DOCUMENT RESUME

ED 042 332 EM 008 197

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TITLE Qualitative Effects of Increasing Subject Matter Content and Mediating Certain Lecture Portions of an Honors Course in College Physics.
PUB DATE 19 Jan 70
NOTE 17p.; Paper presented at Annual Meeting of the Department of Audio-Visual Instruction, National Education Association (Detroit, Michigan, April 27 - May 1, 1970)

EDRS PRICE EDRS Price MF-$0.25 HC-$0.95
DESCRIPTORS Analog Computers, *Audiovisual Aids, Computer Assisted Instruction, Computer Based Laboratories, Curriculum Enrichment, *Enrichment Activities, Gifted, *Honors Classes, Honors Curriculum, Lecture, Mediation Theory, *Military Schools, Physics Curriculum, *Physics Instruction
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ABSTRACT

Freshmen cadets in an enriched mediated honors course in General Physics achieved slightly less on a 40 common-item criteria test than cadets in a traditionally taught honors course in the same subject, although the mediated course included approximately 40 percent more content in the area of modern physics. In the enriched course, audiovisual aids and devices were used on a large scale during lecture hours, and the analog computer was substituted for traditional laboratory demonstrations to illustrate complex physical phenomena. The results were interpreted to mean that extensive acceleration and enrichment of the course were made possible through mediation at only a tiny cut in terms of achievement of the traditional material. No immediate attempt was made to assess attitudes, but in a later study of the same course 70 percent of the cadets were pleased with mediated overview lectures, 93 percent with the use of audiovisual aids, and 80 percent with the use of the analog computer. (Author)

QUALITATIVE EFFECTS OF INCREASING SUBJECT MATTER CONTENT AND MEDIATING CERTAIN LECTURE PORTIONS OF AN HONORS COURSE IN COLLEGE PHYSICS

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19 January 1970

Paper Presented to 1970 Annual Meeting of the Department of Audio-Visual Instruction, National Education Association, Detroit, Michigan

Introduction

Educational programs for gifted students have traditionally involved combinations of acceleration, enrichment, and smaller classes. Seldom, however, does the literature on this subject mention the use of audiovisual aids in particular relation to programs for the gifted.

Given the widely-accepted opinion that audiovisual aids enhance learning efficiency, it seems logical to suppose that these aids should also prove useful in developing accelerated programs for the gifted student, and thereby enable enrichment within the time limits of a particular course.

For the past few years, an honors course in General Physics has been offered to freshman cadets at the United States Air Force Academy who are identified as possessing superior aptitude for the study of physics. The standard version of the course is offered to sophomores as part of the required core curriculum. Multiple regression techniques are employed to identify those cadets with exceptional potential, using such predictor variables as prior academic average, SAT scores, etc.

During the fall of 1969, the Head of the Physics Department decided to investigate the effects of extensive utilization of a variety of audiovisual aids for the purpose of enabling a significant increase in the subject-matter content of this course --- over and above what had been included previously in the honors program. A joint planning effort involving instructors from the Department of Physics and personnel from the Directorate of Educational Research was undertaken to design a course which would include twenty mediated lectures out of a course totaling some 100 hours of lecture and laboratory experiences. Those lectures were to be presented to large groups (45 men), and would serve to introduce new topics. Each such mediated lecture typically would be followed by one or more laboratory and discussion periods.

Laboratory sessions, however, were devoted to enrichment, rather than for demonstration or reinforcement of concepts already covered. In fact, the analog computer was used as an audiovisual aid in all laboratory sessions to extend the concepts covered in lectures by illustrating complex physical phenomena while relieving students of the necessity of engaging in laborious mathematical manipulations. Demonstrations using classical apparatus were performed in lecture sessions via audiovisual aids and devices.

Nearly all of the audiovisual aids and devices used were manufactured locally, and were the result of a team effort among the physics instructors, educational psychologists, graphic artists, and media resource personnel. Approximately 270 35mm slides, 45 overhead transparencies (many of which ployed technamated visualizations), twelve films, and 20 film clips were used in the twenty mediated lectures, plus about a dozen three-dimensional models. Two weeks prior to each lecture, the educational planning team met for about two hours to design audiovisual aids, and to identify requirements for existing media. The results of these conferences were brought to fruition by graphic artists and media resource people of the Directorate of Instructional Technology. All audiovisual aids thus created were assembled by the physics instructors several days prior to each mediated lecture for the purpose of "dry-running" each lesson at least once before the actual presentation.

