projects was the same: to present to the user a flexible display with which he could interact and see the "cause and effect" of the forces and muscle activity acting on gait.

The difference in the projects was in the mode of data entry. The first was given the coordinates of each limb segment from which a "stick" diagram of the leg could be generated to represent the body position every 33 ms. An algorithm was then used to generate the contour of the leg at each position. The second approach was to generate the leg and muscle outlines via a light pen tracing of the cine frame image as seen on the COMIT terminal. Once the leg outline was generated, by either technique, the outline of the major muscle groups was generated and their activity was presented two different ways: a 32 intensity level colour code was used to grade activity from 0 to 100%, or the % activity could be written alongside each muscle. The user could then call up the leg outline for any point in the gait cycle, insert the muscle activity and then examine the position of the limb at successive points in time to see the effect of the muscle activity. A second aim was to display quantitative measures such as reaction force vectors, energy levels, etc.

Success of Projects

The first goal, as described, was achieved successfully, but with some limitations to the user. The turn around time between instructions and display was sometimes delayed so it was difficult to assess rapidly changing events. The second aim was not attempted because of the time and effort required to achieve the first goal.

A logistic problem that severely limited the potential of COMIT was the use of cine film as a data base. There was no ready way to convert the cine data to TV so that it could be displayed on the COMIT terminals.

Conclusions

The project was successful to the extent that it demonstrated a potentially valuable area for the COMIT system. A considerable amount of additional programming was necessary to realize a properly interactive system that was useful for teaching and clinical diagnosis

COMIT ICE HOCKEY PRACTICE

by

Robert C. McKillop

Varsity Hockey Coach

Department of Athletics

Abstract: Computer Ice Hockey practice was developed at the University of Waterloo in order to present the coach's systems to the players in a much more controlled academic setting than is available during practice on the ice. The objectives of the computer practice were: to allow players time to think about the systems and discuss alternatives with the coach; to give the coach a documented evaluation of how well the players knew the material; and to enable new material to be thoroughly taught and understood before going on the ice.

The results of this project were very encouraging to the University of Waterloo Hockey team players and coach. The idea is definitely a valuable one which could be adopted in many other sports as well.

In recent years, coaching the game of ice hockey has taken a very noticeable change towards a much more structured game. This attitude has been given a great deal of credibility with the emergence of such people as Fred Shero, Bob Pulford and Roger Neilson in the ranks of NHL coaches. These men all believe very strongly in a disciplined "system" approach to hockey where all players have basic responsibilities in almost all situations that may arise.

When a coach attempts to implement these systems, he finds that he requires much more ice time than was used in the traditional approach. The availability of ice time is at a premium in almost all locations. This has forced coaches into many alternative methods of presenting their material to their teams and led to the development of the hockey coaching module using COMIT at the University of Waterloo.

This COMIT module was capable of reproducing the various ice hockey systems in a manner that allowed players of the University of Waterloo Varsity Hockey Team to view them and to respond to a series of questions based on specific assignments designated by the coach. The program was designed to allow each player maximum time to study the systems in question and also to provide the coach with a detailed print out of the player's responses to the questions he answered.

There are many advantages of having a program of this nature available to a hockey team. Valuable ice time was not wasted in a time-consuming teaching process of the system. Players were taught using a blackboard and then tested on the computer. The players had an unlimited time period in which to study and respond to questions. This allowed each player to study the problem thoroughly at his own speed before having to respond. The positions of all of the players of both teams were readily visible on the screen and he could see a complete system in one look, something he can not see or perhaps even comprehend while on the ice. The system allowed the player to make one incorrect response to each question before showing him the correct response. This feature meant that the player had to think out his replies based on the knowledge of the previous wrong answer.

The author was responsible for putting all the hockey technical data on the computer. Dr. Moore and his computer associates spent countless hours developing the computer program required, so that all the various systems could be included. The player sat down at the terminal and introduced himself by typing his name on a conventional typewriter keyboard. The player was then asked what position he wanted to study. Upon replying, the player was then asked what area he wanted to study. He had the following choices:

- a) forechecking
- b) backchecking
- c) breakout patterns
- d) power plays
- e) penalty killing
- f) miscellaneous - face-off
- special plays
- g) all of the above

When the player indicated what area or areas he wanted to study, he was then presented with a plan view of the rink on the screen as shown in the Figures. The set-up on the screen showed the player the formation with the offense in one colour and the defense in another. The position he was studying then began to blink (on and off) on the screen so the player knew exactly where he was on the ice surface. The question would then appear on the screen at the side of the rink outline. The player then had to point with a light pen to the place on the screen where he thought the

move. If he was correct, an exit statement appeared along with all of the other players' correct movements so that the player could see his movements in relation to his team-mates' moves. If he was incorrect, he would be told so and asked to try again. If he then succeeded, the above (correct) display would follow. If he was again incorrect, the player would be told so and then the correct movements would appear. The player could study the screen for as long as he wanted; when he was ready to proceed, he simply pressed "enter" and the next step would confront him. This procedure was followed for all questions in all systems. When the player was finished, a record then appeared on the screen. This showed his responses to each question, whether right, wrong or skipped, and then a percentage right and wrong for all questions.

This record was also available to the coach in the form of a print-out. The print-out told the coach who had taken part in the program, and how well he had done in each area. This turned out to be a very valuable asset to the coach. After the player had completed the test on his own position, he was then encouraged to try the tests for all the other team positions as well.

The players could attend the program at any free period during the day and could make very constructive use of free time.

The results of this project were very encouraging. All the basic objectives were met and then some. It was found that the players could easily operate the program and did not feel out of place with it. The program initiated a great deal of discussion between the players and the coach. Usually this was precipitated by incorrect responses to various questions. This type of dialogue is often very difficult to initiate in a normal practice or game setting and turned out to be a major positive aspect of the entire program. The fact that players had to come up with specific answers to each question thoroughly tested their knowledge of the various systems and supplied the coach with these results. The resulting discussion made the players much more aware of all the systems and thus made the hockey club a better team.

When the players were introduced to this system, the team's league record was 0 wins and 7 losses after competing against teams that were not the class of the league. In the next 13 games, the team won 7 games and tied 2 against much superior competition. This result, in the opinion of

the coach and the players, was due in a large part to the team being exposed to this computer hockey practice.

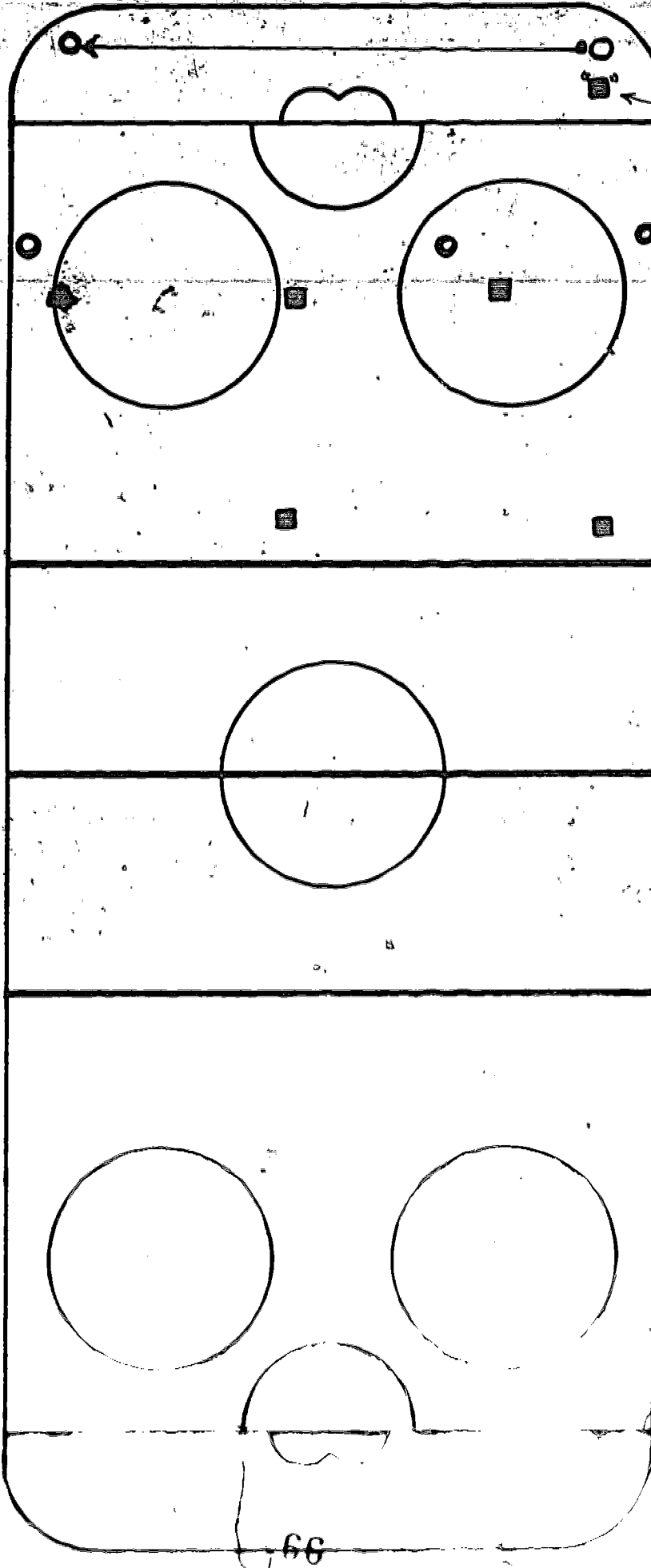
The only major negative comment that can be associated with this project was the tremendous amount of time required to get the system operational. This would be drastically reduced in any future project due to the groundwork laid in this endeavour.

