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AUTHOR Ybarrondo, Brent A.
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ABSTRACT

This study ascertained whether or not computer assisted instruction (CAI) enhanced the quality of the educational experience and resulted in increased learning. The study involved the teaching of a 3-week instructional unit on population genetics and evolutionary processes to advanced placement biology students. The control group (N=38) received the instructional unit alone while the experimental group (N=39) received CAI experiences in addition to the conventional learning activities. The CAI experiences included a computerized simulation of evolutionary trends resulting from natural selection acting upon a population in lieu of the traditional laboratory, as well as an additional tutorial CAI exercise. Both groups were given the same posttest evaluation exercises and the scores compared with a student's t-test at the .05 level of significance. No significant increase or decrease in test scores was demonstrated at this level. Student evaluations of the CAI lessons presented were very high and indicated considerable interest in continued involvement with CAI. This is consistent with other research findings which indicate that students enjoyed the CAI experience, felt that they had learned from it, and would like to participate in CAI lessons in the future. (JN)

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A Study of the Effectiveness of Computer-Assisted Instruction in the High School Biology Classroom

by
Brent A. Ybarrondo
Boise State University
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Abstract

This research was conducted in response to a need perceived by the researcher for data pertaining to the effectiveness of computer-assisted instruction (CAI) in increasing learning in the science classroom in general, and the biology classroom in particular.

A sample of 77 advanced placement biology students in four classes at a large high school in the Pacific Northwest participated in the study. The experimental group numbered 39 and the control group 38. Both groups were presented with a fifteen-day instructional unit, prepared by the researcher, on population genetics and evolution. The control group participated in a traditional bean-coutning laboratory exercise designed to illustrate evolutionary trends resulting from natural selection acting upon a population. The experimental group participated in a computerized simulation of evolutionary trends resulting from natural selection acting upon a population in lieu of the traditional laboratory, as well as an additional tutorial CAI exercise.

The control and experimental groups were demonstrated, by a student s t test at $p<0.05$, to be statistically equivalent in terms of cumulative grade point average, and biology term point totals. Likewise, the control and experimental groups were demonstrated, by means of Chi Square analysis at $p<0.05$, to be statistically equivalent in terms of proportions of juniors and seniors.

The control and experimental groups were given the same posttest evaluation exercises and the scores compared with a student's t test at $p<0.05$. No significant increase or decrease in test scores was demonstrated at this level.

Student evaluations of the CAI lessons presented were very high and indicated considerable interest in continued involvement with CAI. This is consistent with findings reported by Petersen (1984) which indicated that students enjoyed the CAI experience, felt that they learned from it, and would like to participate in CAI lessons in the future. Likewise, in concurrence with the findings of Orlansky (1983) and White (1983), a considerable time savings in terms of concept formation was observed.

Introduction

A currently popular topic in the educational literature is Computer-Assisted Instruction (CAI) in the classroom. While this topic may be popular, there seems to be little data pertaining to effectiveness of the use of microcomputers to implement CAI. At least two questions are raised relative to microcomputers and CAI which include both promotion of increased understanding as well as most effective modes of implementation. Considering the current climate regarding the rapid increase of microcomputers in the public schools, it seems that development of these data is imperative in order that educators may make informed decisions regarding the purchase of hardware and software, as well as the proper implementation of CAI into the curriculum.

Statement of Purpose and Hypothesis

The purpose of this study is to ascertain whether or not CAI does indeed enhance the quality of the educational experience and result in increased learning. This study measured effectiveness in the high school biology classroom, as well as to examine two possible modes (tutorial and simulation) of CAI presentation. This investigation tested the null hypothesis that the addition of the CAI lessons to the author's traditional instructional unit would produce no significant increase in posttest unit scores as compared to those achieved by the control group which received no CAI lessons, in advanced placement biology students at a large high school in the Pacific Northwest.

This study involved the teaching of a three-week instructional unit on population genetics/evolutionary processes to advanced placement biology students. The control group (N = 38) received the instructional unit alone while the experimental group (N = 39) received CAI experiences in addition to the conventional learning activities. All materials, lesson plans, lecture notes, readings, study guides, and evaluations were the same for both groups.

