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ABSTRACT

Presented is a description of a research project related to the use of two modes of instruction, the abstract mode and the applied mode, and gains made from them. A secondary purpose of the investigation was to compare student gains according to area of interest. The writer selected one of the processes of science, the process of measuring, which she considered basic to the new approach in the teaching of elementary science. Preservice elementary school science teachers participated in the study. Data were secured from four elementary science education methods classes. The curriculum, Science - A Process Approach, was used for the instructional materials in the study. The testing portion of the study represents all of the competencies included in the Process of Measuring of the entire program. Tests were constructed and administered. Difference scores were obtained between pretest and posttest administration. It was determined that students enrolled in the methods classes gained more competence from an applied mode of instruction than from an abstract mode. The classification level of students caused no significant difference in learning outcomes as related to the process of measuring. Science oriented students make more significant competency gains by both methods than language art or social studies students. (EB)

BASIC RESEARCH IN ONE PHASE OF COMPETENCY DEVELOPMENT IN THE PRESERVICE TRAINING OF ELEMENTARY SCIENCE TEACHERS

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Introduction

For several years many universities and colleges have been in the process of reappraising their roles in the training of elementary teachers faced with overwhelming demands brought about by the broad and rapid changes that have occurred in society itself. Many faculties involved themselves in a complete new look at some of these urgent problems rather than settling for a temporary adjustment. In designing and developing a new teacher preparation model, educators gave considerable attention to the implications that societal changes have had on the preservice science education of elementary teachers.

The changing culture demanded a new approach to curriculum problems in the schools. Within the past decade the federal government, through the National Science Foundation, sought to bring about rapid advances in the sciences and in science education by generously granting funds for new curriculum projects. This curriculum reform brought about an updating and reorganization of content, as well as new approaches to teaching methods.

Among other problems associated with teaching, the knowledge explosion in science was one with which the future teacher had to be prepared to cope. There was more material in each science field than one person could be expected to learn in a lifetime. Hurd and Gallagher posed three interesting questions pertaining to the vast amount of information available at the elementary school level:

> How can an elementary school curriculum be designed that is up-to-date, when the amount of scientific knowledge doubles in the time it takes a child to progress from kindergarten to high school? What kind of instruction is needed for today's children, who before middle age will have access to eight times as much knowledge as there is currently? Is it possible to invent a science curriculum for use in the elementary school that will enable one to live comfortably and meaningfully with science and to appreciate its changing system of concepts, theories and methods?[1]

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[1]Hurd, Paul DeHart, and James Joseph Gallagher. New Directions in Elementary Science Teaching. Belmont, California: Wadsworth Publishing Company, Inc., 1968, p. 2.

In his article on "Schooling and Education" written for The Great Ideas Today by Encyclopedia Britannica, John I. Goodlad discussed another one of the current problems in the educational process as it affected the prospective elementary school teacher:

> The separate-subject approach creates few immediately apparent problems for the secondary school. Traditionally, high-school teachers have been prepared in a major field and supporting disciplines. Teaching that field in the high school permits a smooth transition from their own studies. Fusing two or more subjects, on the other hand, adds a curriculum-planning burden to teaching demands and often calls for collaborative effort with colleagues . . . .
>
> The separate-subject approach, however, creates some immediately apparent problems for the elementary school. First, elementary-school teachers in most states are prepared as generalists rather than as specialists in subject fields. Second, there is a limit to the number

> of disciplines that can be taught within the time available, and some difficult choices must therefore be made. There simply is no room in the curriculum for thirty or more separate subjects. Third, if the basic structures and concepts of the academic disciplines form the curriculum design of secondary education, what is to be the approach for elementary education? Is there something of a more basic nature than what has been conceived for the high school?[2]

[2]Goodlad, John I. "Schooling and Education," The Great Ideas Today from Encyclopedia Britannica. New York: Praeger Publishing Inc., 1969, pp. 108-109.

Haney pointed out the fact that the majority of elementary school teachers were still expected to teach all facets of the total school program in self-contained classrooms. Few teachers were adequately prepared for these manifold tasks in their undergraduate college programs and therefore the problem was magnified. Haney stated:

> The elementary school teacher who attempts to teach science is in the most precarious position of all. The attempts made by several of the projects to write materials that could be well taught regardless of the qualifications of the teacher have been only partly successful. The elementary science programs are coming to include some highly sophisticated concepts such as systems, interaction and the making of operational definitions. One can only wonder what these can mean to the teacher with anything less than a natural science major in his college background. It is doubtful that the most elaborate teacher's guide could substitute for a teacher who is well grounded in the subject matter of science and in recent developments in child psychology.[3]

[3]Haney, Richard E. The Changing Curriculum: Science. Washington, D.C.: Association for Supervision and Curriculum Development, 1966, p. 33.

