DOCUMENT RESUME

ED 400 208 SE 059 154

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TITLE	Discovery Lab in the Chemistry Lecture Room: Design and Evaluation of Audio-Visual Constructivist Methodology of Teaching Descriptive Inorganic Chemistry.
PUB DATE	[96]
NOTE	30p.; Paper presented at the Annual Meeting of the American Association of Colleges for Teacher Education (Chicago, IL, February 21-24, 1996).
PUB TYPE	Reports - Research/Technical (143) -- Speeches/Conference Papers (150)
EDRS PRICE	MF01/PC02 Plus Postage.
DESCRIPTORS	Academic Achievement; *Audiovisual Instruction; *Demonstrations (Science); Discovery Learning; Educational Strategies; *Inorganic Chemistry; *Science Experiments; Science Instruction; Scientific Concepts; Secondary Education; Student Attitudes; Teaching Methods; Technology

ABSTRACT

Demonstration of chemical reactions is a tool used in the teaching of inorganic descriptive chemistry to enable students to understand the fundamental concepts of chemistry through the use of concrete examples. For maximum benefit, students need to learn through discovery to observe, interpret, hypothesize, and draw conclusions; however, chemical discovery labs are time consuming to prepare and present and may involve hazards. The purpose of this study was to design an effective audio-visual method for teaching descriptive inorganic chemistry and to investigate whether an audio-visual method could be a viable alternative to the live demonstration method. Data were collected for quantitative and qualitative analysis. Quantitative analysis indicated that the audio-visual method does not account for a statistically significant proportion of variance in students' achievement scores. Qualitative analysis of data indicated that there was an equal preference of students for each method. Students favored either method of presentation (audio-visual or live demonstration) over the traditional lecture method. It was concluded that audio-visual discovery lab experiments can be used in teaching descriptive inorganic chemistry, but further research needs to be done to improve the quality and methodological design of audio-visual presentations. Contains 12 references. (JRH)

DISCOVERY LAB IN THE CHEMISTRY LECTURE ROOM: DESIGN AND EVALUATION OF AUDIO-VISUAL CONSTRUCTIVIST METHODOLOGY OF TEACHING DESCRIPTIVE INORGANIC CHEMISTRY.

ABSTRACT

Categorizing compounds, reactions, and properties into classes, types, and groups (*concepts*) helps students to deal with the diversity of information which must be acquired in order to learn descriptive inorganic chemistry; however, the understanding of abstract concepts requires *formal or operational thinking*. Studies suggest that a large proportion of college students have difficulty applying mental operations to abstractions and theories; instead, they carry out certain mental operations based on observations and collected data. Thus, the content needs to be presented at the concrete level for most college students in order to facilitate understanding.

Demonstration of chemical reactions is a tool to be better used in the teaching of inorganic descriptive chemistry, and it should enable students to more fully understand the fundamental concepts of chemistry through use of concrete examples. However, unless presented properly, many students do not benefit from these chemical demonstrations. For maximum benefit, students need to learn through *discovery*: to observe, to interpret, to hypothesize, and to draw conclusions.

Studies examining the effectiveness of learning cycle discovery lab experiments in descriptive inorganic chemistry found this teaching method to be very successful. A limiting factor though was the observation that chemical discovery labs are often quite time consuming to prepare and to present. Furthermore, chemical demonstrations may involve hazards.

This study was conducted in an attempt to overcome these obstacles. Its purpose was to design an effective audio-visual method for teaching descriptive inorganic chemistry (which incorporates the cognitive theoretical approach to teaching and learning)

and to investigate whether an audio-visual method could be a viable alternative to the live demonstration method. Data were collected for qualitative and quantitative analysis. Quantitative analysis indicated that this methodology (audio-visual method vs. live demonstration method) does not account for a statistically significant proportion of variance in students' achievement scores, as measured by knowledge questions from an instructor's exams. Qualitative analysis of data indicated that there was an equal preference among students for each method. Students favored either method of presentation (audio-visual or live demonstration) over the traditional lecture method. The conclusion was drawn that audio-visual discovery lab experiments can be used in teaching descriptive inorganic chemistry, but further research needs to be done to improve the quality and methodological design of audio-visual presentations.