Presuming as many variables as possible to be held constant, the score/grade distributions could, with appropriate statistical analysis, be correlated to the effectiveness of CAI in promoting increased effectiveness and/or efficiency of learning.

Description of the Instructional Unit

This unit was designed to meet the educational goal* and

* "The student should understand how inheritance and environment interact to produce changes in the structure and function in organisms through geologic time."

objectives for this unit as developed by the author. This unit was prefaced with a consideration of the scientific method and a discussion of what constitutes scientific theory.

The computer-assisted instructional material developed by the researcher consists of a comprehensive tutorial program, Charlie's Beagle, written for the Apple II+ and IIe microcomputers, which was augmented by the Evolut simulation program. The tutorial program includes consideration of:

1. The major concepts and principles involved in the theory of evolution by means of natural selection, as developed by Charles Darwin and Alfred Russell Wallace;
2. The historical background of the development of the theory of evolution by means of natural selection;
3. The manner in which environment and inheritance interact to produce changes in the structure and function of organisms through geologic time;
4. The contributions of others such as Georges Cuvier, Jean Baptiste de Lamarck, and Thomas Hutton.

The Evolut program by Conduit was also employed, allowing students to explore the concepts of differential survival inherent in the process of evolution by means of natural selection.

Assumptions of the Study

It was assumed that the sample groups of students in this study did not represent a normal distribution of high school students, or even of high school biology students, given the elective and advanced placement status of the course. The distribution, then, was assumed to be skewed significantly to the high side of grade distributions. For this reason data was gathered regarding the cumulative grade point averages and quarter biology point totals of the students in each group in order to shed light on the nature of this distribution. Furthermore, these data were subjected to a t test to determine the equivalence of the two groups.

Limitations of the Study

The researcher had anticipated certain limitations in the experimental design of this study. Foremost was the possibility of contamination by the researcher, since he was also the instructor. This may have presented some problem in terms of the Pygmalion Effect. The possibility of confounding the findings due to student enthusiasm for microcomputers, in light of their recent advent into

the curriculum, was also considered. There was no pretest administered to either group, owing to practical considerations pertaining to experimental design. Therefore the researcher has no measure of the prior knowledge of the subject matter of the two groups. Since this study has only advanced placement biology students, students which do not fit a normal distribution, the very distribution of students in the sample may have confounded or precluded the observation of results.

Need for the Study

Prior to the study the researcher surveyed the current literature pertaining to CAI in the public schools, both in terms of effectiveness in promotion of learning and in terms of most effective mode(s) of implementation in the curriculum.

With regard to the former, there is indeed a lack of data available to adequately address the question of actual effectiveness of learning promoted by the utilization of the microcomputer as an instructional aid.

With regard to the latter, again data are scanty. The current literature suggests, however, that a problem exists regarding the evaluation of the proper mode of implementation and effectiveness of CAI in the curriculum. Specifically, it seems that software must be of a high quality, both in terms of instructional design and in terms of programming to allow the assessment of effectiveness and proper mode of implementation to be addressed. This preliminary literature survey conducted by the researcher, in conjunction with an extensive review of appropriate commercially available software, as well as development of the researcher's own tutorial program, contributed to the production and procurement of quality educational software for the proposed study, thereby removing the obstacle presented by inferior software.

This researcher believes that this study is one of many such studies which must be conducted soon, so that educators will have the data needed to make informed decisions regarding the role the microcomputer is to play in education in the immediate future and expedite the addressing of this crucial educational issue.

Related Literature

The current concern of the educational community regarding the implementation of the microcomputer involves a very complex and interrelated set of issues. Although presently a popular topic, there is a paucity of adequate data to confirm or reject the notion that CAI using microcomputers is actually effective in enhancing

laboratory experiences. All materials developed including lecture notes, and posttest evaluation exercises were retained. Detailed data were kept for the classes.

