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ABSTRACT

The effects of the inclusion of matched redundant digital audio on achievement, time spent in learning, and attitude toward computer-based instruction (CBI) delivered mathematics were studied with 82 high school students. Differential effects on students of varying entry learning mathematics performance were also investigated. Subjects were assigned to CBI-audio or CBI-text conditions by stratified matched pairs within three existing classes. Both groups completed three lessons from the Alberta (Canada) CBI mathematics curriculum for grade 10. For the audio condition, lessons were modified by adding redundant audio through male voice instructions. Analysis of scores on a mathematics achievement test did not indicate any effects of CBI delivery mode on comprehension and mastery, but did indicate that redundant audio did reduce time required to complete practice questions, implying greater learning efficiency for the CBI-audio condition. No significant attitude differences were found overall, but lower ability students were more positive in the dual channel (redundant audio) condition. Seven tables illustrate study findings. (Contains 11 references.) (SLD)

AN EXPERIMENT ON EFFECTS OF REDUNDANT AUDIO IN COMPUTER BASED INSTRUCTION ON ACHIEVEMENT, ATTITUDE, AND LEARNING TIME IN 10TH GRADE MATH

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Abstract

In the tradition of dual versus single channel research, this field experiment investigated the effects of the inclusion of matched redundant digital audio on achievement in, time spent in learning and attitude towards CBI delivered mathematics at the high school level. Differential effects on students of varying entry learning math performance was also investigated. Mathematics 10 subjects (N=82) were assigned to the two main treatment conditions (CBI_audio, CBI_text) by stratified match pairs within three existing classes. Both treatment groups completed the same three lessons of one unit of Math*Tech 10*. Math*Tech 10* is a course in the Alberta curriculum which is delivered by CBI, contains 110 lessons and incorporates 16 self–diagnostic exams. The three selected lesson files for the treatment condition were modified by adding redundant audio (male voice instructions), except for the exams and those portions of the lesson where random generation were used. Analysis of scores of a math achievement test measuring the objectives of the lessons revealed that assignment to the two CBI delivery modes did not have a significant effect on the overall comprehension and learning mastery of the related mathematical materials. No significant differences between the lower ability students across the two treatment groups were observed. Several different time measures were addressed in the study. Overall study times were equivalent for main treatment groups but higher ability dual channel students took more time overall than their control group counterparts. Regarding time to complete the practice questions built into each lesson, the higher ability dual channel students took less time to complete the questions with equivalent achievement scores, implying greater learning efficiency. Overall there were no significant attitude differences between the two main treatment groups. In the dual channel audio treatment condition, lower ability students were generally more positive about learning than the higher ability students. Additional attitude differences were found. The results suggest that redundant audio, added to Computer Based Instruction to teach high school mathematics, has little effect on achievement but does affect learning time, and attitude formation of students of differing learning ability.

The emergence of more powerful computer hardware and software development tools make it technically feasible to incorporate digital audio speech into interactive Computer Based Instruction (CBI). While technically feasible, little actual research has been undertaken with respect to investigating the educational effects of incorporating digital audio speech on the learning process.

Digital audio speech research has narrowly focused on the mechanics of incorporating digital audio speech into existing text–based applications, the "how to" of digital voice integration. Contemporary research assumes the relative educational effectiveness and desirability of the inclusion of digital audio speech in text–based applications. From a hardware and software perspective, it focuses on discovering the best techniques of incorporating digital audio speech into text–based applications. Areas that have received the most attention for the inclusion of digital audio speech are second language training, distance education, adult literacy, special education, early childhood education and reading programs.

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Little research to date has investigated the relative benefits and educational effectiveness of the inclusion of digital audio speech in CBI applications, the "why" of audio integration. Furthermore, very little information is available regarding the educational effect, benefits and desirability of the inclusion of digital audio speech in CBI in core subject areas in mainstream educational programs, especially at the junior and senior high school levels. Specifically, the research has not addressed whether the inclusion/exclusion of digital audio speech constitutes a significant user variable in the enhancement of student achievement and attitudes towards CBI Mathematics learning at the senior high school level.

Research on Single and Dual Channel Learning in the Context of CBI

Although substantial research has been conducted on the effects of speech and audio, the results as yet do not provide clear direction. This section summarizes some of the key findings and conclusions.

