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ABSTRACT

Research indicates that the educational effectiveness of Microcomputer-Based Laboratories (MBL) may be due to the real time nature of the experience. This article describes a study where kinesthetic feedback was completely removed by giving students only visual replications of a motion situation. If simultaneity of perception is the important variable, then a video recreation of the motion event alongside a graph might be enough to help the students link the real event with the graph. The 165 high school and 72 college students were randomly assigned to one of four groups. The two experimental dimensions were the type of laboratory experience (either VideoGraph or traditional manipulative methodology) and real motion event or not. The laboratory tasks required two hours. Two parallel versions of the Test of Understanding Graphs-Kinematics were used for pretest and posttest. A two-way analysis of covariance was performed on the posttest scores with the pretest as the covariate. There was no significant main effects and no interaction, although the higher posttest scores were made by the VideoGraph students. A comparison of overall pre and posttest scores s owed that learning had occurred in all the four groups. About 80% of college students preferred the VideoGraph technique. (YP)

# The Effect of Simultaneous Motion Presentation and Graph Generation in a Kinematics Lab

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# THE EFFECT OF SIMULTANEOUS MOTION PRESENTATION AND GRAPH GENERATION IN A KINEMATICS LAB


## Abstract

Real-time Microcomputer-based Lab (MBL) experiments allow students to "see" and, at least in kinematics exercises, "feel" the connection between a physical event and its graphical representation. In Brasell's (1987) examination of the sonic ranging MBL, a delay of graphing by only 20 seconds diminished the impact of the MBL exercises. This article describes a study where kinesthetic feedback was completely removed by giving students only visual replications of a motion situation. Graph production was synchronized with motion re-animation so that students still saw a moving object and its kinematics graph simultaneously. Results indicate that this technique did not have a substantial educational advantage over traditional instruction. Since Brasell and others have demonstrated the superiority of microcomputer-based labs, this may indicate that visual juxtaposition is not the relevant variable producing the educational impact of real-time MBL. Immediate student control of the physical event and its graphical representation might be what makes MBL effective .d, in the case of kinematics laboratories, kinesthetic feedback could be the most important component of the MBL learning experience. Further studies are needed in order to clarify this point.

# THE EFFECT OF SIMULTANEOUS MOTION PRESENTATION AND GRAPH GENERATION IN A KINEMATICS LAB

Research indicates that the educational effectiveness of Microcomputer-Based Laboratories (MBL) may be due to the real time nature of the experience—graphs are produced while the data are being collected. This raises questions as to what aspects of this data collection and presentation are critical to helping students make the cognitive links between the actual event and its abstract graphical representation. This study examined the educational impact of just the visual juxtaposition of a motion event with the corresponding kinematics graphs (the "VideoGraph technique"). If simultaneity of perception is the important variable, then a video recreation of the motion event alongside a graph might be enough to help the students link the real event with the graph. In this study, video images of the event were displayed on the computer screen, in an animated movie-like fashion, while the relevant graphs were generated as the movie "plays." If the simultaneous perception of motion and graph is the critical educational experience, then the VideoGraph methodology should be as effective as real-time MBL exercises.

## Methods

Students were randomly assigned to one of four groups. The first experimental dimension was the type of laboratory experience—either VideoGraph or traditional manipulative methodology. The second dimension was whether the students viewed a real motion event or not. A simple projectile motion event was examined by all groups. Previously taken instant stroboscopic photographs served as the source of data for the traditional labs. The stroboscope was set to flash 30 times per second, essentially "freezing" the motion as often as the videocamera had for the VideoGraph groups. The activities of the traditional groups paralleled those of the VideoGraph students. Groups which were to view a real motion event were shown a demonstration of motion similar to that captured in the photographs and on the computer. None of the students actually produced the motion events since they might have received kinesthetic feedback from the experience.

Intact physics classes from three western New York high schools, one local two year college and an area four year college participated in the experiment—a total of 237 students. The 165 high school and 72 college students had all received previous kinematics instruction.

Two essentially parallel versions of the Test of Understanding Graphs—Kinematics (TUG-K) were constructed and validated prior to this study. The twenty four items on the tests measured only graph interpretation skills and not graph construction. After administration of the test to 134 two year college physics students, an overall KR-20 reliability of 0.71 was established, sufficient for the evaluation of groups. There were no significant practice effects between pre and posttest administrations as demonstrated by a paired samples t-test ($df = 14$, $t = .75$, $p = .465$). Students took the pretest during a one-hour session, later spent two-hours working on the laboratory tasks, then took the one-hour posttest. These events took place within a two week time span for any given student.