The author wishes to express his sincere appreciation to Dr. J.B. Moore and his associates for their untiring work in developing the system so that the University of Waterloo Warrior Hockey team could take part in this project.

Fig. 1: Sample of What Player Would see on the Screen:

59.

Question
QFC1



(RW Position
Blinking)

Playing RW

Where should you go?

Explanation:

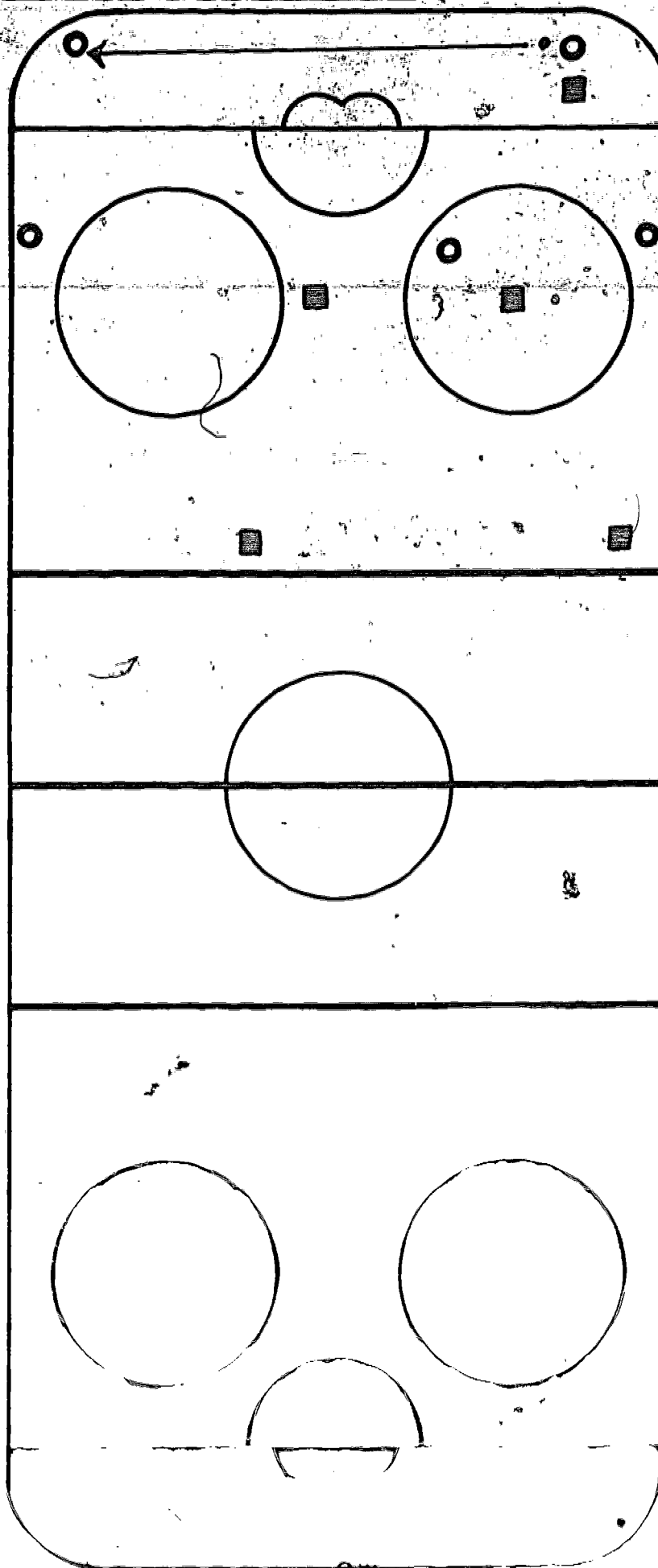
Seeing the question with the RW position blinking on and off, the Player would now take the light pen and indicate where he thinks he should go, now that the puck has gone behind the net to the other defenceman.

If the player responded incorrectly the following would appear.

Fig 2: If Player Points to Wrong Place on the Screen:

60.

Question
QFC1



NO. Must always force
from the front.

Try again.

Explanation:

The player would now
repeat the original
process.

Fig. 3: If Player Points to Correct Place on the Screen:

61.

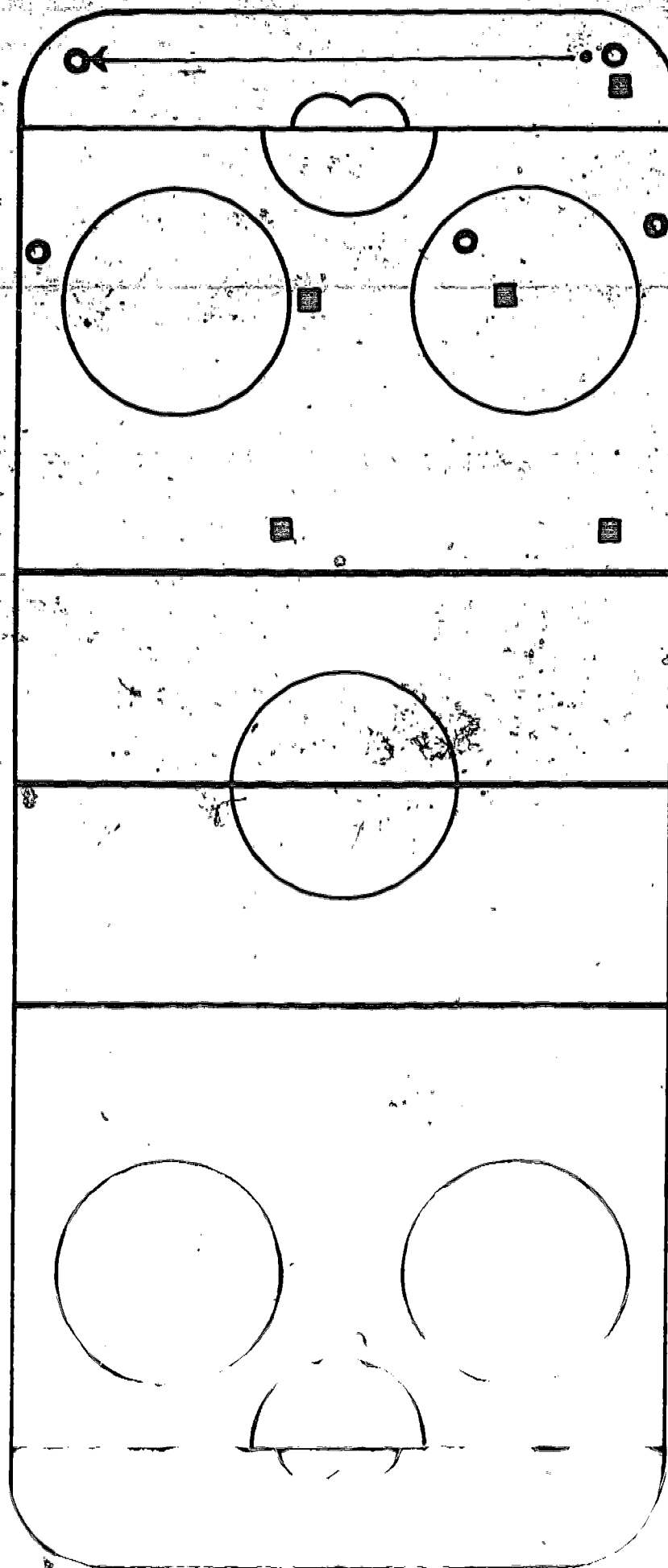
Question
QFC1

Very good.

In forechecking we
always want to force from
the front.