TABLE OF CONTENTS

CHAPTER I

INTRODUCTION

"...Even Stigland, the patriotic Archbishop of Canterbury,
found it advisable."
"Found what?" asked the duck.
"Found it" replied the mouse, rather grossly. "Of course, you know
what "it" means?"
"I'll know what "it" means, when I find the thing," said the duck.
It's generally a frog or a worm. The question is, what did the
Archbishop find?

(Alice's Adventures in Wonderland).

The importance of learning descriptive inorganic (reaction) chemistry is significant for two main reasons. First, chemists who use inorganic compounds must have a knowledge or "feeling" of how to use these compounds appropriately and safely. Second, students must know the descriptive chemistry itself, in order to understand an explanation of phenomena of descriptive chemistry offered by "advanced" theoretical chemistry.

The fact that there is a plethora of detailed descriptive material students must acquire in order to be knowledgeable about descriptive chemistry makes the teaching of this subject challenging. Seeking methods to instruct students as effectively as possible includes the challenge of systematization, organization, and visual presentation of subject matter.

The Problem

Statement of the Problem

The problem was to design audio-visual learning cycle discovery lab experiments in descriptive chemistry and to determine if students perceived these to be viable alternatives to live demonstration discovery lab experiments.

Significance of the Problem

The understanding of basic *concepts and principles* instead of simple "memorization" of material is essential for the effective learning of descriptive chemistry.

Thinking is the process that produces understanding. The *concepts* are the building blocks of thinking which help to organize vast amounts of information into manageable units. Reed (1992) stated that without the ability to form concepts we would find life a confusing series of unrelated experiences. There would be no way of grouping things together, no symbols or shorthand for talking and thinking about similar objects and events. Nothing would be like anything else, and communication would be impossible.

Categorizing compounds, reactions, and properties into classes, types, and groups (concepts) helps one to deal with the diversity of information necessary for learning descriptive chemistry. However, concepts are abstractions which do not exist in the real world. Understanding of concepts requires *formal operational thinking* which is the ability to go beyond observable data and familiar objects, to think hypothetically, to consider alternatives, and to identify all possible combinations.

Studies suggest that a large proportion of college students do not function at a formal operational reasoning level, which is defined by Swiss psychologist Jean Piaget (1963) as the highest stage of mental development. This means that these students will ave difficulty grasping conceptual topics and applying mental operations to abstractions and theories. The students (concrete thinkers), who are functioning below the formal operational level, are able to carry out certain mental operations based on observations and collected data. Thus, the *content level* needs to begin at the *concrete level* for most college students. Recalling the quotation from *Alice's Adventures in Wonderland*, seeing the "thing" would help to understand "it." Herron (1975) suggested that conceptual chemistry can be expressed in terms of concrete examples which model the abstract concepts. Concrete instruction is effective with both concrete thinkers and formal operational learners.

The use of chemical demonstrations as concrete examples is a powerful teaching tool which displays chemical phenomena, stimulates the thought process, and develops observation skills; however, unless presented properly, students do not benefit much from such demonstrations (Roadruck, 1993). encourage the intellectual debate of ideas, the weighing of evidence and have an emphasis on making sense out of observed facts are the ones that lead to the development of formal thought.

Chemical demonstrations, in order to be effective, must be organized and presented using the *cognitive approach to teaching and learning*. The cognitive view sees people as active learners who initiate experiences, seek out information to solve problems, and reorganize what they already know to achieve new insights. Instead of being passively influenced by environmental events, people actively choose, practice, pay attention, ignore, and make any other decisions as they pursue goals (Woolfolk, 1995).

Roadruck (1993) maintained that students should not simply be given "right answers" when observing chemical demonstrations. Rather, the students must be asked to interpret, to hypothesize, to analyze hypotheses, and to draw their own conclusions. In short, students must experience the *phenomenon*, not just the presentation.

In Jerome Bruner's cognitive instructional model (Bruner, Goodnow, & Austin, 1956; Bruner, 1966), the teacher's role is defined as creating situations in which students can learn on their own. Bruner (1966) stated:

> We teach a subject not to produce little living libraries on that subject, but rather to get the student to think...for himself, to consider matters as an historian does, to take part in the process of acquiring knowledg. Knowing is a process, not a product. (p. 72)

Discovery learning models are incorporated in the "*learning cycle*" concept which has been implemented and researched in science classrooms for almost thirty years. Robert Karplus (Karplus and Thier, 1967), influenced by Piaget's mental functioning model, initiated the development of an inquiry-based curricular model which consists of three phases: *exploration*, *invention*, and *discovery*.