Procedure

It was hypothesized that:

A. With the effects of differences in ability and prior achievement controlled, no significant difference in achivement, as measured by final examination questions common to both groups, existed between cadets completing an enriched and mediated honors physics course and those completing a non-mediated honors course containing the standard content.

B. With the effects of differences in ability and prior achievement controlled, no significant difference in achievement, as measured by the final examination taken by both groups, existed between cadets completing an enriched and mediated honors physics course and those completing a non-mediated regular course.

In order to investigate Hypothesis A, the final examination scores of cadets in the Spring 1969 mediated honors course (Group 69H) were compared to those of the Spring 1968 nonmediated honors course (Group 68H), on forty test items which were common to both groups. The Fall 1968 course was excluded because a completely different final examination had been administered. Also, in order to provide a basis for comparison of differences, if any, a similar comparison was made between cadets completing the regular courses in both Spring 1968 (Group 68R) and Spring 1969 (Group 69R). Neither of these courses made systematic use of media, although the content covered in the Spring 1969 course was more similar to that of the mediated honors course. The second comparison, to investigate Hypothesis B, used the final examination scores for students who completed the standard General Physics course (Group 69R), which was taught in the Spring 1969 semester concurrently with the mediated honors course (Group 69H). Both of these courses had the same content coverage and the same 80-item final examination, although laboratory experiences in the regular course were used for the purpose of reinforcing lecture material, rather than enrichment. In the regular course, all presentations were in small (15-18 man) sections with no systematic nor extensive use of classroom audiovisual aids.

For all comparisons, analysis of covariance was employed to equate the treatment groups statistically with respect to those ability/achievement variables which correlated significantly with success in physics. The .05 level of significance, as obtained by F-test, was accepted as evidence

sufficient to warrant rejection of the null hypotheses.

Analysis of the Data

Summary data on the criterion instruments are presented in Table I.

TABLE I

SUMMARY DATA ON CRITERION
INSTRUMENTS FOR ALL TREATMENT GROUPS

Data Item \ Group	68H*	69H*	68R*	69R*	69R**	69H**
Mean	29.81	28.63	22.89	21.95	49.16	58.89
S.D.	5.03	4.15	4.43	4.25	7.35	7.54
KR 20 Reliability	.740	.611	.635	.727	.719	.772
100-Item Reliability	.877	.797	.713	.769	.762	.808
S.E. (meas)	2.565	2.587	3.681	3.897	3.895	3.602

* 40 objective final examination items common to these groups were scored.
** All 80 objective final examination items were scored.

Reliabilities, computed by the Kuder-Richardson formula 20, ranged from .611, for the scored forty items which were common to both Groups 68H and 69H, to .77 for Group 69H on an 80-item test. Since reliability is dependent on the length of the instrument, the Spearman-Brown Prophecy Formula was used to estimate the reliability of each test if it had been 100 items in length. Since standardized achievement test reliabilities range typically from about .80 to .95, the 100-item reliabilities, ranging from .71 to .88 for these teacher-made tests, indicated that they were satisfactory for use as criterion instruments

Table II presents the comparison between both honors groups on the forty items of the final examination which were common to both groups.

TABLE II

ANALYSIS OF COVARIANCE DATA FOR TWO HONORS COURSES
UNDER TWO COVARIATE CONDITIONS

Groups / Covariates	Adjusted Mean Score on 40 Common Final Exam Items		F
	68 H	69 H	
SAT-Verbal	29.98	28.27	3.29
Acad. Composite	30.06	28.08	4.78*

df = 1,145: *p.05 = 3.92; **p.01 = 6.82

Group 68H achieved a mean score of 29.81, while Group 69H achieved a mean score of 28.63. A t-test revealed no significant difference between these means; however, the two groups were found to differ significantly on two predictor variables, which were then used as covariates. Analysis of the data in Table II indicated that Group 68H achieved a significantly higher mean score on the forty final examination items common to the two groups, when the cadets' academic composite score was the covariate. (The academic composite score is a standard score obtained by summing a cadet's four SAT scores and his Prior High School Average score. For his Prior High School Average score, each cadet is assigned a standard score based on his percentile rank in his graduating class. Since the normative group on each subscore has a mean of 500 and a standard deviation of 100, the Academic Composite score has a mean of approximately 2500 and a standard deviation of 500. However, the mean score for admitted cadets is approximately 3100). Thus, Hypothesis A was rejected in favor of the group who completed the Spring 1968 non-mediated course with traditional laboratory procedures and unexpanded content coverage.

