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## An Evaluation of the Overhead Projector In Teaching Kinematics

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## An Evaluation of the Overhead Projector in Teaching Kinematics

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The overhead projector has been used as a teaching aid for several years, in elementary education<sup>1,2</sup> and in engineering drawing.<sup>3</sup> No use of an overhead projector in kinematics has been reported, nor has there been a statistical evaluation of its effectiveness in engineering education.

In the spring of 1959, the author taught two sections of kinematics. In one section, the lectures were written to include blackboard sketches and demonstrations; in the other section the lectures were written to include transparent overlays prepared for the overhead projector. Each transparent overlay presentation consisted of a step by step development of the lecture with one step on each of the transparent sheets. As the lecture progressed, the overlays were exposed to convey the pertinent information visually to the student.

The examination scores for two of the three units covered during the semester were compared by an analysis of covariance with the student's previous Engineering College average grade-point as the related variable. The results are as follows for a significance level of 5%:

Unit 1: Solutions of velocities on four-bar-linkages: no statistically significant difference between sections.

Unit 2: Solutions of accelerations on four-bar-linkages, including Coriolis Law: the scores for the section using the overhead projector were statistically significantly better.

Final examination over Units 1 and 2: The scores for the section using the overhead projector were statistically significantly better.

On the basis of these statistical tests, it is inferred that kinematics can be taught more satisfactorily by means of an overhead projector and prepared

transparent overlays than by means of lectures based on blackboard presentations of the same material.

### Statistical Development

The students in the two sections of kinematics taught during the spring semester, 1959, were considered to be random samples from a population of all students who have taken and will take this course. No systematic factors are known to bias this assumption. The students are also considered to be random samples from the two resulting treatment populations. One population consists of all students who were and will be taught kinematics by the author using lectures based on blackboard demonstrations; the other population consists of a similar group taught by the author using the overhead projector with prepared transparent overlays. The statistical results apply to these treatment populations.

The resulted variable used as the covariate in the analysis of covariance was the student's Engineering College average grade-point based on a minimum of 15 semester hours. The means and variances of the grade-point averages are:

	Overhead Projector Section	Blackboard Section	Totals
Means	2.34	2.46	2.40
Variance	0.17	0.32	0.24

The higher mean and greater variance in the blackboard section reflects a small group of extremely high grade-point students in that section. The students were all in their sophomore, junior, and senior years in the Mechanical and Electrical curricula. For the first examination, there were 29 men in the section taught

by blackboard lectures and 33 men in the section taught by use of the overhead projector. Attrition reduced these numbers to 28 and 31 respectively for the examination on the second unit and the final examination.

The hypothesis tested was: Among sophomore, junior, and senior students in the Mechanical and Electrical Engineering curricula at the State University of Iowa, the material covered in Kine-

matics, Units 1 and 2, can be taught as effectively by a lecture based on transparent overlays for an overhead projector as by a lecture based on the presentation of the same material with blackboard demonstrations.

A significance level of 5%, which is common for this type of analysis, was selected as providing an acceptable risk of Type I and Type II errors.

The statistical summaries are:

UNIT 1. SOLUTIONS OF VELOCITIES ON FOUR-BAR LINKAGES

Source	Degrees of Freedom	Σ Squares and Products			Errors of Estimate		
		Sx <sup>2</sup>	Sy <sup>2</sup>	Sxy	Σ Squares	df	ms
Total subjects	61	940.00	14.59	41.98	12.72	60	
Between sections	1	44.00	0.26	3.45	0.04	1	0.04
Within sections	60	895.13	14.33	38.53	12.68	59	0.215

$ms_{\text{between}}/ms_{\text{within}} = 0.186$   $.05F_{1,60} = 4.00$  not significant

UNIT 2. SOLUTIONS OF ACCELERATIONS ON FOUR-BAR LINKAGES

Source	Degrees of Freedom	Σ Squares and Products			Errors of Estimate		
		Sx <sup>2</sup>	Sy <sup>2</sup>	Sxy	Σ Squares	df	ms
Total subjects	58	549.22	14.22	40.75	14.15	57	
Between sections	1	1.38	0.20	0.52	3.08	1	3.08
Within sections	57	547.84	14.02	40.23	11.07	56	0.20

$ms_{\text{between}}/ms_{\text{within}} = 15.40$   $.05F_{1,56} = 4.02$  significant

FINAL EXAMINATION (GIVEN AT THE END OF THE SEMESTER)

Source	Degrees of Freedom	Σ Squares and Products			Errors of Estimate		
		Sx <sup>2</sup>	Sy <sup>2</sup>	Sxy	Σ Squares	df	ms
Total subjects	58	820.00	14.22	28.39	14.19	57	
Between sections	1	1.44	0.20	0.54	1.18	1	1.18
Within sections	57	818.56	14.02	27.85	13.01	56	0.23

$ms_{\text{between}}/ms_{\text{within}} = 5.08$   $.05F_{1,56} = 4.02$  significant

The examinations were also tested for reliability. The results are:

Examinations	Reliability
Examinations over Velocities (Unit 1)	0.723
Examinations over Accelerations (Unit 2)	0.899
Final Examinations	0.849

The conclusion reached is that for the hypothetical population from which these students are a random sample, higher criterion scores were obtained when the students were instructed by means of transparent overlays and an overhead projector than by means of blackboard demonstrations for the acceleration unit of the course and for the final examina-

tion. From this, it can be inferred that kinematics can be taught more effectively with the overhead projector.