The Subjects

The subjects in this study were 77 advanced placement biology students, juniors and seniors. The experimental group consisted 39 juniors and seniors in advanced placement classes in spring 1984. The control group consisted of 38 juniors and seniors in the same classroom teacher's advanced placement biology classes. These students were in intact classes and were not, therefore, randomly assigned.

The Treatment

No pretest was administered to either the control group or the experimental group. Both groups received a presentation of the researcher's complete instructional unit on population genetics and evolution. This unit required 15 days for both groups. The control group participated in a traditional bean-counting laboratory exercise to simulate the effects of natural selection on allele frequencies in a population.

In lieu of the traditional bean-counting laboratory, the experimental group participated in the directed simulation of the effects of natural selection on allele frequencies in a population with the Evolut simulation program. In addition the tutorial program Charlie's Beagle was utilized for review, reinforcement, and remediation of the concepts taught during the instructional unit. In all, the experimental group received two full days of computer-assisted instruction which amounted to one full day of additional instructional time, as compared with the control group. The CAI exercises were implemented at the end of the instructional unit in order to serve in the augmentation and extension of concepts as well as review and remediaton exercises prior to the posttest exercise.

There were three Apple II microcomputers used in a separate laboratory room. The actual logistics of integrating the CAI with the end of the lesson plans and irregularities of schedule required dividing each class into two groups of ten students. Although this averages to 3.3 students per machine, absences kept the number at 3 per machine.

On day 1 of CAI, group A received the second to last traditional activity called for by the instructional unit lesson plans and group B repaired to a laboratory room with the microcomputers for the first day of CAI. On day 2 the groups

the learning experience. This is a question which must be addressed immediately, in order that educators may make informed decisions as to whether or not, to what extent, and for what purposes microcomputers should be integrated into the curriculum.

Educators are therefore faced with many uncertainties regarding the microcomputer and its most effective mode of implementation into the classroom curriculum. These questions involve practical applications problems, financial considerations, cost-effectiveness, software, as well as faculty training in computer literacy. Not least of all, the educational community must establish whether or not the microcomputer is actually effective and/or efficient, as well as cost-effective, in promoting increased learning as opposed to being simply an amusing widget.

With the tremendous implementation of microcomputers into all facets of our lives has come increasing pressure for the educational community to utilize these powerful tools. Educators have found themselves in the somewhat awkward position of being faced with the prospect of implementing a revolutionary device into the educational process, when in fact, they are unfamiliar with its utilization.

This unfortunate circumstance has resulted in a rash of hardware acquisitions by school districts to alleviate community pressure, only to be followed by the most unpleasant realization that these devices do not operate at all in the absence of appropriate software. With the realization that considerations of hardware alone are insufficient, school boards and administrators are faced with the difficult task of selecting and evaluating which educational software to purchase for inclusion in the curriculum. The difficulty arises from two main areas. First, according to what criteria should this software be evaluated? Second, who should develop educational software?

It is beyond the scope of this paper to provide an in-depth review of the pertinent research on the effectiveness and efficiency of CAI in promoting learning, or to consider issues related to development and evaluation of educational microcomputer software, modes of implementation of CAI into the curriculum, and current and future trends of CAI. The unabridged version of this research (70 pp.) is available from: Boise State University Library, 1910 University Drive, Boise, Idaho 83725.

Procedures

A complete instructional unit was developed by the author consisting of lecture, readings from several texts, vocabulary building, worksheets, questioning sequence/discussion, film, and

e changed activities. On day 3 group A received the last day of traditional instruction and group B received the second day of CAI. On day 4, again the groups changed places.

On the first day of CAI the students worked with the simulation program Evolut by Conduit. This program allows the user to simulate the effects of natural selection on differential survival by allowing the user to control such variables as dominance or codominance, direction of selection, strength of selection, initial percent of alleles in population, and initial size of the population. The program then simulates the increase or decrease of alleles according to the values entered and random number-generated differential survival rates for ten generations in tabular form. At this point the user may either continue for another ten generations, switch to the line graph mode, and/or change the direction and strength of selection before continuing. The program then gives the user the option of starting over or continuing for another ten-generation block, in either the tabular or graph mode. The program will do so for forty generations. The utility of such a program for simulating such classic examples of natural selection such as industrial melanism becomes apparent.