Table III presents data regarding the corresponding comparison of Groups 68R and 69R.

TABLE III

ANALYSIS OF COVARIANCE DATA FOR
REGULAR COURSES UNDER TWO COVARIATE CONDITIONS

Group / Covariate(s)	Adjusted Mean Score on 40 Common Items Final Exam		F
	68 R	69R	
SAT-Verbal	22.88	21.91	7.013**
Academic Composite	22.87	21.92	6.705**

df = 1,563: *p.05 = 3.86; **p.01 = 6.70

This comparison was made to provide a basis for evaluating differences found between Groups 68H and 69H. Similar findings were noted for Groups 68R and 69R as were noted for the 68 H and 69 H groups, inasmuch as the 1968 group scored significantly higher than did the 1969 group under similar covariate conditions. Further interpretation of this and other findings is contained in a later section of this paper.

The comparison of final examination mean scores for Groups 69 R and H is presented in Table IV.

TABLE IV

ANALYSIS OF COVARIANCE DATA FOR SPRING 1969
REGULAR AND HONORS COURSES UNDER SEVEN COVARIATE CONDITIONS

Group / Covariate(s)	Adjusted Mean Score on Total Test		F
	69 R	69 H	
Prior HS Average (PHSA)	49.403	57.268	42.367**
SAT-Verbal	49.323	57.792	46.289**
English Composition	49.203	58.579	57.106**
SAT-Math Aptitude	49.648	55.661	20.589**
PHSA and SAT-Verbal	49.532	56.426	29.783**
PHSA and English Composition	49.442	57.013	35.733**
PHSA and SAT-Math Aptitude	49.886	54.100	9.911**

df = 1,337: *p.05 = 3.87; **p.01 = 6.72

Analysis of the data in Table IV suggested that no covariate or combination of covariates was sufficient to account for the significant differences between the two groups, with respect to achievement on the 80-item final examination. The honors group achieved significantly higher adjusted mean scores, regardless of statistical treatment.

Discussion

The difference in final examination mean scores favoring the traditionally-taught honors group (68H) over the group which completed the mediated honors course with enrichment laboratories (69H) must be interpreted in light of the considerable difference in subject matter content between the two courses. The 69H course had been augmented by ten hours of new material within the same time constraints. This course therefore had correspondingly fewer lecture hours devoted to the content common to both courses. Also, the laboratory experiences in the 69H course differed markedly, in that they were devoted entirely to enrichment rather than to review, demonstration and reinforcement. From Figure 1, which presents comparative course outlines for both courses and keys the final examination items to these topics, it can be seen that the 69H course contained ten fewer lecture and discussion hours devoted to the traditional topics upon which the forty common final examination items had been written. In addition, the 69H course contained nine fewer hours devoted to evaluation of cadet achievement. These hours were used for teaching new topics including relativity, satellites, and nuclear physics, which had been added to the course. As a result, the number of class and laboratory hours devoted to the topics represented on the 40-common-item criterion test, comprised only 60 percent of the total course time in the 1969 honors course. In contrast, 97 percent of the 1968 honors course was devoted to these topics.