The learning cycle concept includes concrete experiences, active involvement of students in the discovery process, and social interaction. David Johnson and Roger Johnson (1985) described the power of social interaction this way:

> Motivation to learn is inherently interpersonal. It is through interaction with other people that students learn to value learning for its own sake, enjoy the process of learning and take pride in their acquisition of knowledge and development of skill. Of the interpersonal relationships available in the classroom, peers may be the most influential on the motivation to learn. (p. 250)

Cooperative learning leads to higher achievements, increasing self-esteem, and improving relationships among the students. Students working in pairs or teams can support each other's learning. Motivation is greater since immediate help from team members is available when students encounter problems.

The learning cycle concept was applied to *descriptive chemistry* by Ryan, Robinson & Carmichael (1980), Whisnant (1982), and Wulfsberg (1983). The experiments were organized as learning cycle discovery laboratories in which students were forced to invent abstract principles of periodicity which organize the students' observations and enable them to predict unobserved facts of descriptive chemistry. The "memorization" required can not be of isolated facts or numbers from a table, but are memories of personal experiences and principles of periodicity which the students have "invented" themselves. The quantitative and qualitative evaluations of the effectiveness of the learning cycle discovery lab experiments/demonstrations showed this method of teaching descriptive inorganic chemistry to be very successful (Wulfsberg, 1983).

Although there is apparent evidence for the effectiveness of discovery lab experiments, the main obstacle to the use of this method of teaching descriptive chemistry is that chemical demonstrations are often very time-consuming to prepare and to present. Furthermore, demonstrations may involve hazards. For these reasons, many teachers avoid live demonstrations in the teaching process (Roadruck, 1993).

Utilization of *audio-visual technology* appears to offer a solution to this problem. Educational media has the capacity to illustrate demonstrations in a safe and time-efficient way to enhance visualization, to capture the students' attention through effects, and to provide the alternative learning experiences which increase motivation for students to learn (Kozma, 1987; Leonard, 1992).

Audio-visual learning cycle discovery lab experiments which incorporate the cognitive approach to teaching and learning could be a viable method of teaching descriptive inorganic chemistry; however, a review of the literature showed that attempts to design an *audio-visual discovery lab* in the teaching of chemistry have not yet been made. The research in evaluation of effectiveness of audio-visual vs. conventional (not discovery) chemical labs is very minimal.

This study attempted to design two audio-visual learning cycle discovery lab experiments which incorporate the cognitive approach to teaching and learning and to evaluate the relative effectiveness of these audio-visual discovery labs experiments vs. live demonstration discovery lab experiments.

Statement of Hypotheses

Null hypothesis 1: Methodology of teaching descriptive chemistry (audio-visual vs. live demonstration) does not account for a statistically significant proportion of variance in the students' achievement scores measuring knowledge on subject matter questions prepared by the instructor and included in the instructor's exams.

Null hypothesis 2: Methodology of teaching descriptive chemistry (audio-visual vs. live demonstration) does not account for a statistically significant proportion of variance in the students' abilities to construct their understanding of fundamental concepts based upon their experiences as measured by the teams' assignments completed during experiments.

Null hypothesis 3: Methodology of teaching descriptive chemistry (audio-visual vs. live demonstration) does not account for a statistically significant proportion of variance in the students' abilities to retain factual information as measured by "visual" questions from instructor's exams.

Null hypothesis 4: Methodology of teaching descriptive chemistry (audio-visual vs. live demonstration) does not account for a statistically significant proportion of variance in the students' abilities to retain conceptual information as measured by conceptual questions from the instructor's exams.

Null hypothesis 5: Methodology of teaching descriptive chemistry (audio-visual vs. live demonstration) does not account for a statistically significant proportion of variance in the students' abilities to transfer knowledge to other situations measured by problem-solving questions from the instructor's exams.

Null hypothesis 6: Methodology of teaching descriptive chemistry (audio-visual vs. live demonstration) do not account for a statistically significant proportion of variance in time to meet the objectives of the lessons.

Null hypothesis 7: At the conclusion of the experimental period, the sample group will show no difference in attitude toward either method (audio-visual or live demonstration).