## Results

A two way analysis of covariance was performed on the posttest scores with the pretest as the covariate. Based on an analysis of the pretest scores, there were no significant differences between students assigned to the different groups, $F(3, 218) = 0.775$, $p = 0.509$. (See Table I.) Although the higher posttest scores were made by the VideoGraph students, statistical analysis of the posttest results found no significant main effects and no interaction. A comparison of overall pre and posttest scores ($t = 4.86$, $df = 221$, $p < 0.001$) showed that learning had occurred since all the lab tasks gave students an opportunity to work with kinematics graphs and their interpretation.

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Insert Table I about here

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Males scored significantly higher than females on both the pretest, $F(1,219) = 4.89$, $p = 0.028$, and the posttest, $F(1,219) = 6.07$, $p = 0.015$. Neither gender learned more than the other, as evidenced by an analysis of the difference between pre and posttest scores (the change score), $F(1,219) = 0.84$, $p = 0.36$.

As might be expected, the pretest and posttest scores varied substantially by school, $F(3,218) = 8.30$, $p < 0.001$, but there were no significant differences in the change scores between schools, $F(3,218) = 0.31, p = 0.82$. College students learned as much from the graphing lab exercises as high school students.

An affect measure given to 55 college students after the experiment indicated a preference (80%) for the VideoGraph technique.

## Discussion

The researchers noted earlier have found significant impact on graphing achievement during microcomputer-based lab experiences. Brasell (1987) noted that students learned more during brief MBL tasks than they did with traditional pencil and paper tasks. Although carried out under similar circumstances, this study did not find any differences in learning about graphs when the VideoGraph technique was compared to traditional tasks. This leads one to consider the differences between VideoGraph methodology and microcomputer-based labs.

A casual examination of what students do during kinematics MBL experiences indicates that they see and control the motion event while the graph is being produced. The VideoGraph technique can present replications of motion events while generating graphs, but other than determining the rate of animation, students cannot control the motion. The ability to make changes—and then instantly discover the effect—appears to be vital to the efficacy of microcomputer-based kinematics labs. A simple visual juxtaposition of event images and graphs is not as good as seeing and "feeling" the actual event while graphs are being made.

A direct comparison of the VideoGraph technique with the real-time graphing of the sonic ranging MBL is needed in order to standardize student tasks and achievement measures. It would also be interesting to vary the amount of control students have over the motion event and see how this impacts on learning. Other (non-kinematics) MBL experiences may not have as great a requirement for real-time data collection and display. A comparison of these MBL labs to student experiences with videodisk images of phenomena (chemical reactions, heating and cooling, etc.) might be informative.

Microcomputer-based laboratory experiences are an especially exciting way to apply new technology to teaching. They allow students to focus on the phenomena at hand and model the actions of real scientists. MBL techniques have proven to be more effective than some of the more conventional instructional methods. By determining what variables make MBL's so effective, researchers may be able to understand more about how students learn. This study, as part of that process, indicates that observation in the student lab setting may be more than just seeing phenomena, but also exercising control over it and receiving feedback from that control. "Hands-on" might be more critical than "eyes-on." Giving each student the opportunity to interact with the phenomenon being studied is central to the laboratory experience.

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Table I

*Student Scores*

| | Traditional | | | | MBL | | | | | | Total | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | View motion | | Did not view | | View Motion | | Did not view | | No Lab | | Experimental | |
| | Mean | s.d. | Mean | s.d. | Mean | s.d. | Mean | s.d. | Mean | s.d. | Mean | s.d. |
| *n* | 51 | | 58 | | 58 | | 55 | | 15 | | 222 | |
| Pretest (24 items) | 11.5 | 3.7 | 12.2 | 3.8 | 12.3 | 3.4 | 12.5 | 3.5 | 12.8 | 3.5 | 12.2 | 3.6 |
| Posttest (24 items) | 12.3 | 4.3 | 13.4 | 4.4 | 12.7 | 4.0 | 13.5 | 4.0 | 13.2 | 4.5 | 13.0 | 4.2 |

*Analysis of Covariance*

| Source | Sum of Squares | *df* | Mean square | *F* | *p* |
|---|---|---|---|---|---|
| Viewed | 19.2 | 1 | 19.16 | 2.91 | 0.090 |
| Treatment | 5.37 | 1 | 5.37 | 0.82 | 0.368 |
| Viewed X Treatment | 0.003 | 1 | 0.003 | 0.00 | 0.984 |
| Pretest | 2412.18 | 1 | 2412.18 | 366.00 | <0.001 |
| Error | 1430.17 | 217 | 6.591 | | |