The lack of a statistically significant difference between the scores for the first unit is attributed to the ability of the students to visualize and extrapolate the effects of the known velocities to other points on the bodies. Because of this, the method of presentation for velocities was not critical. On the other hand, accelerations cannot be visualized as easily, and the more effective method of presentation resulted in a higher set of criteria scores.

The author suggests that other courses might also be taught more effectively by using the overhead projector and prepared transparent overlays.

### Teaching and Examination Procedure

The kinematics course is taught three times a week with each class consisting of approximately one-half hour lecture and over one hour of guided problem solving. This schedule was followed with both sections of the course. The primary difference was in the use of the overhead projector during the lecture portion.

The lecture for the overhead projector section was designed to utilize the transparent overlays to provide a framework for the lecture and show the progress of the lecture by exposure of successive overlays. Since kinematics is essentially the graphical solution of motion problems, the presentation involves trigonometry and graphical constructions. For any one lecture, the mathematical and graphical procedures were divided into four to eight major steps. Each step was placed on a separate sheet of acetate. As that step was reached in the lecture, the sheet was dropped onto the previous sheets and the lectures continued. By using two or more colors in the preparation of the transparencies, the new step can be easily located by the students. A grease pencil can be used to write marginal comments and to underline specific points that are particularly important. When the lecture is finished, the completed solution is before the student.

Questions raised during the lecture were answered immediately. The lec-

ture was then restarted from the point at which the difficulty occurred. Because the transparent overlays can be removed, the solution proceeded without the interference of the later steps. Following the lecture, the remaining questions were answered in a similar manner. The students were encouraged to try to understand the lecture rather than to take notes. The transparent overlays were available during the problem-solving portion of the class period for those who wished to copy the steps into their notes or to refresh their memories by following through the steps at their leisure.

The transparent overlays were used to reduce the tutorial help necessary for students who continue to have difficulties and those students who miss a given lecture. The transparent overlays were also used as a basis for review periods since the basic material for the unit is in a collected form. Because the constructions are already prepared, the material can be reviewed faster and with more constructional accuracy than by working problems on the blackboard.

The other section received lectures in which the theory and problems were presented step by step on a blackboard. Questions were answered by tracing over existing lines, or by erasing part or all of the work and repeating the erased steps when this appeared necessary. Again, all questions were answered as they arose.

Both sections received essentially the same lectures. During the problem-solving portion of the course, a different teaching assistant was assigned to each of the sections.

The examinations consisted of 15, 12, and 11 problems, respectively, for the Units 1, Unit 2, and Final examinations. Each problem consisted of taking only the final one or two steps to a solution. The problems were designed so that the solutions were independent. All students took the same examination at a common time.

The tests were scored with two points for a correct solution and one point if there was a decimal or numerical error or a failure to indicate the sign on angular velocities and accelerations. Points

were not given unless a firm grasp of the principles involved was indicated.

### Construction of the Overhead Projector Transparent Overlays

There are two methods of preparing transparent overlays. One is to transfer the information to the acetate sheets by means of a photographic process and the other is to work directly on the acetate sheet with a special plastic ink.

The State University of Iowa Audio-Visual Department suggested that the individual steps be prepared on separate sheets of tracing paper. These were used with a positive contact-type photographic technique to transfer the information to specially sensitized acetate sheets. Because the tracings can be easily prepared in India ink, this method has the advantage of ease of preparation. The choice of colors is determined by the sensitizing agent on the acetate sheet. The photographic preparation has the disadvantage of relatively high cost and that any variation in the opaqueness of the tracing paper will tend to result in reduced contrast between the desired information and the background. Further, the contrast may be reduced by exposure to sunlight, although artificial light has no effect.<sup>3</sup> If corrections or changes are desired, either a new sheet must be prepared, or corrections made using the second method.

The second method is to use a suitable plastic ink and a tank pen, such as the LeRoy lettering guide pen with a #00 point. As a number of colors are available, the author used red and blue for contrast between steps. This method of

preparation has definite cost advantages if a lettering set is available. The contrast is maximum. Additions and corrections are easily made in the same manner. Mistakes can be "erased" by wiping them with ink thinner. Generally, greater skill is required to work directly on the acetate sheet than to work with India ink on tracing paper.

For this experiment, the image was projected against a standard screen. The author has since utilized a blackboard as a screen with equally good qualitative success. Blackboard images from the photographically prepared transparent overlays lack contrast without darkening the room for a class of approximately 40, but the directly prepared transparent overlays are excellent under these conditions. The projected area is usually reduced in the blackboard projection, which sometimes is a disadvantage.

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