Null hypothesis 8: At the conclusion of experimental period, the sample group will show a favorable attitude toward either method (audio-visual or of live demonstration) over the traditional classroom lecture method.

Organization of the Study

Chapter II describes procedures of the study and research design. Results of the investigation are presented in Chapter III. Chapter IV includes summary, discussion of results, conclusions, implications, and recommendations for further research.

CHAPTER II

THE RESEARCH DESIGN

Setting and Population of Study

The study was conducted at Middle Tennessee State University in Murfreesboro. Sample groups consisted of college students enrolled during the 1995 Fall Semester in Inorganic Chemistry 416/516.

Determination of the Sample Group

Twenty-two students enrolled in the Inorganic Chemistry 416/516 class.

Gender distribution: eight males, fourteen females.

Overall average achievement score in the Inorganic Chemistry class was 73 %.

Type of Research Design

This research was designed using the cross-over design type, which is represented in Table 1. The sample group was divided into two groups, A and B. Each group consisted of four teams (of two to four). Names of these teams are listed in Table 1.

Group A was exposed to the treatment (audio-visual method) in Experiment 1, while B was a control group. Group B was exposed to treatment in Experiment 2, while A was a control group.

This type of research design provided equal opportunity for all subjects in the sample group to be exposed to the treatment and to the control methods in attempting to minimize the following errors:

1. The effect of such independent variables as sex, age, and grade point average on the reliability of study.

2. The effect of a limited number of subjects on the reliability of study.

Organization of Lessons

1. Audio-visual and live demonstration presentations were identical methodologically and performed simultaneously.

2. The lessons selected for the study were organized as learning cycle lab experiments. The learning cycle included:

(a) Exploration (creating preliminary hypotheses and observing chemical demonstrations with minimum guidance).

(b) Invention (analyzing data gathered during exploration and concept introduction).

(c) Concept application (verifying preliminary hypotheses and drawing conclusions).

3. The lessons were accompanied by printed guides/handouts (Appendixes A and B). These handouts included a summarized goal of experiments, tables for organizing observations, and assignments to be turned in. After completing the lesson, the students received summaries of the lessons.

Description of the Discovery (Learning Cycle) Lab Experiments

Experiment 1: Some reactions of cations

In this experiment the students investigated the reaction of chlorides with water, observing cloudiness, heat evolution, and pH changes in order to find relationships of reaction. Students were asked to predict relationships of the reaction tendencies to the atomic properties of the cation.

Experiment 2: Periodicity in the Activity Series of the Elements

In this experiment students were to determine which atomic property of the metals (ionization potential, Allred-Rochow electronegativity, Pauling electronegativity, the size of the ion, or the charge of the cation) is most closely correlated with the activity of the metal.

Collection of Data

The data were collected for ***quantitative*** and ***qualitative*** analysis.

Quantitative Analysis

Data for quantitative analysis consisted of:

1. Grades for teams' hypotheses created during the experiment.

2. Individual scores measured by "visual" and conceptual questions obtained through testing administered the day following experiments.

3. Individual achievement scores were measured by problem-solving questions included in the mid-term exam prepared by the instructor.

4. Individual achievement scores were measured by "visual," conceptual, and problem-solving questions included in the final exam prepared by the instructor.

Twenty-six observations in total were used for the gathering of data for quantitative analysis (four "visual" questions, six conceptual questions, nine problem-solving questions, and six hypotheses, created during two separate experiments).

Statistical Treatment of Quantitative Data

Latin Square Cross-Over Design

The analysis of variance for Latin square cross-over design (Neter, Wasserman & Kuther, 1990) was used to analyze quantitative data gathered in this study. In this type of design (called Latin square cross-over design), the subjects are assigned to the different treatment order patterns given by Latin square. This design is a mixture of repeated measures (within subjects) and Latin square (order patterns form a Latin square).

This estimates and predicts one variable (dependent) from knowledge of other variables (independent). The criterion (dependent) variables analyzed were achievement scores. The predictor variables (independent) were methodology of instruction (pattern) and topics of experiments (order position).