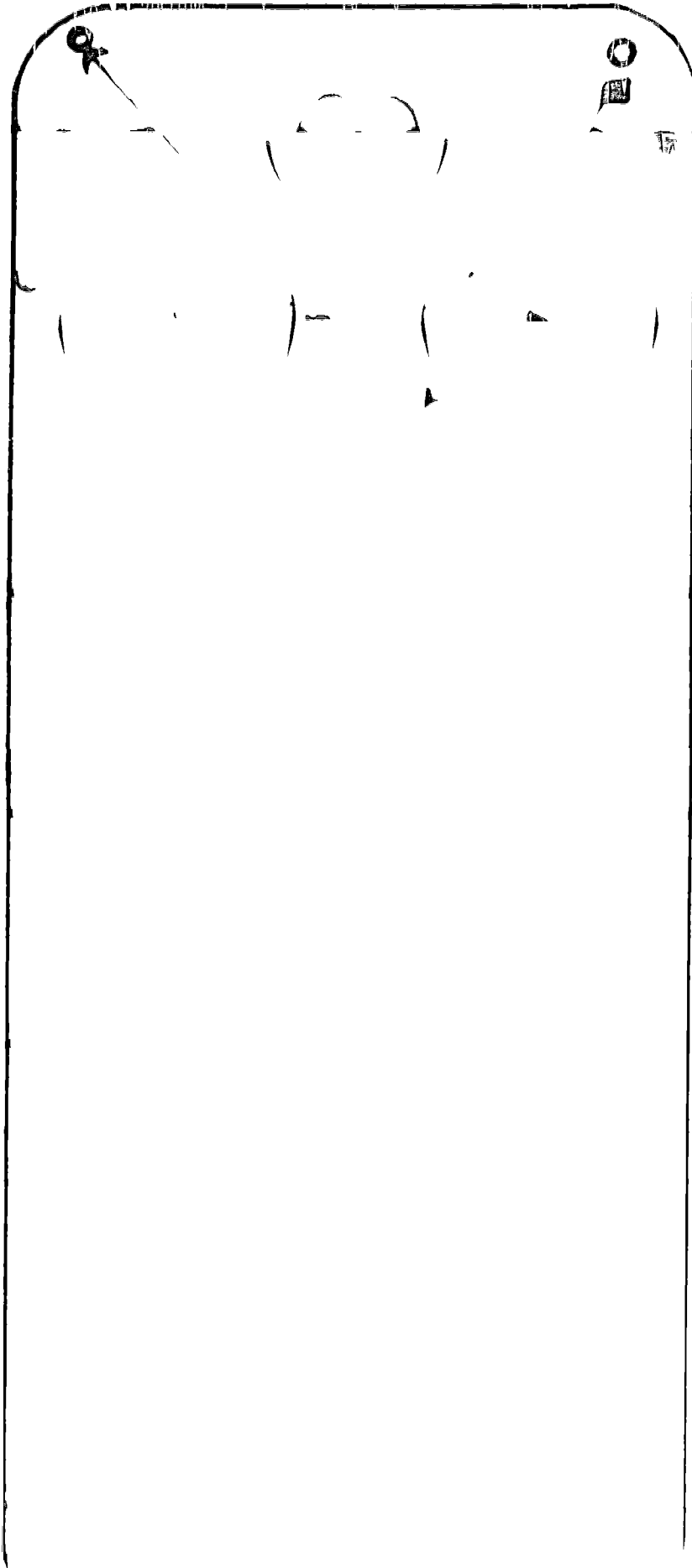
Explanation:

If the player answers the
question correctly he
would then be shown what
is indicated on this
diagram.



4.4.2: Correct comments of All Players are then Shown:

62





I. General Information Regarding the 1981 Session
 This section contained questions pertaining to the en-

ture of the session, number of participants, etc.

====

1.

1.

1.

1.

1.

1.

1.

M A



11

[illegible]

1. The first step is to identify the problem. This involves understanding the current situation and what needs to be improved.

A. The first of these is the fact that the
 B. the second is the fact that the
 C. the third is the fact that the
 D. the fourth is the fact that the
 E. the fifth is the fact that the
 F. the sixth is the fact that the
 G. the seventh is the fact that the
 H. the eighth is the fact that the
 I. the ninth is the fact that the
 J. the tenth is the fact that the

1. The first group of people who are interested in the results of the study are the researchers themselves. They want to know if the study was successful in achieving its goals and if the data collected is reliable and valid.

1000

1. The first part of the document is a list of the names of the members of the committee who have been appointed to study the problem of the shortage of teachers in the public schools of the State of New York. The names are as follows:

- 1. Mr. J. B. Connelley, Chairman
- 2. Mr. J. B. Connelley, Chairman
- 3. Mr. J. B. Connelley, Chairman
- 4. Mr. J. B. Connelley, Chairman
- 5. Mr. J. B. Connelley, Chairman
- 6. Mr. J. B. Connelley, Chairman
- 7. Mr. J. B. Connelley, Chairman
- 8. Mr. J. B. Connelley, Chairman
- 9. Mr. J. B. Connelley, Chairman
- 10. Mr. J. B. Connelley, Chairman

indicates that the project itself may be a glimpse of leisure behavior in the not-too-distant future.

Three other results are immediately apparent from the experience. The department curriculum committee has decided to make use of components developed for the project in a correspondence course to be offered this fall. Dr. Avedon's course notes, cum script, are now in such organized condition, that he has a draft of a manuscript for a publishable textbook. Finally, he looks forward to teaching the course this fall with all of the enhancements developed for the COMIT project. The project stimulated a number of new thoughts on better ways to teach the material, and he is going to try to include some of these methods this fall. We only wish the University were going to retain some of the software from the project to provide all the students with tutorial and review capability if not through the computerized instructional television then via standard UW hardware.

ITEM	DID	WOULD DO
write script	4	1
tape video	6	2
tape audio	5	3
choose visuals	2	4
write tutorials	1	5
write reviews	3	6
add enhancements	7	

Figure: COMPARISON OF THE ORDER OF WORK INTRODUCING USER

COMIT AS A TEACHING TOOL FOR THE HISTORY OF ART

by

Eve Kliman

Assistant Professor

Department of Fine Arts

Abstract: This brief paper reviews our experience of COMIT for an introductory survey course on the History of Art and concludes that its useful application to the subject is relatively limited.

Fine Arts 111 is a course in the history of art which introduces students to the painting, sculpture and architecture of the Western world from ancient Greece to modern times. The course stresses the fact that works of art reflect the preoccupations of their epoch. Students are therefore expected to become familiar with the broad categories of style and meaning in Western art. They are required to recognize their works, to be able to place them historically, and to understand something of their particular meaning.

As an experiment we fed 200 slides into the computer terminals and arranged viewings for approximately 70 students. Some problems of reproduction immediately became evident. The terminals reproduce sculpture and architecture with an acceptable degree of accuracy; colour can remain close to monochrome and fine details are not essential. Reproductions of paintings are much worse, however; the proper colour balance is often impossible to achieve and the quality of the line suffers.

In general the students found it interesting and novel to use the terminals. There were inevitable frustrations, of course, some of them minor. The chief drawback I became aware of was that though the terminals had been scheduled for use, in practice there were a few occasions on which they were not available. Once the equipment had broken down another time it was being overhauled. Even if such interruptions were rare, the fact that they can and do occur creates problems for the management of the course. The problem is insignificant as long as the slides and films are available for the presentation. But if the students are to be tested on material included in the television presentation, even a single breakdown is a significant problem.

For our purposes, books, slides and good quality photographs provide us with simple, flexible tools for teaching. The terminals are unable to do justice to the subtleties of art; particularly of painting and they are somewhat rigid in the way they have to be used with large classes. Our conclusion therefore is that the COMIT project does not provide a workable addition to teaching methods in the Fine Arts department.

by

Paul Beam

Associate Professor

Department of English

Abstract: Purpose of Module - The module is designed to teach analytic method to second year English students in a required course and it requires (depending on student's ability) between four and ten hours of study. It permits a more thorough presentation and review of the lesson than is presently available in any other form.

Structure of Module - The subject of the module is Analytic Criticism and involves four contexts - Linear, Setting, Imagery, Structure. Students may review within and across categories and seek additional information at any point in the lesson. Both voice recording and visual display combine to teach sequences of the lesson and the student is required to respond to points throughout; records are kept of all responses from keyboard and light pen.

Assessment - Throughout the lesson, student responses elicit author comments on the correctness and completeness of each response. Since all responses are recorded, the author can obtain a complete record of each student's performance. This data can be made available to the student for self-evaluation and provides a cumulative data base for subsequent authors to predict student performance. In addition, the COMIT module has some unique memory features which permit the author to check, for example, the time taken to respond or the sequence of answering questions.

Problems - technical, pedagogical and instructional - Response time by the unit is critical - it must be instantaneous, as fast as the student can write, draw or type. Failures here were my greatest frustrations. Next were difficulties in synchronizing audio and visual signals to link the two responses to student requests. Both of these are resolvable by changes in equipment. Results of student performance have been high in comparisons with control groups in conventional lecture/tutorial situations. Personal responses have varied between acute frustration over technical delays to strong feelings of accomplishment and an awareness of materials and methods more complete than any previous learning experience in isolation. Students have not been "isolated by the machine". The questions they now ask are academic responses to the work at a high level.

