Order Number 9118460

The effects of using interactive videodisc laboratory simulation on problem-solving and learning performance of high school chemistry students

Katkanant, Chanida, Ph.D.

The University of Nebraska - Lincoln, 1990

U·M·I
300 N. Zeeb Rd.
Ann Arbor, MI 48106

NOTE TO USERS

THE ORIGINAL DOCUMENT RECEIVED BY U.M.I. CONTAINED PAGES WITH SLANTED PRINT. PAGES WERE FILMED AS RECEIVED.

THIS REPRODUCTION IS THE BEST AVAILABLE COPY.

THE EFFECTS OF USING INTERACTIVE VIDEODISC LABORATORY SIMULATION ON PROBLEM SOLVING AND LEARNING PERFORMANCE OF HIGH SCHOOL CHEMISTRY STUDENTS

by

Chanida Katkanant

A DISSERTATION

Presented to the Faculty of

The Graduate College in the University of Nebraska

In Partial Fulfillment of Requirements

For the Degree of Doctor of Philosophy

Major: Interdepartmental Area of Administration, Curriculum and Instruction

Under the Supervision of Professor Dorothy Jo Stevens

Lincoln, Nebraska

December, 1990

DISSERTATION TITLE

THE EFFECTS OF USING INTERACTIVE VIDEODISC LABORATORY SIMULATION ON PROBLEM SOLVING AND LEARNING PERFORMANCE OF HIGH SCHOOL CHEMISTRY STUDENTS

BY

Chanida Katkanant

SUPERVISORY COMMITTEE:

APPROVED	DATE
Signature	11/1/90
Dr. Dorothy Jo Stevens Typed Name	
Signature	11/1/90
Dr. Ward Sybouts Typed Name	
Signature	11/1/90
Dr. James Fejfar Typed Name	
Signature	11/1/90
Dr. Roger H. Bruning Typed Name	
Signature	
Typed Name	
Signature	
Typed Name	

GRADUATE COLLEGE
UNIVERSITY OF NEBRASKA

THE EFFECTS OF USING INTERACTIVE VIDEODISC LABORATORY SIMULATION ON PROBLEM SOLVING AND LEARNING PERFORMANCE OF HIGH SCHOOL CHEMISTRY STUDENTS

Chanida Katkanant, Ph. D.

University of Nebraska, 1990

Advisor: Dorothy Jo Stevens

The purpose for conducting this study was to investigate the effects of using an interactive videodisc (IVD) laboratory simulation on problem solving and learning performance of high school chemistry students. Problem solving performance was evaluated in terms of Polya's procedural steps, the strategy used during the laboratory experiment, and students' score on problem solving posttest. Learning performance focused on achievement, retention and learning time.

Forty eight high school chemistry students from two public schools in a midwestern city were selected as the sample. Subjects were assigned to experimental (IVD) and control (LAB) groups such that they were equated in learning performance. The IVD group conducted the laboratory experiment using the IVD simulation; the LAB group used hands-on equipment. Instruments designed for assessing the learning outcomes included: 1) an observational coding form, 2) student worksheets, 3) a problem solving posttest and 4) an achievement test.

Results from the descriptive analysis showed that the IVD group spent more time in <u>Devising the Plan</u> and less time in <u>Carrying out the Plan</u> than the LAB group. The IVD group tended to use <u>hypothesis-testing</u> strategy more than the LAB group. Findings from the statistical analysis indicated

that the IVD group had significantly higher scores on problem solving strategy and spend less time in completing an experiment. There were, however, no significant differences between IVD and LAB groups on problem solving ability, achievement and retention scores.

Findings from the study demonstrated the benefits of using the IVD laboratory simulation in facilitating students' problem solving performance and saving learning time. In addition, the IVD lesson seemed to be used as effectively as the hands-on experiment in terms of learning outcomes. Taken together, these findings indicate that IVD simulations could be a promising alternative to supplement and/or enhance laboratory instruction, especially for teaching complex, expensive and time-consuming laboratory techniques.

Acknowledgements

Studying and completing a Ph. D. program in English, which is not my native language or even the second language used in Thailand, has been the most challenging and rewarding accomplishment to me! I am indebted to several professors, at UN-L, who have contributed to my personal and professional growth. Their kind help and endless support has formed the great role model for me and will never be forgotten for my whole life.

I would like to express my deepest gratitude to Dr. Dorothy Jo Stevens, my encouraging and understanding advisor and to Dr. Roger Bruning, my great teacher and endless supporter. Working with both of them has been a very rewarding experience and has provided me with invaluable resources in persuing my future career. Their love, care and support are deeply appreciated and will always be in my heart. My sincere gratitude is also expressed to the members of my committee, Dr. Word Sybouts and Dr. James Fejfar, for their advice, expertise and willingness to help me through this long endeavor.

