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4-1-1973

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Evaluation of an experiment in computer-assisted tutoring*

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It was made apparent from the presentations at the Conference of Computers in Undergraduate Science Education that very few Computer-Assisted Instructional (CAI) programs in physics attempt to evaluate the performance of computer-tutored students in comparison with a control group. In this note, we discuss an experiment in which 23 beginning physics students out of a class of 64 were given a computer-administered tutoring test in place of the regular review recitation session prior to an hour exam on relativity. The performance of the computer-tutored group on the exam was compared to the performance of the rest of the class.

The computer software module used for the CAI exam permits the instructor to make a test containing four types of questions: matching, multiple choice, true-false, or insert word/phrase. For example, the examiner may compose the following question and responses:

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Q2 A MUON IS A PARTICLE WHICH CAN BE CREATED
HIGH ABOVE THE EARTH'S ATMOSPHERE IN A
COLLISION BETWEEN A PROTON AND A NUCLEUS.
THESE MUONS HAVE AN AVERAGE LIFETIME OF
T SECONDS IN THEIR REST FRAME. ASSUMING A
MUON ENTERS THE EARTH'S ATMOSPHERE MOVING
AT A SPEED OF 0.99*C RELATIVE TO THE EARTH,
HOW FAR DOES THE AVERAGE MUON THINK THE
EARTH TRAVELS BEFORE THE MUON DECAYS?
(A) 0.99*C/T  (C) 0.99*C*T (SQRT (1.0-(0.99)**2)
(B) 0.99*C*T  (D) 0.99*C*T/SQRT(1.0-(0.99)**2)
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*This project supported in part by a grant from the Teaching Council of the University of Nebraska.

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CAB IN THE REST FRAME THERE ARE NO DILATIONS OF TIME NOR CONTRACTIONS OF LENGTH. THEREFORE WE CAN SIMPLY USE DISTANCE = VELOCITY * TIME.

WAA YOU HAVE FORGOTTEN THAT DISTANCE = VELOCITY * TIME. TRY AGAIN.

UA OBJECTS IN THE REST FRAME OF THE MUON UNDERGO NO DILATIONS OR CONTRACTIONS. TRY AGAIN.

TY THE DISTANCE COVERED IN THE MUON'S REST FRAME IS GIVEN BY THE PRODUCT OF SPEED AND LIFETIME, OR DISTANCE = 0.99*C*T. THE LIFETIME IN THE MUON'S REST FRAME UNDERGOES NO DILATION.

The question portion of the above (Q2) is presented to the student. If he responds with the correct answer (B), the computer presents a reinforcing statement (CAB) and proceeds to the next question. If the student gives the wrong answer anticipated by the instructor (A), then the computer returns with the appropriate hint (WAA), and the student tries the question again. If the student gives any other answer, he is shown a general clue (UA), and is given another try. If he misses the question on his second try, he is given a statement of how to answer correctly (TY) and instructed to proceed to the next question.

Relativity was discussed in both lecture and recitation for three weeks. The last recitation before the hour exam was used as a review. The computer-tutored sample group was given a 26 question tutorial examination instead of the usual hour-long recitation review. A strong attempt was made to give the same material to both the control group and the sample group. Consequently, both groups were given an outline of the important concepts of relativity and a listing of the 26 tutoring questions (without the correct answers being specified). The oral recitation for the control group discussed the outline; the sample group was handled entirely by the computer.

The students' performance was evaluated by examining the test scores on three separate hour exams. The first two covered the topics of electricity-magnetism and optics, respectively, and none of the students received computer tutoring. The third exam on relativity, for which the CAI was arranged, contained 10 items, each of which was separately evaluated. A t-test comparing the distribution of scores for the computer group with the distribution of scores for the control group was performed for each of the three tests and for each item on the relativity exam. The scores were normalized to make the average of the sample group scores on the first two-hour exams the same as the average of the control group.

Only one item had a significant t-test value ($t > 2.0$) and on this item, the control group received higher scores than the computer-tutored group. This item dealt with identifying the contributions of certain important people to the study of relativity. The computer-tutored group was not presented with a question specifically concerned with these people.

While none of the other nine questions had a significant t-test value, eight had a positive value. These positive values indicate that on eight of the ten questions, the computer-tutored group out-performed the control group. This superior performance, according to the t-test values, would have only a 15% probability of occurring by chance alone. This value, however, is not sufficient to be considered as statistically significant.

The attitudes of the sample students toward their tutoring experience were probed by a questionnaire administered immediately after the hour exam. The results indicated that the students: (a) enjoyed the tutoring session, (b) believed that the computer tutoring was more valuable than the existing recitation section arrangement, and (c) felt that one hour of CAI was an insufficient amount of time to study for the hour exam.

We have concluded that: (a) the amount of work required to arrange for 1-1/2 hours of CAI of this nature is prohibitively large (40 man-hours); (b) the CAI can be shallow—students are poorly prepared on topics not specifically covered in the computer tutoring exam; and (c) there is a high degree of student interest generated by CAI, some of which may account for the slightly superior performance of the computer-tutored students over the control group.

A complete report of this work containing a description of the CAI format, the text of the computer questions, the hour exam on relativity, the complete results of the attitude questionnaire, and the complete evaluation of the performance of the students is available from R.G.F., Dept. of Physics, Univ. of Nebraska, Lincoln, NE, 68508.