Statisitical Treatment of Qualitative Data

Comparative Pattern Analysis

The Comparative Pattern Analysis (Patton, 1990) was used for the treatment of qualitative data. Guba (1978) suggested that in focusing the analysis of qualitative data an evaluator must deal first with the problem of "convergence." The problem of convergence is figuring out what things fit together. This leads to a classification system for the data. Guba (1981) suggested several steps for converting field notes and observations about issues and concerns into systematic categories for analysis. The evaluator-analyst begins by looking for "recurring regularities" in the data. These regularities represent patterns that can be sorted into categories. Categories should then be judged by two criteria: "internal homogeneity" and "external heterogeneity." The first criterion concerns the extend to which the data that belong in a certain category hold together in a meaningful way. The second criterion concerns the extent to which differences among categories are bold and clear. When several different classification systems have been developed, some priorities must be established to determine which category systems are more important than others. The set must be reproducible by another competent judge.

CHAPTER III

PRESENTATION AND ANALYSIS OF FINDINGS

Presentation of Findings : Results of Testing Null Hypotheses

Five null hypotheses were tested via the analysis of variance for Latin-square cross-over design.

Hypothesis 1: *Methodology of teaching descriptive chemistry (audio-visual vs. live demonstration) does not account for a statistically significant proportion of variance in students' achievement scores measuring knowledge on subject matter questions prepared by the instructor and included in the instructor' exams.*

The mean scores were M (treatment) = 74.7, M (control) = 70.5 $F(1, 34) = 1.68$ at $p = .21$. Thus, hypothesis one was not rejected.

Hypothesis 2: Methodology *of teaching descriptive chemistry (audio-visual method vs. live demonstration) does not account for a statistically significant proportion of variance in the students' abilities to construct their understanding of fundamental concepts based upon their experience, as measured by the teams' assignments completed during the experiments.*

The result of the test was $F(1, 6) = 0.14$, $p = 0.72$. M (treatment) = 61.5, M (control) = 56.5. Thus, hypothesis two was not rejected.

Hypothesis 3: *Methodology of teaching descriptive chemistry (audio-visual method vs. live demonstration) does not account for a statistically significant proportion of variance* *in the students' abilities to retain factual information, as measured by "visual" questions from the instructor's exams.*

The result of analysis was $F(1,34) = 0.07$, $p = .92$, M (treatment) = 79.5, M (control) = 77.7. Thus, hypothesis three was not rejected.

<u>*Hypothesis 4:*</u> *Methodology of teaching descriptive chemistry (audio-visual method vs. live demonstration method) does not account for a statistically significant proportion of variance in the students' abilities to retain conceptual information, as measured by conceptual questions from the instructor's exam.*

The result of analysis was $F(1, 34) = 0.10$, $p = .62$, M (treatment) = 81.8, M (control) = 78.7. Thus, hypothesis four was not rejected.

<u>*Hypothesis 5:*</u> *Methodology of teaching descriptive chemistry (audio-visual vs. live demonstration) does not account for statistically significant proportion of variance in the students' abilities to transfer knowledge to other situations, as measured by problem-solving questions from the instructor's exams.*

The result of analysis was $F(1, 34) = 2.88$, $p = .08$, M (treatment) = 75.1, M (control) = 60.6. Although the level of probability (.08) was relatively near to alpha level (.05), the hypothesis five could not be rejected.

<u>*Hypothesis 6:*</u> *Methodology of teaching descriptive chemistry (audio-visual method vs. live demonstration method) does not account for statistically significant proportion of variance in time to meet the lesson objectives.*

This hypothesis was not tested because the instructor presenting the live demonstration did not have the opportunity to collect data during the experiment.

<u>Hypothesis 7:</u> *At the conclusion of the experimental period, the sample group will show no difference in attitude toward either method (audio-visual vs. live demonstration).*

Qualitative analysis of data (50 % of students favored audio-visual method and 50% of students favored live demonstration method) indicated that hypothesis seven can not be rejected.

<u>Hypothesis 8:</u> *At the conclusion of the experimental period, the sample group will show a favorable attitude toward either method (audio-visual or live demonstration) over the traditional classroom lecture method.*

Qualitative analysis of data (95% of students favored both audio-visual method and live demonstration method; 5% of students favored traditional classroom lecture method) indicated that this hypothesis can not be rejected.

{Hypotheses seven and eight were tested via qualitative constant pattern analysis.}

Analysis of Findings

Discussion of Results of Quantitative Analysis

None of the five null hypotheses related to quantitative data were rejected.