Even though these larger issues were beyond the scope of this particular study, it was appropriate to point out some of the problems that were a part of teacher education programs so that the results found in this investigation would assume the proper perspective and perhaps be used for further study in a model for teacher preparation in elementary science methods.

Statement of the Problem

This study investigated the effects of presenting the process of measuring to preservice elementary school science teachers by the abstract and applied modes of instruction. The primary concern of the study was to compare the gains made by students receiving the abstract mode of instruction with those receiving the applied mode. A secondary purpose of the investigation was to compare student gains according to area of interest.

Research Design

Mindful of the fact that one of the problems besetting teacher education today is the present trend to reappraise science education courses, the writer selected as the focal point of this study one of the processes considered basic to the new approach in the teaching of elementary science. It seemed appropriate that, if teachers are expected to emphasize these processes in their teaching, the study of processes and their relationship to the basic concepts of science should be an integral part of their college training. By strengthening the quality of science methods courses, these future teachers would be enabled to understand both process and content of science and could be better equipped to organize and explain the meaning of scientific information.

One of the basic processes, that of measuring, had particular appeal to the writer as a process that is applicable to a study of this nature. Since a process is a means by which scientists gather information about the unknown, so it was thought that the process of measuring would be of considerable interest to those planning to teach scientific processes to children.

Another reason for the choice of the process of measuring was the interest that is being manifested at the present time by the National Science Teachers Association to encourage all school science programs to convert to the metric system. This conversion to the metric system in the United States appears to be necessary as well as inevitable, because the system is now in use by most of the other countries of the world. The change would not pose a very great problem in the secondary schools because the majority of the secondary science teachers have had some specialized training in their fields and have used the metric system. The training requirements, however, would be greater in the elementary schools since most elementary teachers have not had a great amount of science training.

The idea for the two modes of presentation of the measuring process to the participants in this study came from one of the issues that Ipsen listed in his report, Issues in Elementary Science Education, which was published by the National Science Teachers Association:

> 3. Abstract vs applied Should the methods of science be demonstrated only in their application to scientific investigation, or will abstract demonstrations serve as well?[4]

[4]Ipsen, D.C. Issues in Elementary School Science. Washington, D.C.: National Science Teachers Association, 1970, p. 16.

This research study was designed to compare the results of the two modes of instruction, abstract and applied, in teaching the process of measuring to preservice teachers at Murray State University. This investigation was also designed to study the effects that classification of students and their interests could have on learning outcomes as they are related to the two modes of instruction.

The data for this study were secured from four elementary science education methods classes during one semester at Murray State University. There were twenty-five students in each of two classes and twenty-six students in each of the other two classes with a total of one hundred two students involved in the study. These four classes were assigned as a class to the experimental treatments by the use of a table of random numbers as prescribed by Guilford.[5]

[5]Guilford, J.P. Fundamental Statistics in Psychology and Education. New York: McGraw-Hill Book Company, 1965, p. 139.

The average age of the Abstract Group was found to be 23 years, 6 months, and that of the Applied Group was 21 years, 4 months, with an average age of 22 years, 5 months, for the total group. Table I shows that the students participating in the study had a total number of 1385 semester hours in science and mathematics courses combined. Of that total, 491 semester hours were in mathematics and 894 semester hours were in science. Biology was decidedly the choice of both groups and those hours were almost equally divided between the two groups. Physical Science was the second choice of both groups in science with the Applied Group having 166 semester hours as opposed to 114 hours for the Abstract Group. In mathematics, the Abstract Group had a total of 257 semester hours and the Applied Group had 234.

In seeking instructional materials for this particular study, the writer found that most modern science curricula shared certain purposes and characteristics. These curricula were designed to present instruction that would be intellectually stimulating and scientifically authentic. Science--A Process Approach, however, had characteristics which made it somewhat different from other curricula. One of the distinctive features was that the learning experiences were ordered in sequences of instruction to increase competence in the processes of science, one of which is the focus of this study. Another feature was that objectives were written in behavioral terms and could be observed as outcomes of learning. Still another characteristic was that methods for evaluating achievement and progress were an integral part of the instructional program. A close relationship between science and mathematics was demonstrated in Science--A Process Approach. This approach also pointed out the cooperative planning of science and mathematics programs and demonstrated that this cooperative planning was both feasible and desirable. In addition, considerable emphasis was given to the program of teacher education, since the people who developed the program envisioned the urgent need for new pre-service programs in science education for elementary school teachers.