One of the three stages of our short term memory seems devoted to image retention (iconic memory for visuals, echoic memory for auditory and haptic for touch and senses) (Dempster, 1985). People can discriminate among 4 sounds at a time but the short term echoic storage lasts only 2 seconds before accuracy of recall begins to decline (Darwin, Turvey & Crowder, 1972).

Studies have examined learning from single and dual channel sources. McLuhan observed in 1969 that when information is simultaneous from all directions at once, the culture is auditory and tribal, regardless of its pas or its concepts.

Hartman (1961) identified 4 kinds of multichannel information: redundant (e.g., identical audio and text; related (pictorial representation and verbal description); unrelated as in a picture accompanied by a different spoken word; and contradictory (simultaneous presentation of a picture of a man and the spoken word 'women'). Baecker & Buxton (1987) identified several uses for sound; communicating, seizing attention, enhancing visual stimuli, and relieving overload on the learner's information processing and constructivist learning system. As a practical example in video, Hanson (1989) recommended using redundant audio and video if information is to be learned, otherwise use non-redundant audio to direct attention to the video channel.

Hartman (1961) reviewed nine studies comparing simultaneous audio-print presentations with audio alone or print alone and found seven of those supported simultaneous presentation with the remaining being equal. Hsia (1968) concluded that communication efficiency and dependability were higher when audio and visual channels were present compared with audio and visual alone.

Hsia (1969) argued that simultaneous audio visual presentation of identical or highly redundant information should increase the performance of low intelligence learners to that of high intelligence learners. Kozma (1991) suggested that students who are more knowledgeable about the subject can proceed faster and vice versa; these suggest research on interactions between aptitudes of learners and multichannel treatments.

Channel research involving audio is far from conclusive. Barron (1991) for example, found no difference between students who learned via CBI with and without audio. In terms of learning time, Laddaga, Levine and Suppes (1981) found students took the same amount of time in CBI audio as CBI non-audio but perceived the audio as taking longer. When students were allowed to choose audio vs non-audio CBI instruction, about half chose audio.

The Research Study

The purpose of this study was to determine the effects of CBI and redundant audio, as measured by achievement, attitude and time spent in learning 10th grade math concepts. In addition to comparing CBI_audio and CBI_text, differential effects on students of varying entry learning math performance was investigated. It was expected that the treatments would effect students of different learning histories differently.

Materials and Procedures

Math*Tech 10* is a course in the Alberta curriculum which is delivered by CBI, contains 110 lessons and 16 exams, and is suitable for distance delivery and individualized instruction.

Three lessons on Equalities and Inequalities developed in Authorware Professional 1.6 were selected and utilized in their original screen design, instructional content and feedback. CBI_audio was modified by adding redundant audio, except for the exams and those portions of the lesson where random generation was used. Each lesson includes instruction and a practice section.

The male voice audio of on screen text instructions and student performance feedback was digitized using a MacRecorder. After extensive pretesting of various combinations of sampling and compression rates in conjunction with the specific hardware/software parameters of the MacIntosh Classic and Authorware Professional environment, the 11 Khz sampling rate was selected. This sampling rate offered the best available quality voice recording given the test-site parameters – 4 MB RAM, 20 MB MacIntosh Classic Hard Drive, 512 K cache. As noted by Barron (1991), the 11 Khz sampling rate exceeds acceptable industry standards for voice recording at the time of the study. Due to the CBI_audio lessons' large size and demand on processing speed, all lessons (CBI_audio and CBI_text) were run on 30 stand- alone MacIntosh Classic learning stations rather than delivered through the school's MacJanet network. Program modifications resulted in differential file sizes (CBI_audio = 17 MB, CBI_text = 1.2MB). Audio compression was not used in this study due to technological limitations. Data were collected in the Fall of 1993 from a large suburban high school

The lessons took 335 minutes to complete over 5 days. Students (N = 82) from the three classes (2 teachers) in a single high school were randomly assigned in stratified matched pairs to treatment (CBI_audio) or control (CBI_text).

The field experiment used a two-factorial design (ability X treatment) across three dependent variables (achievement in, time spent in learning and expressed attitude towards CBI mathematics). The two levels of entry level math abilities were measured by scores in the previous year of mathematics (higher ability students mean Grade 9 final mark = 86.30, lower ability students mean Grade 9 final mark = 61.14).