The students used the materials provided by the Evolut package to first simulate selection according to various parameters on various populations, in order to observe the resultant evolutionary trends. When this basic utility was mastered, the students then simulated industrial melanism, codominance, or genetic drift, according to the topic assigned their three-person group. On these one-page handouts were corresponding questions designed to direct their inquiry utilizing the program. While the researcher was concerned that development of sufficient operating skills would preclude the accomplishment of both tasks in the allotted 50 minutes, the students were proficient in operating the program within 10 minutes and easily accomplished the simulation of approximately some 150 generations while manipulating the parameters and predicting or observing the outcome.

On the second day of CAI the students worked with the researcher's tutorial/game program Charlie's Beagle. Charlie's Beagle is a comprehensive branching tutorial program which utilizes a game format in order to motivate. The safe return of H.M.S. Beagle depends upon the user's responses to some 20 multiple-choice questions. Responses are entered with the selection of a letter choice and carriage return, while frame advancement is accomplished by a carriage return. Given the rather effective trapping of inappropriate responses, the program is rather difficult for the user to "crash." Therefore, this program is designed to operate in a stand alone capacity. When a response to a question is entered, the program branches to appropriate feedback, reinforcement, or remediation subroutines before branching to the game mode. In the game mode, the user encounters pirates, storms, increases or

decreases in supplies, cannonballs, and/or time remaining, according to whether or not their responses were correct before returning to the main program and presentation of the next question.

Data Gathering

As noted above, there was no pretest administered to either group. A two-part, two-day posttest evaluation exercise was administered to both groups. The test consisted of an essay question component comprised of 5 questions designed to promote higher levels of reasoning, of which the students chose 3 worth 10 points each for 30 points total. These were scored by the researcher according to a highly specific set of criteria set forth in a four page typewritten answer key developed by the author.

The second portion of the posttest was composed of 10 true/false questions and 30 multiple choice questions worth 70 points total.

When the posttest evaluation had been completed, the 11 point Student Evaluation of Computer-Assisted Instruction Unit form* was distributed two per student, one each for Evolut and Charlie's Beagle.

* See Appendix A.

Analysis of Data

Introduction to Table 1

The control group consisted of 15 juniors and 23 seniors, while the experimental group consisted of 16 juniors and 23 seniors. A Chi Square analysis at $p<0.05$ shows no significant difference between the observed and expected junior/senior ratios in the control and experimental groups. These data are summarized in Table 1.

Table 1

Chi-Square for Junior/Senior Distribution in the Sample

	Control Group	Experimental Group
Juniors	15	16
Seniors	23	23
N	38	39

Chi Square calculated = 0.074
Chi Square significant
at $p<0.05$ and df=1 = 3.841

Introduction to Table 2

Means, standard deviations, ranges, and standard error of the means were calculated for each group for cumulative grade point average, proportion of quarter point total in biology, and posttest evolution unit scores. These data indicate that both the control and experimental groups support the assumption that these students do not represent a normal distribution of high school students in general or biology students in particular, but rather, represent a distribution skewed significantly toward the high side. These data are summarized in Table 2.

Table 2

Mean, Standard Deviation, Range, and Standard Error of Mean for Sample Criteria

	Control group (N=38)	Experimental group (N=39)
Cumulative Grade Point Average		
Mean	3.50	3.35
Standard Deviation	0.42	0.45
Range low	2.59	1.95
high	4.00	4.00
Standard Error of mean	0.70	0.70
Proportion of Quarter Point Total		
Mean	0.84	0.82
Standard Deviation	0.11	0.10
Range low	0.56	0.50
high	0.99	0.95
Standard Error of mean	0.02	0.02
Evolution Unit Posttest Scores		
Mean	84.50	84.90
Standard Deviation	9.81	9.35
Range low	61.00	64.00
high	97.00	98.00
Standard Error of mean	1.59	1.50

Introduction to Table 3

A student's t test was employed at a level of significance of $p<0.05$ to test whether the control and experimental groups differed significantly in terms of any of the three parameters examined in table 2. At $p<0.05$ the t test showed no significant

difference between the control and experimental groups on the basis of cumulative grade point average and, similarly, a t test showed, at $p<0.05$, no significant difference between the two groups on the basis of quarter point totals in biology. This, together with the Chi Square analysis of the proportions of juniors and seniors in each group, indicates that these two groups are statistically equivalent.