The testing portion of this study represents all of the competencies included in the Process of Measuring of the entire Science--A Process Approach program. These competencies, or observable performances, are a part of the Process Measures for Teachers and the Individual Competency Measures of the eighteen lessons in the learning hierarchy for the Process of Measuring.

Test A and Test B, which were constructed for this study, were designed as performance tests for the subjects involved in the investigation to measure the proficiency in the tasks specifically covered in the learning program. The performance of each task was considered either totally correct or totally incorrect, depending on whether the student did or did not exhibit the appropriate behavior. The tests covered exactly what the program as a whole designated as the Process of Measuring, no more and no less.

In the testing of the competency tasks, parallel questions were used with different measures involved. Test A was constructed from the competency measures of the odd numbered lesson sections and the even numbered sections from the parallel set. Test B was constructed from the competency measures of the even numbered lesson sections and the odd numbered sections from the parallel set. This procedure followed the one described by Anastasi[6] in her discussion of Split-half Reliability. For further

[6]Anastasi, Anne. Psychological Testing. New York: The Macmillan Company, 1954, pp. 108-109.

reliability, Test A was administered as a Pre-Test and Test B as a Post-Test for one class in each instructional group and the reverse was true for the other class in each mode of instruction.

Two modes of instruction, abstract and applied, were employed for this investigation. Essentially artificial material and abstract ideas characterized the abstract mode of instruction. In the applied mode, the students used actual measuring instruments and an endeavor was made to create real-life situations insofar as possible. Otherwise, the lessons followed the same instructional pattern as it was given in the original materials.

One of the most important dimensions of this study was assumed to be the teaching procedure in that both modes of instruction were fairly presented to all participants by one instructor. The writer made every endeavor to give fair treatment to all subjects of this investigation and to permit no factors to operate in a manner that would tend to give significant advantage to either method of instruction.

The analytical procedure of this investigation followed the description given by Kirk[7] for a Completely Randomized Factorial Design (CRF-pqr),

[7]Kirk, Roger E. Experimental Design: Procedures for the Behavioral Sciences. Belmont, California: Wadsworth Publishing Company, Inc., 1968, pp. 217-224.

which gave a simultaneous evaluation of three main effects: (1) Method, (2) Classification, and (3) Interest. In this study, the three main effects have pqr=12 treatment combinations. A total of 102 subjects was randomly assigned to the twelve treatment combinations. Four interactions were evaluated from the three-treatment design.

All 102 subjects enrolled in science education methods classes at Murray State University during the semester were included in this study thereby meeting the assumptions pertaining to normality of distribution and randomness. Hartley's F-Maximum Test was used to satisfy the assumption of homogeneity of variance, and conditions were met for treatments in a completely randomized factorial design. Difference scores were obtained by subtracting the scores on the Pre-Test from the scores on the Post-Test, all of which were higher than those on the Pre-Test. The .05 level of significance was deemed acceptable for this study.

Presentation and Interpretation of the Data

Table II, The Analysis of Variance Source Table for Difference Scores, gives a summary of the analysis of Method, Classification, and Interest; the two-way interactions of Method and Classification, Method and Interest, and Classification and Interest; and the three-way interaction of Method, Classification and Interest. There was a significant difference at the .01 level between the Applied Group and the Abstract Group, but no significant difference was found between the Juniors and Seniors at the .05 level. A significant difference was found in the Interest Group. This variance was significant at the .01 level. In examining the two-way interactions, a significant difference at the .01 level was found for Method and Classification and for Method and Interest; but the variance for Classification and Interest was not significant at the .05 level. The analysis of variance indicated no significant difference at the .05 level for the three-way interaction of Method, Classification, and Interest. In Table II, the total sum of squares is not shown because, with unequal n's in each cell of the Completely Randomized Factorial Design, the SS does not equal SS_{Total}. Since no computational check of the SS for unequal n's was thereby available, an equal n Analysis of Variance was done to make sure that the numbers of the unequal n's were within a reasonable span of the same numbers with the equal n's. In doing the equal n computation, scores were inserted at or right around the mean so that the variance of the group would not be changed. Sums of squares were then checked and found to have a close approximation each to the other.