Data Sources

The dependent variable of achievement was measured by a series of content examinations and a 25 item Unit exam targeted to the objectives of the three lessons. Time spent in learning was assessed using the built-in clock function of the computer and included completion of instruction module, completion of practice questions and total connect time. Attitude was assessed through a 42 item Likert- type instrument designed to identify attitude towards learning mathematics by computer.

Results- Achievement

Analysis of scores of a math achievement test measuring the objectives of the lessons revealed no difference between the two treatment groups (Table 1) and no difference between lower ability students across the two treatment groups (Table 2).

Table 1

t-test for Paired Samples on Final Exam Scores

No of Pairs: 41 df: 40 t-value(0.95): -.06

Group:	Mean:	SD:	SE:
CBI_audio	64.83	18.17	2.84
CBI_text	65.00	17.50	2.73

Table 2

ANOVA - Lower Ability Students Final Exam Scores

Source	df	Sum SQ	Mean SQ	F	P
Between:	1	107.3	107.3	.45	.51
Within:	40	9547.0	238.7		
Total:	41	9654.3			

Group:	Mean:	SD:	SE:	Range
CBI_audio	52.58	17.07	3.73	24.5-84.3
CBI_text	55.76	13.64	2.98	32.4-80.6

Results-Time

Several different time measures were addressed in the study. Overall study times were equivalent for CBI_audio and CBI_text (Table 3) but the higher ability audio students took more time (22.3%) overall (Table 4). Regarding time to complete the practice questions built into each lesson, the CBI_audio students took less time (25.9%) than the CBI_text group (with equivalent achievement scores), implying greater learning efficiency for CBI_audio condition than for CBI_text (Table 5).

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Table 3
t-test for Paired Samples on Time Spent in Learning (Seconds)

No of Pairs: 41 df: 40 t-value(1.67): 1.41

Group:	Mean:	SD:	SE:
CBI_audio	4421.7	1370.2	214
CBI_text	4064.8	1460.2	228

Table 4
ANOVA -Higher Ability Students on Time Spent in Learning (Seconds)

Source	df	Sum SQ	Mean SQ	F	P
Between:	1	5.69	5.69	4.32	.045
Within:	38	50.00	1.32		
Total:	39	55.72			

Group:	Mean:	SD:	SE:
CBI_audio	4126	1302	291
CBI_text	3372	969	217

Note: SumSq & Mean SQ X 1,000,000

Table 5
ANOVA-Practice Exercise Time (Sec)

Source	df	Sum SQ	Mean SQ	F	P
Between:	1	6.16	6.16	6.05	.02
Within:	80	81.39	10.17		
Total:	81	87.55			

Group:	Mean:	SD:	SE:
CBI_audio	2115	777	121
CBI_text	2664	1196	187

Note: SumSq & Mean SQ X 1,000,000

Results–Attitude

In the CBI_audio condition, lower ability students were more positive about learning (13%) than the higher ability students (Table 6). Overall there were no attitude differences between the two treatment groups (Table 7). Additional attitude differences were found.

Table 6
ANOVA - Lower / Higher Ability Students Within CBI audio

Source	df	Sum SQ	Mean SQ	F	P
Between:	1	542.3	542.3	5.15	.03
Within:	39	4105.5	105.3		
Total:	40	4647.8			

Group:	Mean:	SD:	SE:	Range
CBI_audio	54.65	10.35	2.31	35.4-74.9
CBI_text	61.93	10.18	2.22	36.7-81.4

Table 7
t-test for Paired Samples on Expressed Attitude Scores

No of Pairs: 41 df: 40 t-value(0.75): .32

Group:	Mean:	SD:	SE:
CBI_audio	58.38	10.78	1.68
CBI_text	57.71	8.79.2	1.37

Educational Importance of the Study

The results suggest that redundant audio, added to CBI to teach high school mathematics, has little effect on achievement but does affect learning time and attitude formation of students of different learning ability. In light of the energy and effort required to incorporate audio into general instruction, the file space required (given current levels of file compression) and current speeds of processing and delivery of instruction to students, one can legitimately question the payoff in terms of achievement, attitude, or learning time. The value of audio in terms of securing a publisher for courseware should be investigated as a separate issue. Further hypothesis and implications are discussed in the full presentation.

Suggestions for further research include an examination of the cost-effectiveness with respect to developing and delivering audio relative to achievement, instructional time and attitude. The sex of the voicing was controlled--one could investigate effects of different voicings, such as peer or authoritative voice crossed with gender. Finally, the use of non-redundant audio should be investigated.

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