The mean scores on questions contained in mid-term and final instructor's exams and testing administered the day following experiments (18 questions total) were compared for treatment (audio-visual method) vs. control (live demonstration) statistically by analysis of variance for Latin-square cross-over design. The mean score for audio-visual method was higher than for live demonstration method; however, p-value was more than .05, which indicated that *methodology of instruction does not account for a* *statistically significant proportion of variance in achievement scores measuring knowledge by subject matter questions from the instructor's exams.*

The grades of the teams' hypotheses created during experiments were compared statistically on the basis of six observations (combined assignments for Experiment 1 and for Experiment 2). Mean scores for the audio-visual method were slightly higher; however, this difference was not statistically significant (p-value was higher than .05). Thus, results of statistical analysis indicated that *methodology does not account for difference in students' ability to construct knowledge based on their experimental observations which was measured by grades on students' hypotheses created during experiments.*

The students' abilities to retain factual information were measured by "visual" questions on the basis of four observations (questions) contained in testing administered the day following experiments, a mid-term exam, and final instructor's exam. The mean score for audio-visual method was higher than for live demonstration method; however, results of statistical analysis (p-value higher than .05) suggested that *there was not a statistically significant difference in the students' abilities to retain factual information when they were taught by audio-visual method vs. live demonstration method.*

The students' abilities to retain conceptual information were measured on the basis of six conceptual questions contained in testing administered the day following experiments, a mid-term exam, and final instructor's exams. Mean achievement score for treatment was higher than for control; however, p-value (>.05) indicated that *methodology does not account for a statistically significant proportion of variance in students' abilities to retain conceptual information.*

The students' abilities to transfer knowledge to other situations were measured by eight problem-solving questions from the instructor's mid-term and final exams. The mean achievement scores were slightly higher for treatment than for control. *The result of statistical analysis ($p >.05$) indicated that methodology does not account for statisti-cally significant difference in students' abilities to transfer knowledge to other situations.*

Discussion of Results of Qualitative Analysis

The null hypotheses seven and eight related to qualitative data were not rejected. The data for testing these hypotheses were collected by questions intending to test the students' attitudes toward the audio-visual method and live demonstration method (The students' responses are presented in Appendix E.).

Question: What were the strengths and the weaknesses of the audio-visual presentation of chemical reactivity trends?

Students' comments about the strengths of the audio-visual method were grouped into what emerged as four categories of response. The categories of response were:

1. Interest - i.e., "interesting," "exciting," "impressive," "capturing attention by effects."

2. Self-access - i.e., "ability to rewind," "can contol," "can replay and freeze," "possibility to check out."

3. **Safety** - i.e., "no hazard," "got to see more dangerous reactions without fear."

4. **Organization of lesson** - i.e., "very well organized, well written," "a lot of material in concise form," "correct amount of time."

The students' comments about weaknesses of audio-visual presentation were also grouped into four categories of response. The categories of response were:

1. **Ability to interact with the teacher** - i.e., "no one to ask questions," "can't ask questions," "inability to explain if it is not clear."

2. **Method of presentation** - i.e., "not real life presentation," "experiments were not carried out in real life," "with video it is difficult to get the full effect of reactions."

3. **Speed of presentation** - i.e., "video seemed to go too fast," "camera moved too fast," "video went much too fast."

4. **Clarity of presentation** - i.e., "reactions weren't quite easily seen," "was difficult to see."

Question: What were the strengths and the weaknesses of live demonstration presentation of chemical reactivity trends?

The students' comments about the strengths of the live demonstration presentation were grouped into three categories. These categories were:

1. **Ability to interact with the teacher** - i.e., "we were able to ask the questions," "could ask questions," "can ask: what about, what if"?

2. **Method of presentation** - i.e., "it is live, it is real," "clear sense of real life applications," "experiments being carried out in real life," "getting to actually see the reaction take place."

3. **Organization of the lesson** - i.e., "well-organized," "easy to understand."

The students' comments about the weaknesses of the live demonstration presentation were grouped into four categories:

1. **Self-access** - i.e., "can not go back and rewind," "if you missed it, its over..," "reaction can be seen only once," "if you missed one part, you are lost."

2. **Difficulties to view** - i.e., "not everyone can get a good look at the reactions because of seating arrangements," "inability to all class to view."

3. **Safety** - i.e., "the vapors were nasty," "more chance of personal injury."

4. **Interest** - i.e., "exciting," "didn't have the visual effects to hold my attention," "not as...as video."