After a significant F was found from the analysis, it was then appropriate to test the interactions. Table III is the Summary Table of Simple Main Effects for Interaction of Method and Classification. In Table III, Method with Juniors, Method with Seniors, and Classification with Abstract Method proved to be significant at the .01 level. Classification with Applied Method was significant at the .05 level.

Figure 1 is a graphic representation of Means for Applied and Abstract Methods of Juniors and Seniors. The Applied Method was better than the Abstract Method for both Juniors and Seniors. Juniors did better than Seniors with the Applied Method, but Seniors did better than Juniors with the Abstract Method. With each method, however, the Juniors and Seniors were different from each other.

Table IV is the Summary Table of Simple Main Effects for Interaction of Method and Interest. Significant at the .01 level are the F values for Method with Science Interest, Method with Language Arts Interest, Interest with Applied Method, and Interest with Abstract Method. The F value for Method with Social Studies Interest, however, was found to be not significant.

Figure 2 shows Means for Methods of Groups by Interest. The Applied Method was better for the two Interest levels of Science and Language Arts than the Abstract Method. The Social Studies Interest was not significantly different under the two methods.

The three categories of Interests were further examined by the Tukey Test of Honestly Significant Difference, since a test of simple main effects does not give a three way comparison.

Conclusions

In terms of the findings of this investigation as it related to the teaching of the process of measuring to preservice teachers in elementary science methods classes, the following general conclusions were reached:

1. Students enrolled in science education methods classes for elementary teachers gain more competence in the process of measuring from an applied mode of instruction than from an abstract mode of instruction.

2. The classification level of the students causes no significant difference in the learning outcomes as they are related to the process of measuring.

3. In considering the area of interest, students interested in science and mathematics or in language arts gain significantly more competency in measuring by the applied method than those interested in social studies.

4. Applied and abstract modes of instruction rank the same with students interested in the social studies.

5. Science oriented students make more significant competency gains by both methods than the language arts students or the social studies students.

Recommendations

As the present investigation reached completion, the writer recognized the difficulty of generalizing from the findings of one study in one university. However, in the context of the limited scope of this study, the following recommendations were considered appropriate:

1. To establish greater reliability for the findings of the present study, more studies with other variables may be replicated in other universities.

2. Research needs to be conducted on each phase of the process of measuring to particularize the elements that adapt themselves to one mode of instruction.

3. Similar studies in the other basic processes of science would identify elements in those processes for which certain modes of instruction would be more effective.

4. Research should be conducted to determine which mode of instruction is more applicable to all of the basic processes of science and which mode is more applicable to the integrated processes of science.

5. Investigations should be made to compare the teaching effectiveness of those students who received preservice training with emphasis on processes of science and those who were in content oriented science education methods classes.

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TABLE I

COMPARISON OF TOTAL NUMBER OF SEMESTER HOURS OF BASIC SCIENCE AND MATHEMATICS COMPLETED BY THE PARTICIPANTS

Subject	Abstract Group	Applied Group	Total
Science			
Astronomy	0	4	4
Bacteriology	4	0	4
Biology	221	222	443
Botany	23	16	39
Chemistry	30	23	53
Geology	21	16	37
Physical Science	114	166	280
Physics	3	14	17
Zoology	13	4	17
Mathematics	257	234	491
Total	686	699	
Grand Total			1,385

TABLE II

THE ANALYSIS OF VARIANCE SOURCE TABLE FOR DIFFERENCE SCORES

Source	SS	df	MS	F	p
A (Method)	329.13	1	329.13	60.73	<.01
B (Classification)	5.80	1	5.80	1.07	n.s.
C (Interest)	468.23	2	234.12	43.20	<.01
AB	60.28	1	60.28	11.12	<.01
AC	112.28	2	56.14	10.36	<.01
BC	3.39	2	1.70	.31	n.s.
ABC	1.24	2	.62	.71	n.s.
W. cell	487.68	90	5.42		
Total	n.a.	101			

TABLE III

SUMMARY TABLE OF SIMPLE MAIN EFFECTS FOR INTERACTION OF METHOD AND CLASSIFICATION

Source	SS	df	MS	F	p
A at b_1 (Method with Juniors)	408.98	1	408.98	75.46	$<.01$
A at b_2 (Method with Seniors)	56.08	1	56.08	10.35	$<.01$
B at a_1 (Classification with Applied Method	23.74	1	23.74	4.38	$<.05$
B at a_2 (Classification with Abstract Method)	66.17	1	66.17	12.21	$<.01$
W. cell	487.68	90	5.42		