My appreciation is extended to my colleague and mentor, Dr. Linda Zech who provided suggestions and guidances during the conduct of my research study. I am also very fortunate to have Doris Weimer as my data interpretation consultant and my "resident" grammarian as well as my dearest resource person. My studying during these past years could never been such a happy and pleasant time without the care, help, and encouragement of my great Jordanian friend, Bassam Shanti.

My special thanks are also extended to the two excellent science teachers , Mr. Joe Dappen and Le Etta Sprackling. They are both very receptive to technology and never hesitate to let their students take most advantage of it.

Lots of love and gratitude go to my parents, Chew Kuey and Cheonjit. Love and appreciation go to my five sisters, Lawan, Kay, Lakkana, Nidjakarn and Vanvilai, and finally to my two brothers, Mana and Manote. I am very proud to be the youngest and dearest member of such a wonderful loving and caring family!

TABLE OF CONTENTS

LIST OF TABLES

APPENDICES

CHAPTER 1

INTRODUCTION

Context of the Problem

A long standing problem exists among many science educators as to the most productive method of laboratory instruction. Many educators believe that the science laboratory, besides fostering a conceptual and intellectual understanding of knowledge (Fields, 1985; Fix & Renner, 1979; Karplus, 1977) should develop and promote a high level of cognitive skills such as scientific thinking and problem-solving (Anderson, 1976; Beasley, 1985; Shymansky, Kyle, & Alport, 1983; Woener, 1987). Such skills are very desirable and have become the major goals in the new science curricula developed during the past decade (Bates, 1978; Hofstein & Lunetta, 1982; Hodson, 1988; Shymansky et al, 1983). However, the strategies needed to best develop these skills remain unclear (Hofstein & Lunetta, 1982; Lawrenz, 1985). The best types of experience and how they may be blended with the regular class instruction, have not been objectively evaluated. There are vast differences in teaching strategies from one laboratory to another and these different teaching approaches are bound to affect the learning and outcomes. Researchers have not comprehensively examined the effects of laboratory instruction on student learning and cognitive growth in contrast to other modes of instruction (Hofstein & Lunetta, 1982; Hounshell, 1985). The growing body of literature concerning the role of laboratories in science teaching suggests that there is a need to gain more understanding of the dynamics of laboratory instruction and what students really learn and gain, because such knowledge may provide solutions of how best to organize laboratory instruction (Bryce & Robertson, 1985; Gallagher, 1987; Ivins, 1985).

Researching "new kinds" of instructional support that will improve instruction and enhance learning continues to be a consistent challenge to science educators. To prepare students to meet the challenge of today's rapidly changing technology, such support is required in science education, now more than ever before. One of the latest instructional technologies that holds great promise for improving instruction is the videodisc (Evans, 1988; Peterson, Sherwood, Kinzer, Hasselbring, Bransford, Williams, & Goin, 1987; Withrow, 1986). Developments in videodisc instruction are occurring at a rapid rate (Hamilton, 1987; Lehman, 1986; Phillipo, 1988). By combining the sophisticated video images with the versatile capabilities of computers, interactive videodisc (IVD) provides new, exciting opportunities for educators to increase the efficiency and effectiveness of science education (Fuller, 1984; Lehman, 1986; Leonard, 1986, 1989; Rusell, 1984; Sherwood et al., 1987). Because of its unique feature of "interactivity," the learner's role has been changed from passive observers to active participants, thus promoting learning (Kadesch, 1981; Livengood, 1987; Russell, 1984; Souden, 1987; Weller, 1988; Wenger, 1987). The IVD chemistry laboratory simulation lessons enable students to literally perform the same laboratory experiment with the videodisc simulation that they would in a traditional laboratory. In particular, IVD laboratory simulations are especially useful in teaching time-consuming procedures, hypothetical conditions, potentially dangerous procedures, and investigations that require expensive materials or equipment (Knapp, 1987; Lunetta & Hofstein, 1981; Smith, Jones & Waugh, 1986). According to Davis (1985), students who worked with the chemistry IVD laboratory simulation could learn and identify specific content, information, concepts or ideas as well as students working in the traditional laboratory. In relieving students from having to manipulate apparatus, IVD can eliminate

what appears to be the least important aspect of science instruction such as pouring and mixing the chemicals; thus students are engaged in exercising the higher-level intellectual skills which are seldom reinforced in traditional laboratory instruction (Hofstein and Lunetta, 1982; Knapp, 1987; Withrow, 1985).