Finally, a t test showed, at $p<0.05$, no significant difference between the two groups on the basis of posttest evaluation scores on the population genetics/evolution unit. These data actually test the hypothesis of this investigation. These data are summarized in Table 3.

Table 3

Student's t Test Results

@ $p<0.05$ $df = 75$ results are significant with values of t) or = 1.980

---

t Test for cumulative G.P.A. t = 1.400

For this t, p = 0.162 Not significant

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t Test for quarter total points biology t = 0.999

For this t, p = 1.679 Not significant

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t Test for evolution unit posttest scores (Testing the hypothesis) t = 0.184

For this t, p = 1.849 Not significant

Introduction to Table 4

The means, standard deviations, range and standard error of mean were computed for responses to each of the 11 specific points on the Student Evaluation of Computer-Assisted Instruction Unit form* for each program. These data are summarized in Table 4.

Table 4

Each of the following eleven points were evaluated by the students in the experimental group on a "low" to "high" rating, 1 to 5 respectively. Values are tabulated for mean (x), standard deviation (sd), and range (r).

(N=77)	Evolut			Charlie's Beagle		
* question no.	x	sd	r	x	sd	r
1	4.53	0.65	3 - 5	4.46	0.70	3 - 5
2	4.03	0.88	2 - 5	4.29	0.86	2 - 5
3	4.33	0.86	2 - 5	4.11	1.08	1 - 5
4	4.33	0.96	2 - 5	4.77	0.55	3 - 5
5	4.22	0.87	2 - 5	4.63	0.69	2 - 5
6	4.28	0.97	2 - 5	4.86	0.49	3 - 5
7	4.56	0.50	4 - 5	4.77	0.65	2 - 5
8	4.17	0.91	1 - 5	4.46	0.74	3 - 5
9	3.72	1.16	1 - 5	4.04	0.88	2 - 5
10	4.17	0.77	3 - 5	4.39	0.64	3 - 5
** 11	4.71	0.63	2 - 5			

* See Appendix A. Student Evaluation for CAI Unit form.
** Question 11 is a request to indicate desire to participate in CAI in the future. For this criterion, the data were combined (N=77).

Summary

Two groups of junior and senior advanced placement biology students were presented with a fifteen-day instructional unit, prepared by the researcher, on population genetics and evolution. The control group participated in a traditional bean-counting laboratory exercise designed to illustrate evolutionary trends resulting from natural selection acting upon a population. The experimental group participated in a computerized simulation of evolutionary trends resulting from natural selection acting upon a population in lieu of the traditional laboratory, as well as an additional tutorial CAI exercise.

The control and experimental groups were demonstrated, by a student s t test at $p<0.05$, to be statistically equivalent in terms of cumulative grade point average, and biology term point totals.

The control and experimental groups were demonstrated, by means of Chi Square analysis at $p<0.05$, to be statistically equivalent in terms of proportions of juniors and seniors.

The control and experimental groups were given the same posttest evaluation exercises and the scores compared with a student's t test at $p < 0.05$. No significant increase or decrease in test scores was demonstrated at this level.

Student evaluations of the CAI lessons presented were very high and indicated considerable interest in continued involvement with CAI.* This is consistent with the findings reported by Petersen (1984) which reported that students enjoyed the CAI experience, felt that they learned from it, and would like to participate in CAI lessons in the future.

Conclusions

Given no statistically significant difference in the posttest scores of the two groups, the null hypothesis that the inclusion of the CAI lessons would not increase the effectiveness of learning, was accepted. The experimental group received one full extra day of instructional time, and still there was no significant increase in posttest scores.