TABLE IV

SUMMARY TABLE OF SIMPLE MAIN EFFECTS FOR INTERACTION OF METHOD AND INTEREST

Source	SS	df	MS	F	p
A at c_1 (Method with Science Interest)	170.67	1	170.67	31.49	$<.01$
A at c_2 (Method with Language Arts Interest)	289.20	1	289.20	53.36	$<.01$
A at c_3 (Method with Social Studies Interest)	2.63	1	2.63	.49	n.s.
C at a_1 (Interest with Applied Method)	385.39	2	192.70	35.55	$<.01$
C at a_2 (Interest with Abstract Method)	200.25	2	100.13	18.47	$<.01$
W.cell	487.68	90	5.42		

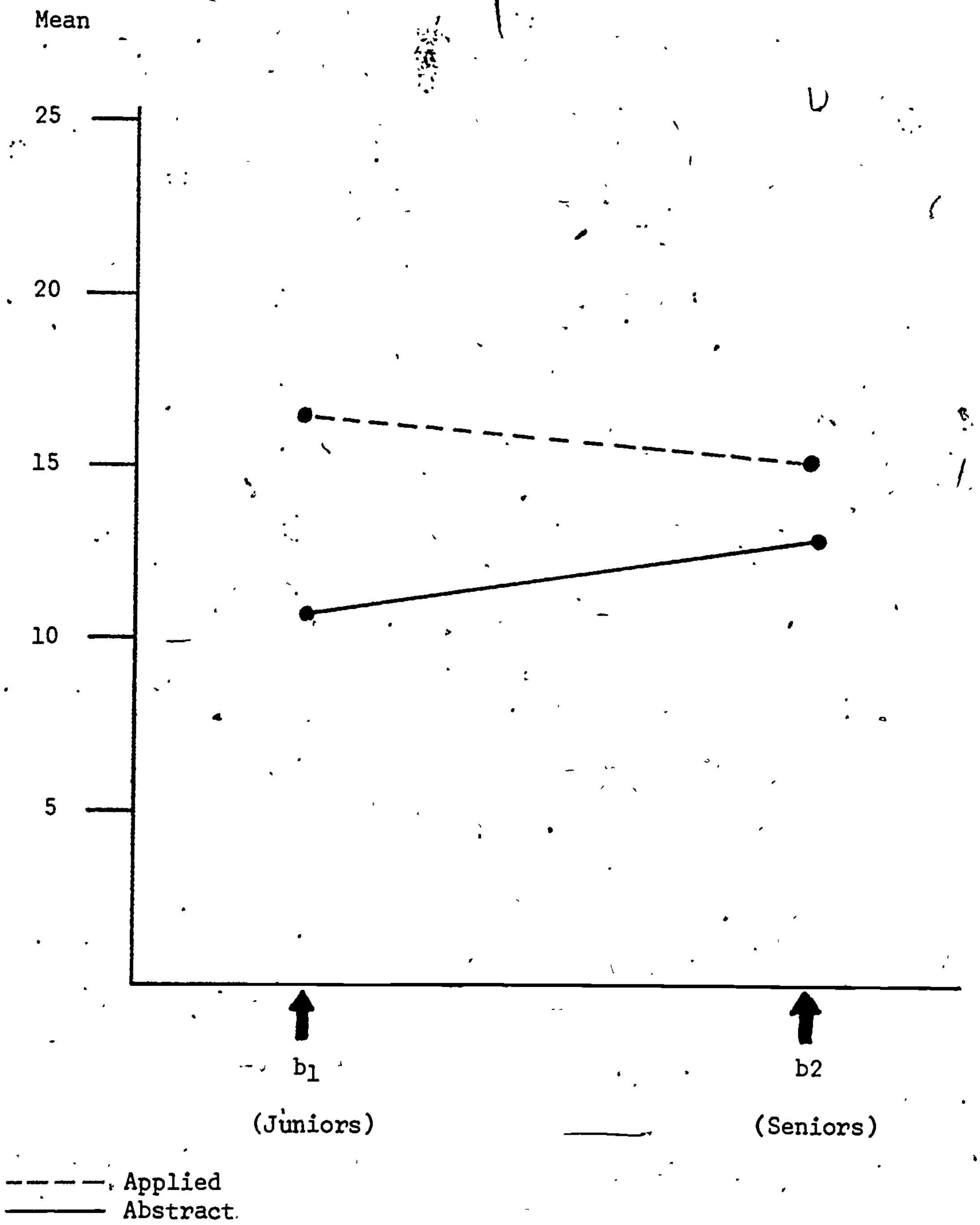

Figure 1

Means for Applied and Abstract Methods of Juniors and Seniors

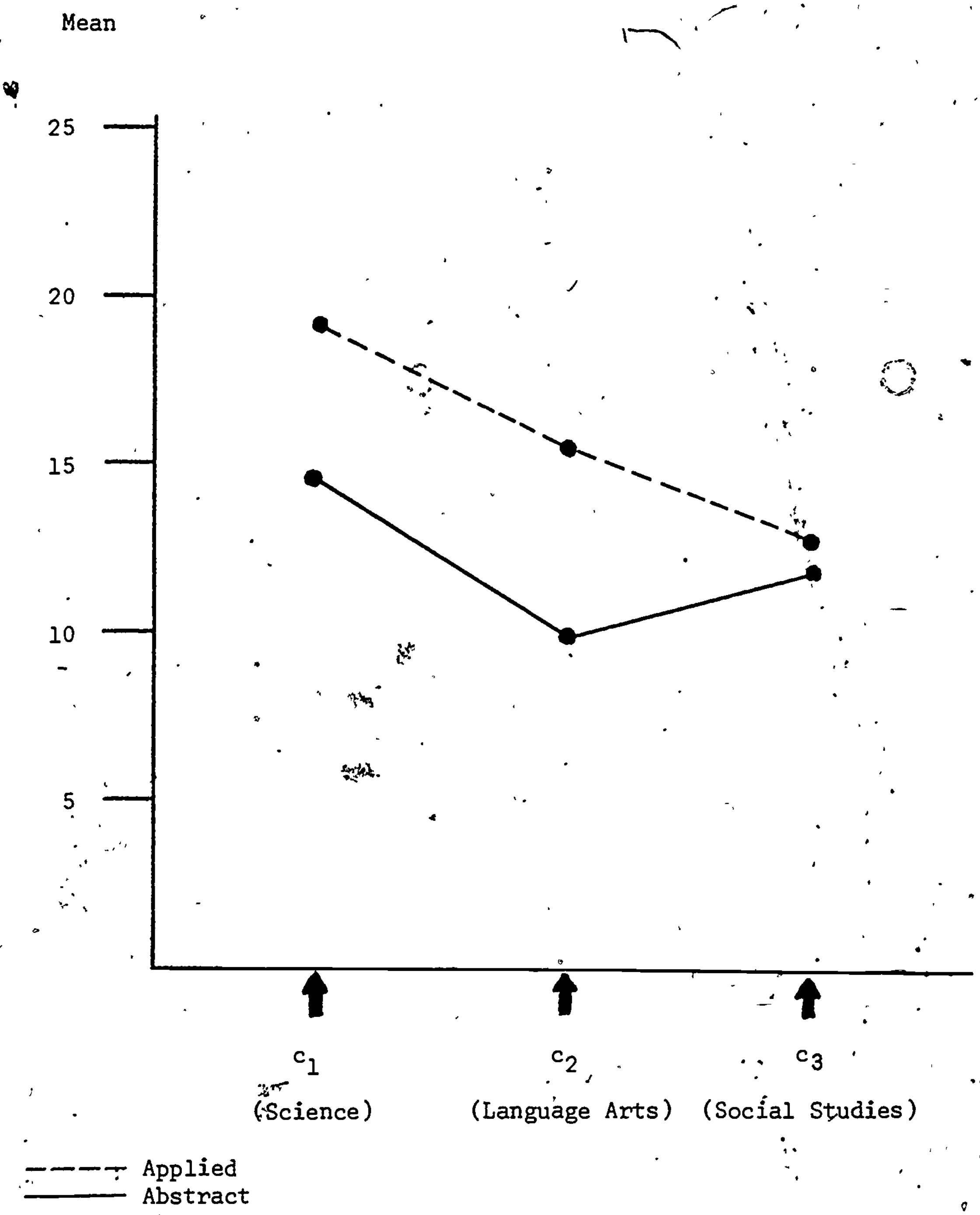

Figure 2

Means for Methods of Groups by Interest