The COMIT English module uses most of the interrelated devices of sound, sonic pen, keyboard, slide and terminal display in a lesson which, depending on the student's interest and ability, may last from four to ten hours and which forms an integral part of our second-year course in critical analysis.

From the outset I sought to present a combination of a lesson, a test and a means of detailed assessment which would permit (or oblige) a student to learn more by his or her involvement in the lesson than I could provide in a similar period of classroom time. I hoped that the user would be able to examine in detail those areas which seemed to best offer insights into the methods of analysis and I planned to watch over the students' reactions and choices of direction using the whole range of the machine's ability to record, time and compare statistically the user's performance. Throughout the project I have regarded the module - the student's use and development of the material under the lesson's direction - as yet another extension of my teaching method. Over the years I have become increasingly aware of the advantages to students in selection of learning time, the ability to reuse lecture material for greater comprehension and review and the permanence of records which are present in the simple expedient of recorded lectures. The Correspondence Program further taught me the advantages of several new kinds of organization of individual lessons and of the whole pattern of a course. I was anxious to extend this into a more sophisticated lesson and COMIT offered this possibility.

Finally, class size and the kinds of unwarranted assumptions an instructor must make about "average" levels of training and preparation, the "average" number of illustrations one should use to walk between a class's boredom and confusion, the degree of "participation" one can permit in a contest with the clock and the reactions of the class as a whole - these questions made me seek answers in kinds of teaching over which the individual student had greater control and to which he or she was obliged to make many contributions. The idea of the student constructing the lesson with emphasis on areas of best understanding at an optimum rate of progress seemed to be a good adjunct to my teaching in the course.

As in most disciplines, large areas of English lend themselves to facts and concepts - "genres" are categories of similar structures, "periods" presume similarities by chronological proximity. I tried to avoid these completely and chose instead part of a course in which two thirds of the students' year mark is derived from material which can be read orally in class. The rest of the course is to have readers become aware

it is uncompromising in its insistence that each user meet each of its questions, puzzles or requests for knowledge and structure and it will not proceed on the happy assumption that the person sitting in front of it actually does understand and declines to answer because the question is not of sufficient interest.

At the outset my purposes in COMIT were twofold; I sought a teaching device which made no compromise with the best academic standards of my subject and which involved the student at each stage of the lesson more directly than the conventional lecture method can. It is not a question of belief but rather a matter of fact that modules of this kind meet both conditions. Questions of their role vis a vis an instructor, how much of this kind of instruction is optimal, the demands on academic resources in their implementation, matters of cost and the social and pedagogic research we derive are all, in the long run, peripheral. The project's value lies in its thoroughness and the ability to have students take charge of their own learning; Any module's flexibility, across and within disciplines, depends only on the imagination and skill of the authors and designers who create it. Not only in COMIT, but in other systems already functioning in higher education, the only functioning adverb is not "how" or "whether" but "when."

References:

- [1] P. Beam, "Comparative Teaching Techniques: A Computer Module and Criticism", U.C.T. Studies in English, Cape Town, South Africa, Vol. 7, pp. 76-98, Sept., 1977.
- [2] P. Beam, "The Design of a Computer-Directed Teaching Module in Analytic Criticism", Third International Conference on Computing in the Humanities, University of Waterloo, August 2-5, 1977.
- [3] Eileen Elkeer, "The COMIT Project: An Executive Overview", a report prepared for The Educational Research Division, I.B.M. Canada Ltd., May, 1978.

Appendix: The passage used in the COMIT English module on Analytic Criticism is shown below:

When the Present has latched its back-gate behind my trembling stay,
And the May month flaps its glad green leaves like wings,
Delicate-filmed as new-spun silk, will the neighbours say,
"He was a man who used to notice such things?"

If it be in the dusk when, like an eyelid's soundless blink,
The evening-hawk comes crossing the shades to alight
Upon the wind-warped upland thorn, a gazer may think,
"To him this must have been a familiar sight."

If I pass during some late night blackness, mothy and warm,
When the hedgehog travels cautiously over the lawn,
One may say, "He worked that such innocent creatures should come
But he could do little for them; and now he is gone." to no harm,

If when hearing that I have been stilled at last, they stand at the door,
Watching the full-starred heavens that winter sees,
Will this thought rise on those who will meet my face no more,
"He was one who had an eye for such mysteries?"

And will any say when my bell of leaving is heard in the gloom,
And a crossing breeze cuts a pause in its outrollings,
Till they rise again, as they were a new bell's boom,
"He hears it not now, but used to notice such things?"

REFLECTIONS ON A COMPUTERIZED MULTI-MEDIA
INSTRUCTIONAL TELEVISION MODULE

by

D. K. Erb

Professor

Department of Geography

Abstract: The development of a COMIT module has involved a broad spectrum of experiences. Initially the concepts presented sparked visions of fascinating combinations of computer graphics, slides, tapes, films, student-computer interaction and many other potential "tools" to be utilized in geographical education. The selection of a subject however, lead to a rapid revision of initial concepts. In addition, the methodology of module development soon established the necessity for a much more detailed knowledge of the chosen subject. The steps which had appeared relatively simple and straightforward became complex and time consuming. Finally, the emergence of a reasonably complete module permitted testing to begin and the problem of testing to come to the fore. Attempting to draw conclusions on the basis of inadequate testing results yielded recommendations for the future.

Initial Concept

As originally presented, the objective of Computerized Multi-Media Instructional Television was to combine educational television with computer assisted instruction and to evaluate the educational capability of this marriage.

To a geographer with specializations in the fields of geomorphology and remote sensing, the potential was fascinating. Imagine being able to incorporate in one unified module such diverse but interrelated teaching components as colour movies (video tapes), colour slides, sequential images with appropriate annotation (letters, arrows, dashed lines, etc.), dynamic computer graphics (in which lines could be made to move across the screen, letters could be made to flash on and off to emphasize audio comments, and colours could be used to distinguish the various segments being discussed), a sonic pen (which could be used by the student to indicate his or her selection in response to a visual or spoken query) and audio commentary overall (discussion, explanation, or query). Visions of colour movies showing waves breaking on a beach at normal speed and then in super slow motion, followed by graphics illustrating the way in which water particles moved in a "normal" wave, then

in a wave breaking on a beach, the whole backed by the sounds of breaking waves and a discussion of wave dynamics, and followed by a series of questions to evaluate the students' comprehension of the factors and concepts involved, and of an almost infinite number of similar possibilities, were generated. Enthusiasm ran high.

Module Development

Then the crucial question was posed; given the need to test this apparently unlimited potential system, what small segment of a course currently being given should be developed into a COMIT module?

From the many possibilities, a segment which seemed ideally suited to the technique (as discussed above), or a segment which formed a small, important, but difficult to grasp, part of the course, could be selected. Based on numerous factors, but primarily the difficulty experienced by students in understanding the concept and the consequent length of time spent on explaining it, the subject of parallax, as used in remote sensing, was chosen.

Parallax is defined as: "The apparent displacement of the position of a body with respect to a reference point or system, caused by a shift in the point of observation".

Initially, the approach taken in attempting to set up a module was, in essence, to translate the lecture format to the COMIT format. A considerable number of weeks later, weeks which involved pages and pages of writing, innumerable diagrams, and enlightening discussions with the COMIT advisors, a significant factor became evident; the "author" didn't know as much about parallax as he thought he did!

This somewhat less than earth-shaking discovery led to an intensive review of the literature on the subject. This in turn led to another discovery; many other authors of texts and reference works, were unable to explain the concept of parallax clearly and concisely, or in any event, had not bothered to do so in their works!

However, an acceptable explanation was eventually formulated and the problem of developing the module was again attacked.