Size of Groups

Groups of ten students per three machines produced an average 3.25 students/machine, and absences kept that number to 3

* See Table 4, question no. 11

per machine. Three students per machine may, in fact, be optimal. The researcher observed that this size of group kept students on task, promoted dialog, promoted peer-tutoring, while hands-on experience for each student was still possible. Also small groups allowed the instructor to give each group individual attention that would be less likely in larger groups, or in a situation where each of thirty students had his/her own machine. This is consistent with the findings of Daly et. al. (1981) which stated that groups of six students per machine, or less, appeared to be optimal and with those of Dawes (1977) which indicated that three students per machine was optimal.

Motivation

The researcher observed a significant increase in motivation towards learning when students reached the CAI portion of the instructional unit. This is consistent with findings reported by North (1978) which indicated that students' interest in an experiment is better maintained when results are quickly and easily maintained. Student comments regarding the Evolut simulation included complaints that the time requirement for calculations, ranging from 105 seconds with a small population to 6 minutes 45 seconds for large populations, was unacceptably long and the researcher observed that even with such a relatively short time span student interest wavered. However, the time requirement for such calculations in the BASIC programming language on a machine based on an eight-bit microprocessor represents an unavoidable limitation of such hardware and software configurations.

Noonan (1981) reported that around the fifth repetition of a simulation, students were observed to be entering values already calculated and designed to produce specific results. Students in the experimental groups in this study were similarly observed to be entering such values, to the delight and surprise of the researcher who had anticipated possible problems regarding the mechanical operation of the program. These observations are good indications that students were looking at the results of past decisions and making new choices based on the observed effects.

It is clear that microcomputer simulation of the effects of natural selection on populations led to an increase in understanding of the process as compared to that which resulted from the bean-counting laboratory exercise in the control group. This was substantiated by comments to that effect on the Student Evaluation of Computer-Assisted Instruction Unit form.* This increased ability to see evolutionary trends undoubtedly resulted from the microcomputer simulation of some 150 generations of populations which were subject to the students' manipulation of

* See Appendix A.

selection and population parameters. This is clearly superior, in terms of efficiency of elucidation of evolutionary trends, to the three or four generations which students were able to simulate in one class period of bean-counting.

Thus, the intent of the simulation was indeed served. Therefore, the utility of microcomputer simulation exercises in developing higher-order conceptual understanding becomes clear.

Value of CAI

While this study did not demonstrate an increase in the effectiveness of learning of the material presented in the instructional unit, it did appear to demonstrate an increase in learning efficiency in terms of time required for students to grasp the concept involved. This is consistent with observations reported by Day (1983), Orlansky (1983), and North and Dent (1978). Concepts were apparently grasped more quickly, resulting in time savings for students and instructor. Day observed this time-savings to be of practical value in terms of an increase in teaching economy with retention (if not increase) of educational value. Furthermore, the student is able to re-run the experiment, if necessary, and, being free of experimental mechanics, concentrate on concepts presented. This is certainly significant in the classroom setting, which often finds the instructor struggling to find time enough to cover the curriculum of the course.

Related Literature

This researcher concurs with the assertions of Forman (1982) that CAI can produce the same results in achievement in less time and that attitudes of teachers and students towards CAI are positive. Likewise, this researcher concurs with the assertions of Thorvildsen (1982) that:

1. Comparisons of CAI and traditional instruction remain inconclusive;
2. Student attitudes towards the subject matter were better when using CAI than when using traditional instruction;
3. Teacher and student attitudes toward CAI are positive;
4. The development of effective CAI programs is extremely difficult, complex, and time consuming.

Recommendations and Implications

A rather significant limitation of this investigation involves the sample itself. Since the sample used in this study was comprised of advanced placement biology students with an overall cumulative grade point average of 3.42, it seems clear that these students do not represent a normal distribution of biology students, or of high school students in general. Likewise, the fact that this class is an elective class might imply a predilection towards the learning of or interest in biology. The researcher believes that the very nature of the sample chosen for this investigation might well have obscured observation of any actual increase in learning effectiveness since it may fairly be presumed that an inordinate proportion of tnese students would have earned high scores regardless of the inclusion of the CAI lessons. Indeed, a consideration of the cumulative grade points, term biology point totals, as well as scores on the instructional unit in question reveal a very skewed distribution of scores. These data support the assumption that this sample does not represent a normal distribution of high school students in general or biology students in particular.