FIGURE 1

CLASS PERIODS AND CLASSIFIED TEST ITEMS BY CURRICULAR TOPIC FOR HONORS COURSES TAUGHT DURING SPRING 1968 AND SPRING 1969

TOPIC	Class Periods				Common Test Items		Different Test Items			
	68 H		69 H				68 H		69 H	
	Lect.	Lab	Lecture	Lab	Level	No.	Level	No.	Level	No.
Vectors	2	1	1		1	1			1	1
					2	1				
					3	1				
Kinematics	3	3	2 (1-L)		1	1	1	1		
					3	2				
Dynamics	5	1	4 (1-L)	3 (a)	3	1	1	2	1	2
							2	1	2	1
							3	1		
Circular Motion	2		2 (1-1)		1	1			1	1
					2	1				
					3	1				
Work	2		2 (1-L)		2	1	1	1	1	1
Energy	2	2			1	2	1	1	1	2
					2	1				
Systems of Particles	5		5 (1-L)		2	1	3	1	1	2
									2	1
Conservation of Momentum	3	6	3 (1-L)	2 (c)	1	2			1	1
					2	2	3	2		
Harmonic Motion	2		2 (1-L)	1	2	2	1	1	2	2
							3	1		
							4	1		
Electricity and Magnetism	6	1	3 (1-L)		2	2	1	2	1	1
							3	3		
Electric Fields	3	1	3 (1-L)		1	1	1	1	1	2
					3	3	2	1		
							3	1		
Magnetic Fields	5	1	3 (1-L)	2 (c)	2	1	1	2	1	2
					3	1	2	1	2	1
							3	2		
Current	2	2	3 (1-L)		1	1			1	1
									2	1
Capacitance	4		3 (1-L)		2	1	1	1	1	1
							2	1	2	2
Charge	3		2		2	1	3	1	1	2
Induction	3		3 (1-L)		1	1			1	1
					2	1			2	1
Waves	4		4 (2-L)	1	1	1				
					2	2				
Gravity	2	2	2 (1-L)		3	2			1	1
									2	1
Lab Techniques		1		6 (b)	2	1	3	1		

FIGURE 1
(CONT)

TOPIC	Class Periods				Common Test Items		Different Test Items			
	68 H		69 H				68 H		69 H	
	Lect	Lab	Lecture	Lab	Level	No.	Level	No.	Level	No.
The Nucleus			2 (1-L)						1	4
Nuclear Transformations			3 (2-L)						1	4
Relativity			3 (1-L)						2	1
Satellites			1	1 (c)						
Oscillations			1	1 (c)						
Coordinate Systems			2 (e)							
Individual Projects		8 (d)		10 (d)						
Problem Solving Session	3		3							
Evaluation	19		9							

(a) One of these laboratory hours was strictly for enrichment purposes and did not reinforce the subject matter covered in lectures.

(b) These six hours were devoted to learning computer skills necessary for utilization of the analog computer. The 1969 honors course made use of the analog computer in all laboratories for the generation and demonstration of physical functions and to better integrate mathematical operations with physical phenomena.

(c) These laboratory periods were for enrichment purposes and did not reinforce or review material covered in lectures.

(d) In the Spring 1968 course, these eight laboratory periods were devoted to the investigation of individual projects selected from a list of subjects which had been covered in lectures. In the Spring 1969 course, however, cadets were given complete freedom to investigate any topic, regardless of whether it had been covered during the course.

(e) The two-hour lecture on coordinate systems was taught in the laboratory environment, using the analog computer as a training aid.

NOTE: The designation "(1-L)" folliwng certain lecture sessions of the Spring 1969 course indicates that, of the total hours devoted to this topic, the number shown within the parentheses was taught to the entire 45-man group in a "lectinar", which is a semicircular 76-man classroom designed for maximum media support capability while still keeping the instructor at eye level with all students and at a distance of not more than 20-25 feet. The term "lectinar" was coined locally to connote the compromise between lecture and seminar.

In comparing Group 69H to Group 69R, it was expected that using as covariates those variables which had been shown by multiple regression analysis to best predict success in physics, would have mathematically accounted for any significant difference between the two group means. This was not the case, however, as significance was obtained, in favor of the honors group, regardless of the covariate conditions. Similar results were noted for Groups 68H and 68R. These consistent differences, therefore, were assumed to be the result of unidentified and thus uncontrolled variables, i.e., motivation or need for achievement, and not the effect of quantifiable differences in prior achievement or ability levels between the groups.

It should be noted that this study made no attempt to assess any group differences in attitude toward either the subject matter or the method of presentation. However, the honors course was taught in the Fall 1969 semester in almost exactly the same way as had it been taught during the Spring semester. Students in the fall course were asked to react to the course content and to various aspects of the teaching methodology employed. Responses to this questionnaire appear in Appendix A, and indicated a predominantly favorable reaction to the teaching methodology, and to the new "modern physics" topics which the course included.

Specifically, 93 percent of the cadets indicated that the use of audio-visual aids had improved their understanding of the subject matter. Seventy percent felt that the mediated overview lectures had aroused their interest in the subject matter. Eighty-four percent indicated that they had enjoyed the course, and seventy-two percent felt that they would rather have been enrolled in the honors program (as they were), instead of the regular course. Regarding the use of the analog computer as an audiovisual aid, 87 percent of the students indicated that they would rather <u>not</u> return to the usual type of physics experiments, and 80 percent felt that the analog computer

had helped them to comprehend physical principles. Finally, the intent to use laboratories for enrichment purposes was apparently successful, as 70 percent of the students felt that the analog problems either extended textual material or had no relationship to it, whereas only 30 percent indicated that the analog problems reinforced the textual material.