The first approach involved a spot on the screen, a student, and his or her thumb. The student closed his left eye and held his thumb between his right eye and the screen such that it obscured the spot (Figure 1 a); then,

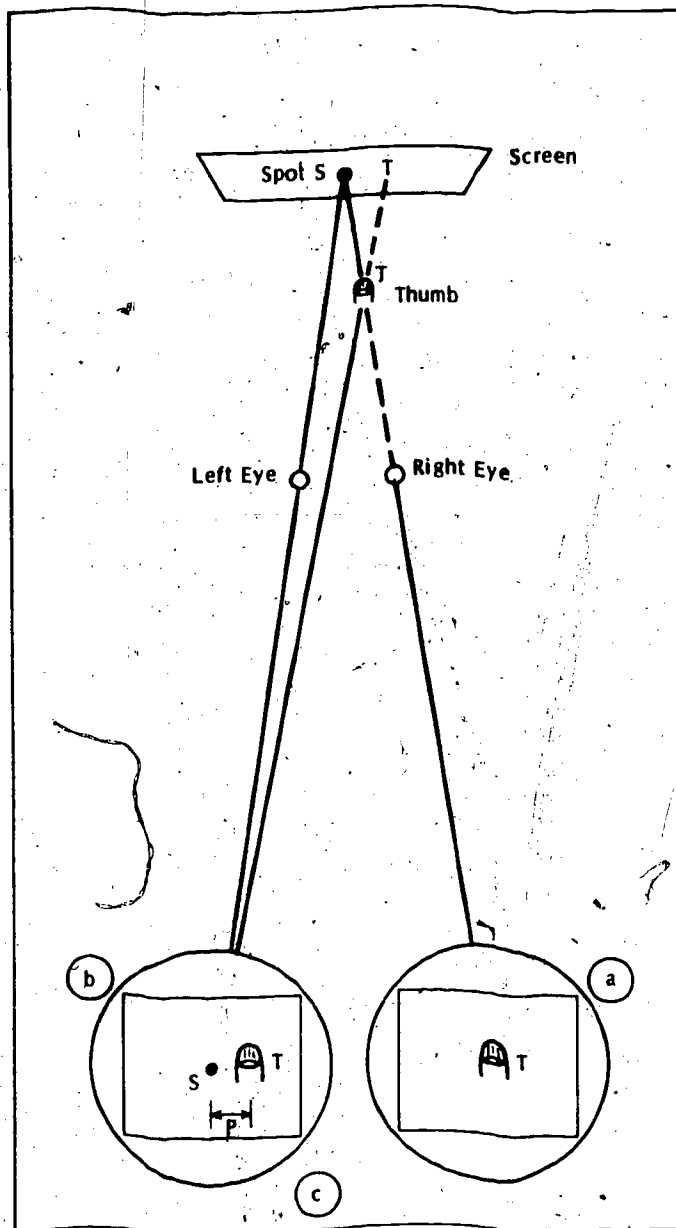


Figure 1 - a, b, & c.

- a. Right Eye View - Thumb, No Spot
- b. Left Eye View - Spot, Thumb to the Right
- c. S - T in 1.b. is Parallax Displacement P

maintaining the same position (ie. not moving his head or his thumb), he closed his right eye and opened his left. At this point he could see the spot again and the thumb appeared to have shifted to the right of the spot (Figure 1 b). This apparent shift in the position of the thumb with respect to the reference point on the screen, when viewed from two different points in space (the right eye view and the left eye view), is called parallax displacement (Figure 1 c).

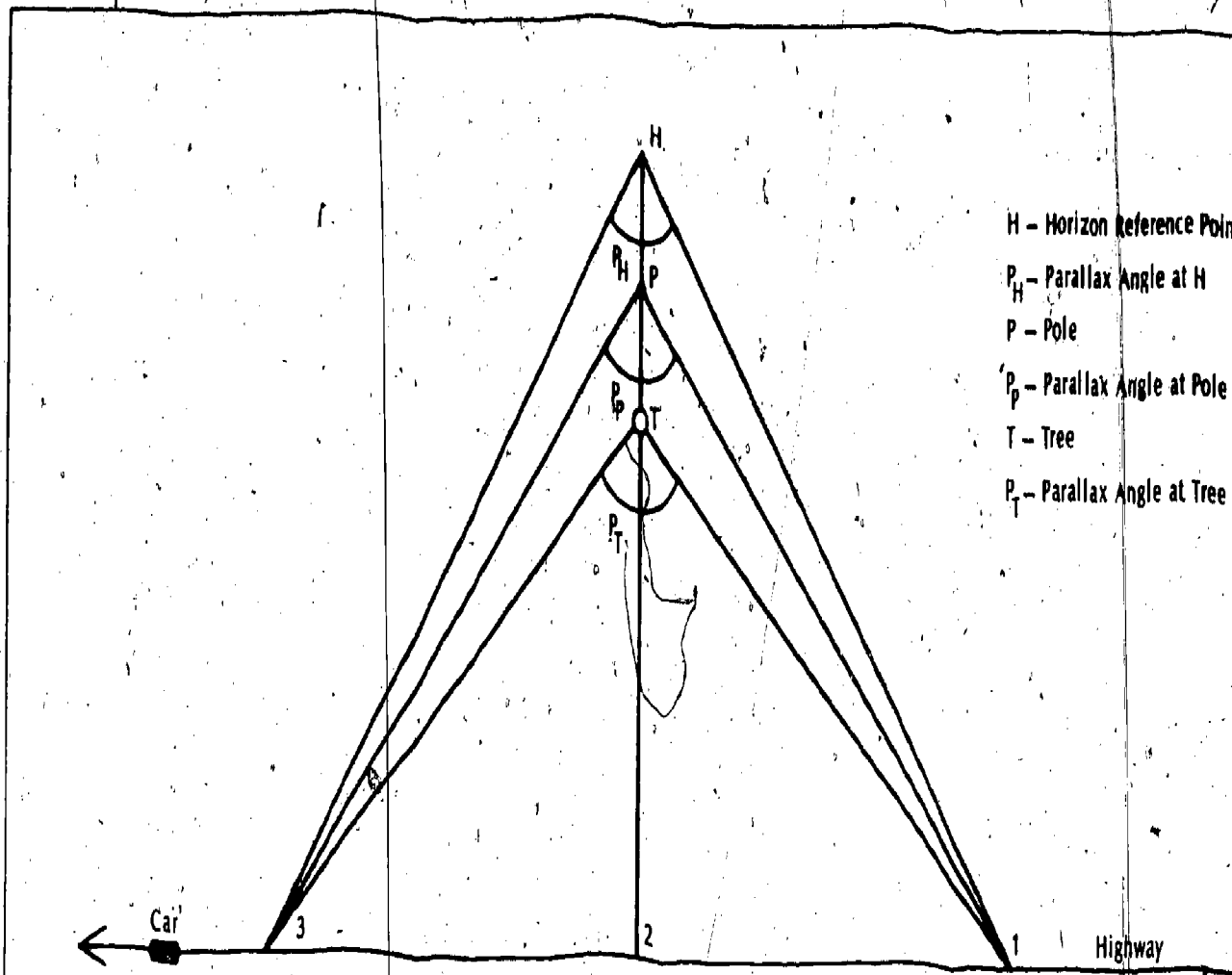
Problems of relating this simple example to the geometry of a sequential pair of air photos led to a number of revisions, and eventually, after a considerable length of time, to a somewhat different example involving a tree, a pole, and a car moving along a highway. This produced a sequential set of images which not only illustrated the apparent displacement of one body with respect to another and, in turn, both with respect to a reference point, but also permitted the utilization of a movie or video tape sequence which related the concept to a common every-day experience (Figures 2 a,b,c).

It was possible to display the geometry of this situation on the screen using slides; and also, using the dynamic computer graphics capability, to illustrate in a sequential format, the relationship between the angle of parallax (Figure 2) and the linear displacement of the features on the image, ie. linear parallax (P).

Throughout this developmental stage, it was necessary to keep in mind the necessity for interaction between the student and the "message" being presented on the terminal screen. A whole series of questions had to be devised (and answers provided) to lead the student to an understanding of the concept being presented. A number of incorrect answers had to be devised as well, (for each question) and a system of feed-back included such that, if a student selected the incorrect answer, he could request a review of the material, or a "hint", in order for him to satisfy the requirements before he proceeded to the next step.

Intermediate phases of the module involved measuring the apparent displacement (parallax) on the screen using scales incorporated in the image (Figure 3), and, in the final phases, the translation of this example to the aerial photograph and the geometry of parallax measurement as a method of determining heights of objects (Figure 4).

However, since this paper is not attempting to explain parallax, but rather to evaluate the COMIT approach to explaining parallax, no further