For this reason, it is the recommendation and intention of the researcher that this research be repeated with a more normal distribution of high school students. Specifically, the researcher suggests that tenth grade biology students, a <u>required</u> course, would more likely produce more clearly observable results, in terms of any actual increase or decrease in learning effectiveness which might result from the inclusion of these CAI lessons.

Bibliography

Barnato, Carolyn, and Barnett, Kathy Microcomputers in Biology Inquiry American Biology Teacher 43 (7): 372, 377-378 October 1981

Cohen, V. B. Criteria for the Evaluation of Microcomputer Courseware Educational Technology 23 (1): 9-14 January 1983

Conduit, University of Iowa, P.O. Box 388 Iowa City, IA 52244

Daly, Michael, and Hillier, Douglas Computer Simulation of Population Growth (Schizosaccharomyces pombe) Experiment J. Biological Education 15 (4): 266-268 Winter 1981

Dawes, John A. A Simulation Model Approach to the Study of Evolution J. of College Science Teaching 7 (2): 102-104 November 1977

Day, M. J., Randerson, P. F., and Bartlett, J. R. Computer Simulation of a Microbial Genetics Experiment as a Learning Aid for Undergraduate Teaching J. Biological Education 17 (1): 40-42 Spring 1983

Forman, D. Search of the Literature The Computing Teacher January 1982

Noonan, Larry Computer Simulations in the Classroom Creative Computing 7 (10): 132-134 136, 138 October 1981

Norman, J. C., and Dent, M. T. Computer Simulation of Mutagenesis J. Biological Education 12 (3): 224-228 September 1978

Orlansky, Jesse Effectiveness of Computer-Assisted Instruction: A Different Finding Electronic Learning 3 (1): 58-60 September 1983

Petersen, Nils Designing a Simulated Laboratory Byte 9 (6): 287-296 June 1984

Scandura, Joseph M. Three Roles for the Computer in Education Educational Technology 23 (9): 15-16 September 1983

Steffin, B. A. A Suggested Model for Establishing the Validity of Computer-Assisted Instructional Materials Educational Technology, 23 (1): 20-22 January 1983

Steinberg, E. R. Reviewing the Instructional Effectiveness of Computer Courseware Educational Technology 23 (1): 17-19 January 1983

Thorkildsen, R. J. Research on Computer-Assisted Instruction (Mimeographed) 1982

Toffler, Alvin The Third Wave Morrow Publishing, New York, New York 1980

White, Mary Alice Synthesis of Research on Electronic Learning Educational Leadership 40 (8): 13-15 May 1983

Appendix A

Student Evaluation of Computer-Assisted Instruction Unit

Directions: Please rate the Computer-Assisted Instructional CAI unit as honestly as possible by circling the number which best describes your impressions of the CAI unit presented. Your comments and suggestions are invited on the reverse of this form.

Name of the CAI unit evaluated: _____

	High				Low
1. The CAI unit was well prepared	5	4	3	2	1
2. The CAI unit was useful in increasing the user's comprehension of the concepts presented	5	4	3	2	1
3. The CAI unit provided an opportunity for comprehension of the concepts presented which is uniquely possible with the use of a microcomputer	5	4	3	2	1
4. The CAI unit was more motivating to the user than traditional methods of instruction	5	4	3	2	1
5. The CAI program was well written and used vocabulary which was appropriate for the user	5	4	3	2	1
6. The CAI program was easily operated by the user	5	4	3	2	1
7. The instructional text was formatted for clear screen display	5	4	3	2	1
8. Feedback was used appropriately	5	4	3	2	1
9. The program is of an appropriate timespan to maintain attention	5	4	3	2	1
10. Please indicate your <u>overall</u> (i.e. effectiveness) rating of this CAI package	5	4	3	2	1
11. Please indicate your desire to participate in CAI in the future	5	4	3	2	1

Comments / Suggestions (continue on back):