There is a growing body of research reporting the use of IVD and its instructional effectiveness. Often cited were increased learning and retention (Bunderson, Baillio, & Olsen, 1984; Hupp, 1984; Larsen, 1987; Peterson, Homeister, & Lubke, 1988; Young, 1984), reduced learning time (Bunderson et al., 1984; Daynes, 1984; Gibbons, Oslen, & Cavagmol, 1982; Glenn, Kozen, & Pollak, 1984; Ketner, 1984), and teachers' acceptance of this media (Davis, 1985, Daynes, Brown, & Newman, 1981; Karwin & Henderson, 1985; Stevens, Zech, & Katkanant, 1987, 1988). Most of the research was, however, conducted in military and higher education settings which focused on training applications.

The past decade has marked a period of extensive development of interactive video-computer based instruction in science lessons. Previous evaluation of interactive computer-based chemistry lessons (Chabay & Smith, 1977) and of videotaped laboratory experiments (Haight & Jones, 1986) suggested that the combination of video with computer-based interaction could be a useful teaching tool. Interactive videodisc pre-laboratory instruction (Russell, Staskin & Mitchell, 1985) and laboratory simulations (Brooks, Lyons & Tipton, 1985; Davis, 1985) have been successfully used and accepted by students in general chemistry courses. Findings from the study conducted by Smith et al. (1986) showed that the use of IVD in pre-laboratory instruction can lead to student achievement in chemistry that equals or exceeds that of traditional laboratory experimentation. Studies conducted at

the University of Nebraska-Lincoln (Stevens et al. 1987, 1988) comparing two methods of implementing the IVD chemistry laboratory lesson as pre-laboratory and post-laboratory instruction, found no significant differences in student achievement and attitude. However, observations from the study showed that there were differences in these two methods of instruction with respect to students' time on task, type of errors made, and accuracy in experimental results.

Most of the prior research studies have investigated the effects of IVD instruction on basic learning outcomes such as achievement, retention, attitude, and learning time. Very few studies, however, have attempted to assess outcomes in terms of problem solving, which has long been identified as one of the most basic objectives of science instruction (Bates, 1978; Champagne & Klopfer, 1981; Tobin & Fraser, 1989). According to Lawson, Costenson, & Cosneros (1986), research on instructional materials and methods related to the learning process and problem solving, is needed to aid improvement in science instruction. In light of this need, the present study was designed specifically to investigate the effects of using an IVD simulation lesson on problem solving and learning performances of high school chemistry students.

Problem Statement

The purpose for conducting this study was to compare the effects of two methods of instruction on problem solving and learning performance of high school chemistry students. The two methods of instruction were: 1) instruction in which students used the videodisc lesson to study the content, followed by conducting the experiment in the laboratory (LAB group), and 2)

instruction in which students used the videodisc lesson to study the content, followed by conducting the experiment using the IVD laboratory simulation (IVD group).

Problem solving performance was defined as 1) the procedural steps and 2) the strategy students used to identify the set of unknown chemical solutions in the laboratory experiment; and 3) their ability to identify the set of unknown solutions on paper-pencil posttest. The problem solving procedural steps were evaluated based on the observational coding form, which was assessed by the researcher and a trained observer to determine how closely each group of students, in conducting the laboratory experiment, followed the four steps of problem solving as proposed by Polya (1971). The problem solving strategy was evaluated by the score on the student worksheet - based on the efficiency of the strategy they employed to identify the set of unknown chemical solutions in the laboratory experiment as well as the accuracy of their results. The problem solving ability was determined by the score on the paper-pencil posttest - based on the efficiency of the strategy they employed to identify the set of unknown chemical solutions under the given conditions as well as the accuracy of their answers. The students' learning performance focused on 1) achievement, which was determined by the score obtained from the achievement test; 2) retention, which was determined by the score obtained from administering the achievement test four weeks later; and 3) learning time, which was determined by the average time used by students in each group to conduct one laboratory experiment.

Hypotheses of the Study

The following null hypotheses were tested:

1. There is no difference between the LAB and the IVD groups' problem solving procedural steps used to identify the set of unknown chemical solutions in the laboratory experiment, as determined by observational coding form and videotape protocols.
2. There is no difference between the LAB and the IVD groups' problem solving strategy used to identify the set of unknown chemical solutions in the laboratory experiment, as evaluated by the score on the student's worksheet.
3. There is no difference between the LAB and the IVD groups' problem solving ability as determined by the score on the problem solving posttest.
4. There is no difference between the LAB and the IVD groups' achievement and retention scores as measured by the achievement test.
5. There is no difference between the LAB and the IVD groups' learning time in terms of the average time used to complete one laboratory experiment.