H - Horizon Reference Point

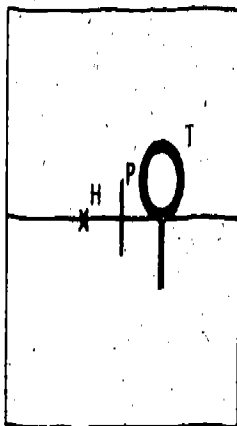
P_H - Parallax Angle at H

P - Pole

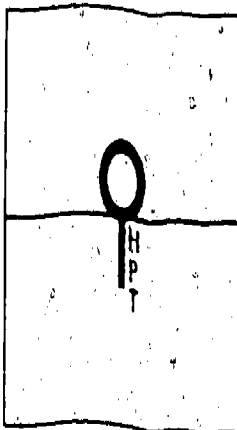
P_P - Parallax Angle at Pole

T - Tree

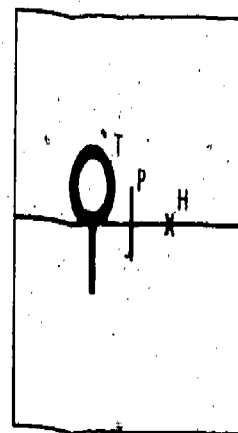
P_T - Parallax Angle at Tree



(c) Point of View 3



(b) Point of View 2



(a) Point of View 1

Figure 2

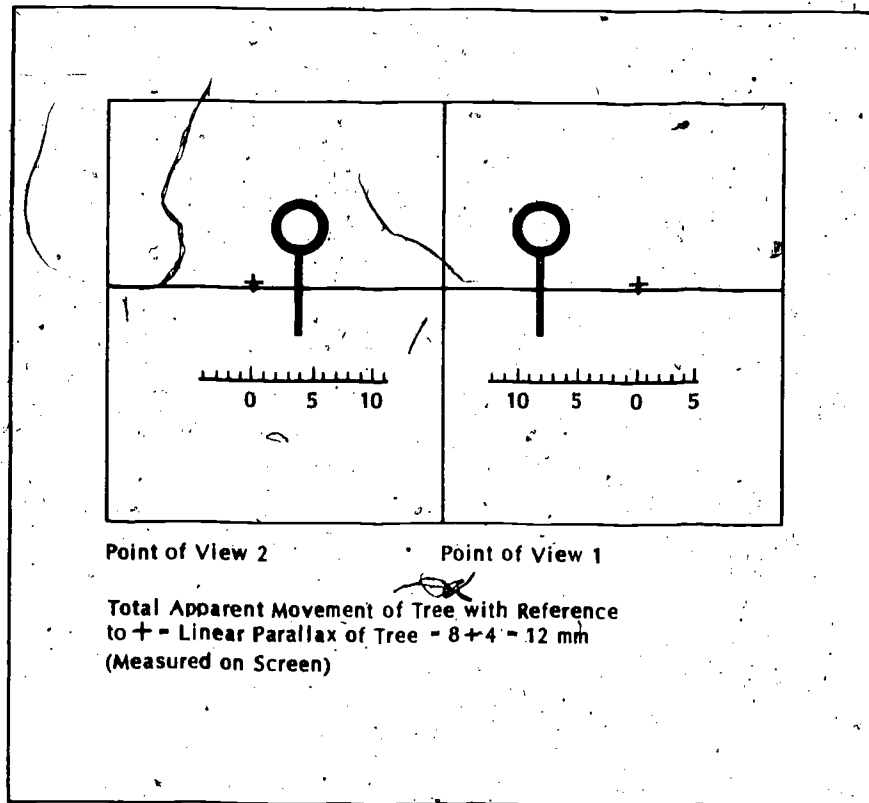


Figure 3

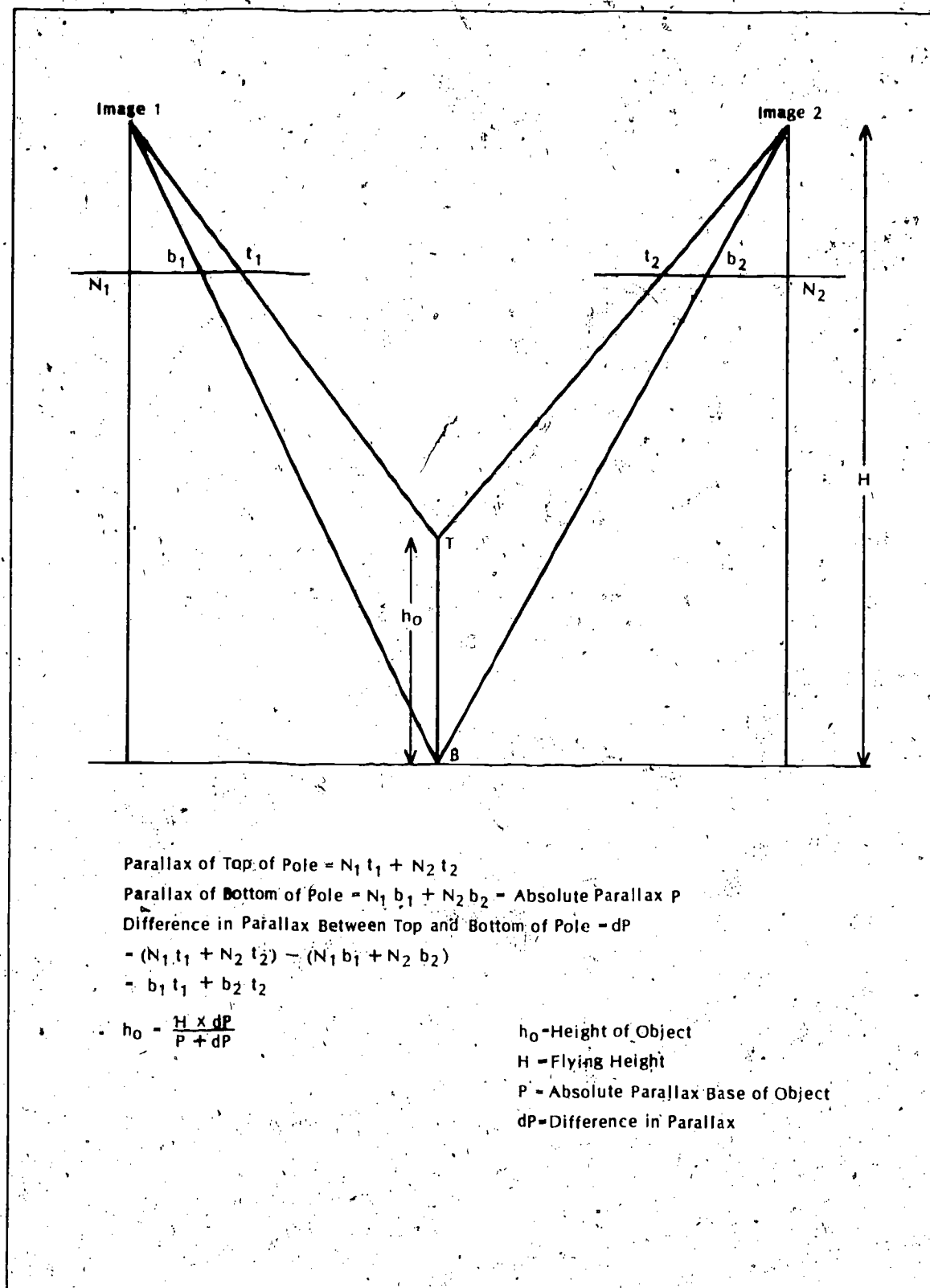


Figure 4

discussion of the actual module steps will be presented.

Having developed the module, the next step was to test it on the members of a class who were responsible for the concepts involved. At this point, one of the major disadvantages became apparent. The author, who at this point at least, should be assumed to know the answers, ran through the completed module on the terminal and determined that the time required was approximately 2½ hours. This was partly due to the fact that it was necessary to use a loose-leaf binder containing all the illustrations and diagrams instead of having them on the screen as previously proposed. This discrepancy or problem was in part the result of the author being on sabbatical during this phase of the programme.

The time required to complete the module when combined with a class of 120, obviously involved a major logistics problem; not only in terms of computer time itself, but also in terms of scheduling access to the limited number of terminals available. As a result, it was decided to use a small volunteer class sample and have them arrange their own scheduling. This proved to be another error. By the time the course had reached a stage involving the use of the concept, it was determined that only a few of the students had actually made appointments and worked through the module. The resulting comments were of minimal assistance in evaluating the system's capability.

This leads to some conclusions with respect to Computerized Multi-Media Instructional Television as a method of teaching a concept.

Conclusions

First, it does not appear to be a system which can be utilized to teach small components of a course, involving large numbers of students. Even assuming a relatively large number of terminals and access to these terminals over extensive periods of time during a normal day, the computer time required and the problems of scheduling the use of the terminals would be excessive.

Second, it is a system which demands a great many hours of input on the part of the author in order to develop a relatively simple module. This assumes an even greater number of hours of input on the part of an assistant, to programme the computer and handle the technical aspects, especially if video tapes, slides, audio tapes and many of the other elements which provide such a fascinating potential, are utilized.

Third, an author, or would-be author, should have or acquire a good working knowledge of computers and computer programming. It is difficult to foresee problems involving question format, answer format, graphic development, video, audio, and slide inclusion, etc., without any background knowledge in the field.

Fourth, unless experienced in COMIT module development, it would be advisable for an author to produce one or two trial modules before attempting a final effort. Familiarization with the problems associated with module development obtained in this trial period would permit the author to save a great deal of time in selecting and planning segments of his course to be presented in module form.

Fifth, the author should be fully familiar with the course segment or concept to be developed as a module. If the author can combine this capability with those discussed in three and four above, development of COMIT modules should not be too difficult.

Sixth, the nature of the subject matter has a great bearing on the use, development and effectiveness of the module format. Very difficult concepts requiring active faculty-student dialogue would not appear to be suitable in this context.

Seventh, in order to evaluate the effectiveness of a module, a statistically valid class sample should be selected, together with a control group subject to the standard method, and the two groups upon completion of the course segment involved should write an identical test. In addition, time expended by the students in the two methods should be taken into consideration. Finally, the opportunity for the one group to re-run the module if details of the concept were not clear, should be taken into account.