Conclusions

The data suggested that the systematic use of audiovisual aids for overview lectures may assist materially in enabling educational enrichment for the academically gifted college science student.

The results appeared to transcend the limitations of this study, i.e., uncontrolled teacher variable, uncontrolled interaction between the methodology employed for lectures and laboratories, and the variation in course content between the groups. Even when the class time devoted to certain topics was decreased by approximately one third, only a small drop in achievement resulted for these traditional topics. In return, the course was made more comprehensive in terms of twentieth-century developments in the discipline. And finally, a similarly-taught course the following semester met with overwhelmingly favorable student reactions.

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APPENDIX A

56 Cadets Questioned

PHYSICS 220H QUESTIONNAIRE -- FALL 1969

Instructions: Please answer all questions. Check answer which is closest to your response.

1. Has the rotation of instructors in lab and lectinar distracted from your studies?

   A. YES 11%
   B. NO 89%
   C. NO OPINION 0%

2. Many of our class meetings have been in groups of 2 sections. Have you felt a lack of individual attention?

   A. YES 23%
   B. NO 77%
   C. NO OPINION 0%

3. Would you rather spend full time in smaller sections:

   A. YES 23%
   B. NO 68%
   C. NO OPINION 9%

4. Did the lectinar overview presentations arouse your interest in the subject matter?

   A. YES 70%
   B. NO 23%
   C. NO OPINION 7%

5. Was the amount of material covered in the lectinar overview presentations excessive?

   A. YES 25%
   B. NO 68%
   C. NO OPINION 7%

6. Do you think the use of the lectinar with audio-visual aids improved your understanding of the subject matter?

   A. YES 93%
   B. NO 3%
   C. NO OPINION 4%

7. On which general topic(s) would you rather spend more time?

A. Electricity and Magnetism 11.5%
B. Nuclear Physics 30%
C. Relativity 23%
D. Atomic Physics 7.5%
E. Mechanics 9.5%
F. Quantum Physics 17.5%
G. Other 1%

8. On which general topic(s) would you rather spend less time?

A. Mechanics 34%
B. Harmonic Motion 23%
C. Electricity and Magnetism 28%
D. Atomic Physics 8%
E. Relativity 3.5%
F. Energy 3.5%
G. Other 0%

9. Do you now wish you had been enrolled in regular Physics 220?

A. YES 28%
B. NO 72%

10. Did you enjoy the course?

A. YES 84%
B. NO 16%

11. Would you rather have more of the usual type of physics experiments and fewer analog computer experiments?

A. YES 11%
B. NO 87%
C. NO OPINION 2%

12. How many hours did you spend in learning how to solve a simple physics problem on the analog computer?

A. 1-2 hours 39%
B. 2-4 hours 41%
C. 4-6 hours 15%
D. More than 6 5%

13. How did the analog problems relate to the text material?

A. Re-inforced text material 30%
B. Extended text material 53.5%
C. No relationship 16.5%
D. Confused matters 0%

14. Did the analog computer help you to comprehend any physical principles?

A. YES 80%
B. NO 20%

15. Below are listed the lab exercised. A choice of responses is given for each lab. Please add any comments you wish.

LAB 1 - Linear Drag Force

A. excellent 19%
B. good 49%
C. fair 17%
D. poor 0%
E. don't remember 15%

LAB 2 - Quadratic Drag Force-Terminal Velocity

A. excellent 26%
B. good 45%
C. fair 14.5%
D. poor 0%
E. don't remember 14.5%

LAB 3 - Rocket Problem

A. excellent 41%
B. good 44%
C. fair 9%
D. poor 2%
E. don't remember 4%

LAB 4 - Simple Harmonic Motion

A. excellent 36%
B. good 41%
C. fair 12.5%
D. poor 3.5%
E. don't remember 7%

LAB 5 - Orbits

A. excellent 27%
B. good 45%
C. fair 16%
D. poor 4%
E. don't remember 8%

LAB 6 - Driven Damped Harmonic Motion

A. excellent 25%
B. good 39.5%
C. fair 19.5%
D. poor 8%
E. don't remember 8%

LAB 7 - Particle Motion in Crossed E and B Fields

A. excellent 23%
B. good 30%
C. fair 28.5%
D. poor 5%
E. don't remember 13.5%