Question: Which method of presentation did you prefer: video or demonstration? Which method did you learn more from? Why was this?

A favorable attitude to the audio-visual method was professed by 50% of the students; the other 50% favored the live demonstration method. Thus, there were not any differences in students' attitudes toward either method; however, 57% of students decided that they learned more from live demonstration method due to its being interactive, 33%

learned from audio-visual method due to its ability to capture attention, and 10 % decided that they learned equally from both.

The fact that a higher number of students believed that they learned more from live demonstration is in conflict with analysis of quantitative data which indicated trends of mean scores related to audio-visual presentation to be higher.

The possible explanation is that the students considered the ability to interact with the teacher to be an important aspect of learning, which is in agreement with the cognitive approach to construction of knowledge. Unfortunately, the audio-visual method was not presented in an interactive way. However, an audio-visual presentation was more time efficient (the instructor who presented the live demonstration did not have time to complete some demonstrations) and gave the students an opportunity to acquire and analyze more of the learning material. This might explain the fact that the students acheived higher scores in relation to the audio-visual method.

Question: Overall, did either method of presentation of chemical reactions contribute more or less to your understanding of inorganic chemical reactivity than two additional days of lecture? Why or why not?

Analysis of the students' responses showed that 5% of the students preferred lectures because of "better learning from the notes taken from lecture than from viewing an experiment," and 95% of students preferred discovery labs presented by either method because "both methods provided a break from regular classroom lectures." "contributed to better understanding of reactivity of chemicals, which we had to understand in later chapters," "showed what exactly was being discussed," "seeing those chemical reactions I was able to think...," "seeing something actually happen helps to reinforce principles that would have to be imagined otherwise," and "ability to create my own hypothesis by just seeing the presentation and not relying on the textbook."

Thus, students' attitudes toward utilization of either method of presentation of discovery labs vs. traditional classroom lecture were favorable. As the result, we concluded that the need for further development of this discovery style of teaching was evident.

CHAPTER IV

CONCLUSIONS, IMPLICATIONS, RECOMMENDATIONS

Conclusions

Conclusions in Relation to Implementation of Audio-Visual Method

1. There are no differences in the students' knowledge of subject material related to two designed discovery lab experiments if they are taught by the audio-visual method vs. live demonstration method.

2. There are no differences in the students' abilities to create their own hypotheses during experiments if they are taught by the audio-visual method vs. live demonstration method.

3. There are no differences in the students' abilities to retain factual information if they are taught by the audio-visual method vs. live demonstration method.

4. There are no differences in the students' abilities to retain conceptual information if they are taught by the audio-visual method vs. live demonstration method.

5. There are no differences in the students' abilities to transfer knowledge to other situations if they are taught by the audio-visual method vs. live demonstration method.

6. There was no difference in the students' attitude toward either method (audio-visual or live demonstration).

7. The students believed that there were both advantages and disadvantages to each approach. The main disadvantage of the audio-visual method: it was not interactive. The main advantage: it was interesting and captured thei students' attention.

8. There was a preference in the students' attitudes toward both methods of presentation of discovery lab experiments (audio-visual and/or live demonstration) vs. traditional classroom lectures.

Conclusion in relation to design of audio-visual discovery lab experiments

The students indicated an overall satisfaction with the strategy of use of audio-visual presentations of chemical demonstrations; however, improvement needs to be made in methodology of lessons (to make them more interactive) and in quality of presenting of factual information (clarity and speed).

Implications

The audio-visual discovery lab experiments can be used in teaching inorganic chemistry in both colleges and schools and in the design of a telecourse method as a long-distance learning model.

Recommendations

The study supports the following recommendations:

1. The audio-visual discovery lab experiments should be used in the teaching of descriptive inorganic chemistry.

2. Research studies investigating the possibility to increase the effectiveness of audio-visual method through making it more interactive should be conducted.

3. Research studies investigating the possibility to increase the effectiveness of the audio-visual method through the use of digital animation should be conducted.

4. Research studies investigating the optimum speed of presentations of chemical reactions should be conducted.

5. Research studies investigating the students' abilities to retain knowledge over time when using the audio-visual teaching method should be conducted.

6. Quantitative research studies investigating the effectiveness of audio-visual discovery lab experiments vs. conventional classroom lecture method should be conducted.

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Lois J. Lipson
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