Eighth, if an author were to plan on using some, or all, of the various audio/visual capabilities of the system, knowledge of some of the basics of television programming such as story-board preparation, scenario writing, video "tricks", etc., would seem to be advisable.

Future

Most of the potential, which fascinated this author when the programme was first discussed, was not realized in the development of the module discussed here. The capabilities are still there, but it will require a different programme to make effective use of them. In this context, a multi-

unit module designed to present a complete segment of a course would seem not only feasible, but also desirable. In its initial implementation, it would not have the one-to-one, student/terminal interaction, but would be designed to complement rather than supplement a faculty member, in a classroom situation. However, individual units, making up the larger module, could be utilized, with appropriate visual or audio programmes, to provide the students with a very effective review facility (using a Comit-type terminal).

The above format could be developed for a full course, thus removing the repetitive aspect of a professor's programme and allowing him or her much more time for preparation, discussion, and interaction with the class - regardless of size. The length of each unit would be determined by the proportion of the lecture period assigned for discussion.

Finally, this type of module format could easily be included in off-campus (remote lecture theatre), in-home computer terminal, or conventional television/telephone, educational programmes.

LEARNING FROM COMIT: THE EDUCATIONAL IMPLICATIONS

by

Christopher K. Knapper

Teaching Resource Person

University of Waterloo

Abstract: Experiences with the COMIT System of Computer-Assisted Learning are reviewed in relation to five evaluative criteria: effects on student learning, effects on student attitudes, effects on teachers, institutional effects, and extra-institutional effects. Conclusions are drawn concerning the possible future pedagogical role of computer assisted learning systems.

The impact of the computer on contemporary society has been so great during the past two decades that there are few individuals living in the industrial nations whose daily lives remain untouched by this aspect of modern technology. Education has of course been markedly affected by computers, especially with regard to administration and planning. Paradoxically, however, methods of teaching and learning within the educational system have been remarkably little influenced by the computer in any direct sense -- with the obvious exceptions of the use of computers as tools for numerical computation and as a means of teaching programming skills. This state of affairs is perhaps not as surprising as it may seem if we examine historically the impact on learning of instructional technology -- or indeed the impact of pedagogical innovations in general. On the whole, teaching techniques have been remarkably resistant to change, and it might plausibly be argued that no innovation has had any substantial impact on the way students learn -- at least in the formal education system -- since the invention of the printing press.

COMIT is one of the most sophisticated systems of computer-assisted instruction. As John Moore's introduction to this volume describes, it combines the facilities of a powerful computer with a rich and versatile presentation mode that is capable of supplying moving colour pictures, complex graphics and sound. The student's method of responding is also flexible, permitting communication by sonic pen or keyboard. This is an awesome facility, and it is consequently of immense interest to examine in some detail the attempts that have been made to use the COMIT system and, in particular, to assess the success of the system from an educational and

pedagogical standpoint. In this respect the preceding reports from COMIT course developers have great relevance.

Assessment Criteria:

In attempting to evaluate COMIT, the question immediately arises of what yardsticks are to be used to judge the effectiveness of such an instructional system. I propose to use five criteria: Effects on student learning, Effects on student attitudes, Effects on teachers, Institutional effects, and Extra-institutional effects.

(a) Student Learning. There will be little disagreement among teachers that a principal aim of instruction is to facilitate student learning. Learning, however, is not a unitary concept, and those responsible for the design of instruction must give careful consideration to the particular type and level of learning it is hoped to achieve. Bloom (1956) in his well-known Taxonomy of Educational Objectives [1] lists six types of learning (see Table 1) and it is interesting to note that all six types are represented in the COMIT modules described in the preceding papers.

Table 1. Types of Learning (from B. S. Bloom, Taxonomy of Educational Objectives, 1956)

Knowledge	-- of specifics
	-- of ways and means of dealing with specifics
	-- of the universals and abstractions in a field
Comprehension	-- translation
	-- interpretation
	-- extrapolation
Application	-- use of rules, methods, concepts
Analysis	-- of elements
	-- of relationships
	-- of organisational principles
Synthesis	-- communication
	-- planning
	-- derivation of a set of abstract relations
Evaluation	-- internal evidence
	-- external criteria

Of considerable interest here are the ways used by the different modules to achieve different learning ends. These range from drill-and-practice techniques and remedial instruction, as described by Delahey to teach offensive line play in football, to fairly elaborate simulations of real-life

situations where students are required to apply the knowledge they have attained, achieve some synthesis, and evaluate the efficacy of theoretical notions in relation to the simulated data. A good example of the latter approach is Thompson's programme to teach survey sampling, which exploits a capacity in which the computer excels (storing detailed information and arranging for its retrieval in a variety of different formats) and which would be virtually impossible to achieve by any other teaching technique that can be used in the classroom, as opposed to the "real world".

It is often, erroneously, assumed that the computer should be used to replicate as far as possible the function of the human teacher. (Indeed it is a common error in technological development to devise a machine that performs inefficiently exactly because it is made to ape human performance -- for example the common idea of a robot that looks, walks, and talks like a human would be an incredibly inefficient use of machinery for most purposes.). Computer-Assisted Instruction (as opposed to Computer-Managed Learning, for example) often tends to start from the basis that the learning material should be presented by the computer and confined to this mode of presentation. However, there is no reason why the computer need play such a direct teaching role. It may for instance be used as a learning aid, much like a dictionary or calculator, and indeed this is what Winter has done in using the machine to display various properties of human gait. The computer is also a convenient testing device (it was used for this purpose in nearly all of the COMIT modules) and a useful means of diagnosing each learner's knowledge and abilities so as to guide students to material uniquely suited to their individual needs.

This ability at efficient diagnosis, and the idea that the computer can cater to individual learning differences in a way that is not possible in the classroom, is a potential advantage of CAL that is frequently put forward by the system's advocates. Unfortunately in practice CAL, in common with previous instructional technologies such as programmed instruction, has a rather disappointing record of achievement. In reality, few modules employ very sophisticated diagnosis of student aptitudes (let alone student learning styles) and most of the branching techniques used for remedial purposes are fairly primitive, even in comparison with what was possible on the teaching machines of 15 years ago. There are good reasons why this potential strength of CAL has as yet gone largely unrealized: the deficiency

is probably due largely to the immense effort of time and commitment involved to write and programme material for this purpose. Hence the modules that in principle could cater to a wide variety of individual differences, and which are capable of continual improvement on the basis of a detailed examination of student responses, may remain in a crude and unmodified form indefinitely. Naturally, it is too early to say whether this will be so for the programmes developed in COMIT, although the fact that the system in its present form has been dismantled makes the question somewhat unfair or irrelevant.

If it is accepted that some demonstration of student learning is important evidence of teaching success, then attention turns to the types of evidence that might be useful for this purpose. Evaluation of any teaching intervention may be carried out in terms of a change in knowledge or (in the case of the teaching of a skill) behaviour compared to the abilities demonstrated immediately prior to the start of the teaching. Such "pretest - post-test" comparisons, if they are to be meaningful, should be related to carefully stated learning objectives that can be operationalized in terms of specific behaviour change. (Even then it is often difficult to know whether the change was due to the teaching, to some extraneous factor, or a combination of both.) Sometimes an attempt is made to supplement evidence of such changes on the part of learners by comparative measurements for a group of people to whom the material was presented in some other way (or to whom it was not presented at all). A full discussion of the design and shortcomings of such evaluative strategies is beyond the scope of the present paper. Suffice it to say that several of the contributions to the present collection describe attempts at evaluation that incorporate pre- and post-tests as well as comparisons with other teaching techniques. Some general comments about just what conclusions can be drawn from such studies are made at the end of this paper.

(b) Student Attitudes. A measurement of learners' attitudes to a system of instruction, while less important than evidence of student learning, is of value, not least because favourable attitudes are likely to facilitate learning (or, conversely, unfavourable attitudes are likely to be highly disadvantageous for learning). Nearly all of the preceding papers report on student reactions to their experience with the COMIT system, gathered either by means of a structured questionnaire or from informal interaction

with the module author. As is often the case with teaching innovations (indeed with any teaching technique) both positive and negative attitudes are reported. Negative comments relate to the monotony and lack of flexibility of the system: aspects that different authors attempted to deal with by different means, such as humour or the provision of ancillary notes. Another feature of the system frequently mentioned in a negative vein was its impersonality compared to a real, live teacher, and one attempt to combat this feature and add a "human element" to the learning experience is described by Avedon and Stewart.

This brings up the important question of the "man-machine interface" and the related, more general question of motivation in learning. Unfortunately our knowledge of the process by which humans relate to machines in both positive and negative ways, as well as our understanding of why machines are exciting for some individuals and frightening for others, is disappointing to this point, notwithstanding increasing attention by researchers to the question. It is interesting, for example, that most of McBean's students could spend no more than two or three hours at the COMIT terminal, while we know that students of similar age and intelligence will spend much longer periods passively watching a somewhat similar machine (television) or interacting with machines that seem on the face of it far less challenging (pinball machines, slot machines, and so on).