Theoretical Perspective

The development of student ability to solve problems and to engage in reflective thinking has been cited as an essential outcome of instruction by many educators (Champagne & Klopfer, 1981; Dewey, 1933; Glaser, 1984; Stewart, 1982). This study assumed that such a desired outcome could be attained and/or enhanced through the use of interactive videodisc instruction. The assumption was based upon information-processing theory.

According to the theory of human information processing proposed by Schneider and Shiffrin (1977), there are two kinds of information processing: automatic and controlled . Automatic processing is a fast, parallel, effortless process that is not under direct subject control. The sequences are thus carried out automatically without requiring the subject's attention, and therefore they use little or none of the capacity of working memory. Controlled processing is a slow, generally serial, effortful, capacity-limited, subject-controlled process. Individuals usually use the controlled process when dealing with novel or complex information. Since the process requires the subject's attention, only one sequence of information can be processed at a time. It is possible, however, to carry out two tasks concurrently without much decrement in performance if one of the tasks can be performed automatically (Schneider & Fisk, 1982). As such, problem solving capacity can be greatly increased by learning to use automatic processing for the more routine elements of an activity, making available the controlled processing resources for the complex and novel aspects of problem solving (Frederiksen, 1984).

Information processing theory is highly relevant to the teaching/learning process, as evidenced by a number of studies that deal with the application of cognitive science to instruction (Anderson, 1981a; Glaser, 1978; Lesgold, Pellegrino, Fokkema & Glaser, 1977, Snow, Federico & Montague, 1980a, 1980b; Tuma & Glaser, 1980). The application of the information-processing theory is most evident in developing reading skills. For example, with much practice the basic skills required in reading, such as decoding orthographic forms, retrieving word meanings, and establishing relationships among semantic proposition, may become automatic, making possible the huge amount of information processing that is required of a

skilled reader (Chall, 1983; Frederiksen, 1980, 1981, 1982; Perfetti & Lesgold, 1977).

The study of problem solving with large knowledge bases has provided evidence of the power of human thinking to use a large knowledge system in an efficient and automatic manner in ways that maximize the capacity of the working memory (Glaser, 1984). In observations of how experts and novices solve problems in specific areas such as physics (Egan & Schwartz, 1979), chess playing (deGroot, 1965; Chase & Simon, 1973; Simon, 1974) and in diagnoses of patients' symptoms (Norman, Jacoby, Feightner & Campbell, 1979; Wortman, 1972), researchers found that the expert could solve the problem much faster than the novice. The increase in processing speed of the expert appeared to be accounted for by the lack of interference from the parts of the task that have become routine and automatic (Frederiksen, 1984).

In this study, to identify the unknown chemical solutions in the laboratory, students had to perform two tasks at the same time. One task was manipulating the experiment; the other was the thinking process which involved observing, analyzing, and drawing conclusions. By using the videodisc simulation, students could perform the first task through automatic processing (i.e. press the button to choose the chemicals to be added), thus being able to fully concentrate on the thinking process.

Based on the information processing theory, it is assumed that students who learn to identify the unknown chemical solutions through the IVD laboratory (IVD group) will have a better chance than students working in the laboratory (LAB group) to process the information in an efficient way and have more opportunities to develop the automatic processing through the practice with realistic settings. Therefore, it is hypothesized that the IVD group will employ a better problem solving procedure and then be able to

complete the task faster than the LAB group. Facilitating learning environment as such, it is also expected that the IVD group retains the material better than the LAB group.

Definition of Terms

Major terms used in this study are defined as follows:

Problem solving ability - an estimate of individuals' skills to determine an answer to a problem. In this study the problem was to identify the set of unknown chemical solutions on paper-pencil posttest.

Problem solving procedural steps - a combination of skills used in working toward the solution of a problem. Based on Polya (1971), problem solving usually involves four steps :

1) understanding the problem - involves discussing the problem: What is the unknown? Is it possible to satisfy the conditions? Is the condition sufficient to determine the unknown?
2) devising a plan to solve the problem - involves drawing a diagram or matrix, discussing how to choose combinations of chemical solutions to experiment with, discussing reactions, determining/using the results.
3) carrying out the plan - involves mixing the chemical solutions, observing reactions and recording/inputting the result.
4) looking back - discussing the questions about: Can you check the result? Can you derive the result differently? Can you use the result, or strategy, for some other unknown? etc.

Problem solving strategy - a method students employed in obtaining a solution to the problem. The strategy, in this study, was classified as:

- Random search - the problem solver uses trial-and-error strategies to