In terms of positive attitudes to COMIT, many students expressed pleasure at the idea of proceeding at their own pace and being able to review the material presented -- attributes that are not confined to CAL, but are greatly facilitated by such a system. In the case of favourable comments to the general notion of learning via such a system (and there were many such comments) it is important to recognize that there may be a confounding influence caused by the very novelty of the system and the fact that learners were part of a special experiment (the "Hawthorne effect"). On the other hand, some of the negative comments may come from conservative students who are resistant to any new type of learning. Furthermore the greatest area of negative reaction -- which concerned the technical problems with the system -- relates to features of COMIT that could almost certainly be remedied in the future.

(c) Effects on Teachers. The attitudes of authors and instructors to the experience of working with COMIT reflect the same divergence of opinion as do those of the student learners, and range from considerable enthusiasm about the general potential of the system to a measure of disillusionment, with positive attitudes predominating (perhaps not surprisingly in view of the need to justify the great amounts of time and energy expended on preparing the modules). The negative comments were clearly influenced by frustrations with technical aspects of the system (frequent breakdowns and slow response time) and the immense amount of authoring time required.

Of even more interest, however, are the comments by authors about the teaching/learning process itself that have applicability far beyond the COMIT system or computer assisted learning. For example, three of the authors, as a result of working on the preparation of their modules, soon realized that their knowledge of the material and their understanding of the best way to organize the material for efficient learning was far less than they had assumed at the outset, in spite of several years of lecturing on basically the same topics. If this was primarily a self-insight, there were other insights into the learning process itself. For example, four of the authors came to the realization that learning is essentially an active process that requires students to respond constantly and frequently, rather than passively receiving transmitted material, as happens frequently in so much traditional teaching. Authors also commented on another learning principle that is well known to psychologists but frequently ignored in the classroom, the notion that effective learning requires frequent and immediate information to students about how well they are progressing with the learning task. At least one of the authors raised the important issue of social factors in learning, to what extent students benefit from working alone at their own pace as opposed to learning with and from other people. Hence McBean felt that many of his students were able to benefit from being able to work in pairs when reviewing the material in the module.

It is important to realize that these insights about the learning process are not restricted to learning by computer, but are generally applicable. At the same time, it is instructive to see how effectively they were brought home by the experience of working with a new instructional system, such as COMIT, that places new demands on the teacher, especially with regard to the way he or she analyzes, selects, and structures the

material to be learned. Even for experienced teachers it appears that involvement with a new medium of instruction leads to a rethinking of principles and techniques previously taken somewhat for granted. To this extent experience with COMIT is of undoubted benefit to those involved in designing and administering the different modules.

(d) Institutional Effects. Over the three year existence of the COMIT project there was a considerable outlay of institutional funds and resources and an even greater investment of time on the part of the project staff and module authors, not to mention the effort and involvement of the many hundreds of student learners. Yet the essential components of the system have now been disbanded with little likelihood that the University of Waterloo -- at least in the short term -- will change its basic methods of teaching. Why is this the case, and why has this been the fate of so many experiments in educational technology in established educational institutions?

Part of the answer lies in the inherent conservatism of academics -- and students -- when it comes to the implementation of new methods of teaching and learning. Additional reasons relate to the basic complement of skills that most faculty bring to the teaching process (few faculty are trained in pedagogy and most learn through the examples of their own teachers), to the considerable costs involved (to cite just one example, the costs of providing and servicing an adequate number of terminals), and to the general reorganization of the university system that would be required in terms of timetabling, classroom arrangements, and so on. Furthermore, at a time when universities are threatened with severe financial stringencies and the very job security of university teachers is challenged, the political climate is probably not conducive to the introduction of a radical change in teaching methods, especially when the arguments for effectiveness are equivocal. Hence in the immediate future innovations like COMIT will probably remain in the domain of experiments to be tried and tested in forward-looking institutions, by faculty who are willing to devote their time and enthusiasm largely for the reward of their own self-satisfaction and personal insights into the learning process.

(e) Extra-Institutional Effects. In his introduction to this collection Moore states that one aim of the COMIT project was to see what implications might result from the experiment for extramural education. He points out

that this system seems to have particular promise in that its basic component is an ordinary colour television monitor (though supplemented with a number of sophisticated additions, such as a light pen, keyboard, and so on). It seems probable, however, that any hopes to introduce such a system on a widespread basis are rather premature.

In the first place, there appear to be formidable technical obstacles to the efficient operation of such a system, even when it is used "in-house" on a fairly small scale, and with constant technical assistance available to students using each terminal. Secondly, the authoring time required to produce material is vast, especially when it is borne in mind that the segments represented by the modules described here comprise only a fraction of the material normally presented in the one-term courses of which they form part. Thirdly, it is probable that the outside clientele for such a system is probably considerably more conservative about pedagogical matters than the student body in established institutions of higher education. In this regard the British Open University is an interesting case in point. Although this is a remarkable social innovation, from a technological and pedagogical point of view it is fairly orthodox, relying on the traditional mainstays of further education -- correspondence courses, personal tutors, textbooks (albeit extremely well organized ones) and traditional lectures during the compulsory periods in residence. The television component of the Open University is just that -- good television programming, involving none of the interactive element that is a principal feature of COMIT and CAL in general.

COMIT and the Future Role of Computers in Education:

A number of the experiments with COMIT described in previous papers have attempted to compare the system with other teaching methods. In the last analysis, however, such an approach is probably unproductive. Rather, we should try to analyze which media of instruction, including the human teacher, are most suited for particular pedagogical ends and for particular individual learners. This is a research question of great importance, about which very little is known as yet.

In the COMIT system the computer, it could be argued, is best seen not as a teacher, but as a "super-coordinator" of instruction -- potentially better than the human teacher at this task, though whether acceptable in this role by the human learner is something that has yet to

be determined. Certainly COMIT is far from cheap as a coordinating system, even though it is far less expensive in this role than when it is used as a direct teaching device. It must then be asked if it is worth this cost, or whether we shall continue to use our existing systems, largely human, or some alternative non-human, non-computerized system, such as written modules that are capable of guiding learners to a variety of existing resources.

If we accept the computer as a useful coordinator of instructional resources, then we must seriously question the notion that all the material involved has to be presented directly on the computer itself. The system will depend ultimately, I would suggest, not solely on its efficiency, but also on its flexibility. This is the future challenge of computers in education, and an issue for which the COMIT experiment has provided invaluable empirical data.

Reference:

- [1] B. S. Bloom, Taxonomy of Educational Objectives: Handbook 1. Cognitive Domain, McKay, New York, 1956.

COMIT SYMPOSIUM

SCHEDULE FOR PARTICIPANTS

A SYMPOSIUM ON COMIT

Presented under the auspices of the
Computers in Education Committee and the
Teaching Resource Person

Place: MC 5158

Date: Thurs, 6 April, 78

Time: 1:00 p.m.

FINAL PROGRAMME

Call to Order 1:05 p.m.
G.C. Andrews, Chairman, Computers in Education Committee

Introductory Remarks 1:10 p.m.
T.A. Brzustowski, Vice-President (Academic)

A Brief Summary of the COMIT Project 1:15 p.m.
J.B. Moore, COMIT Project Director

Some COMIT Highlights 1:35 p.m.
E. Elkeer, IBM, Project Coordinator

Representative Papers by COMIT Participants:

1. COMIT: The Leisure Experience 1:50 p.m.
E.M. Avedon and T.O. Stewart, Dep't of Recreation

2. Armchair Survey Sampling: An Aid in Teaching Survey Design 2:10 p.m.
M.E. Thompson, Dep't of Statistics

3. Student Response to Computer-Aided Teaching 2:25 p.m.
E.A. McBean, Dep't of Civil Engineering

Coffee 2:40 - 3:00 p.m.

4. COMIT and Offensive Line Play in Football 3:00 p.m.
W. Delahey, Dep't of Athletics

5. COMIT and Hockey Systems 3:15 p.m.
R.C. McKillop, Dep't of Athletics

6. A COMIT English Module 3:30 p.m.
P.D. Peam, Dep't of English

7. Computer-Assisted Instruction in Organic Synthesis 3:45 p.m.
V.A. Snieckus, Dep't of Chemistry

General Discussion and Summary 4:00 p.m. - 4:30 p.m.
Moderator: C.K. Knapper, Teaching Resource Person

RECEPTION: Following the Symposium, there will be a reception in the Faculty Club for all persons attending the Symposium. Wine and Cheese (approx.) will be served. 4:45 - 6:30 pm

Note: All persons wishing to attend the Symposium must contact Heather Baker (Ext. 3132) to reserve a place