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ABSTRACT

Reported is a study to examine relationships between academic and professional factors and the attainment of selected elementary school science teaching competencies. Competencies were measured but no attempt was made to equate the presence of the competencies with effective teaching. The assumption was made that these competencies are part of the larger domain of effective teaching. Data were obtained from a population of pre-service elementary teachers enrolled in an undergraduate course in elementary science education. Most had completed their science courses and many their teacher education courses. Data included material from student academic records, interviews, and use of Welch Science Process Inventory (Form D). Significant correlations were noted between laboratory skills, science process competencies and the understanding of science processes, with the university science grade averages; between set induction competency and the pre-service teacher's attitude toward science, and between the understanding of the science process and the college science grade average and attitude toward science. (EB)

A Study of the Relationship Between Various Academic and Professional Factors and Selected Elementary School Science Teaching Competencies.

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INTRODUCTION

With the advent of the major elementary science curriculum projects during the last decade, the improvement of the science education of the elementary teacher has been a considerable concern. Many advances have been made in an attempt to improve the science teaching effectiveness of the elementary teacher. The subject matter content of science courses has been integrated and related more closely to the needs and interests of the elementary teacher. (7,9) Several program have been developed which emphasize skill in the use of science processes and their application to elementary school science teaching. (6,8) Microteaching (2) has been widely used to provide elementary teachers with the opportunity to develop and practice specific teaching skills, e.g., asking higher order questions in a science lesson.

Many of these approaches are being integrated into comprehensive efforts to prepare elementary teachers in all three areas, i.e., the development of requisite psychomotor skills, e.g., the construction of microecosystems; the use of science process skills, and development of teaching skills that are particularly useful in science teaching. These efforts have been heightened in several states, e.g., Florida (3) by the institution of competency-based certification programs. The AAAS report on the Preservice Science Education of Elementary School Teachers added further support. It suggested that a research emphasis and priority should be assigned "to determine what competencies of the elementary teacher of science should be." (1, p.41)

The study reported is a pilot effort to examine a selected facets of a few of these competencies that seem to be useful in effective elementary school science teaching. No attempt is made to equate the presence of these competencies with effective teaching, but the assumption is made that these competencies are part of the larger domain of effective elementary school science teaching.

DESIGN OF THE STUDY

The objective of the study was to examine the relationship between various academic and professional factors and the attainment of selected elementary school science teaching competencies. The academic and professional factors included a number of factors commonly reported in the literature in studies and reports about the science education of the elementary teacher. The competencies were selected as being representative of the type required in elementary school science teaching. Another important consideration was that these particular competencies could be tested for within the normal operation of the elementary science methods course in which the study was conducted.

The science teaching competencies selected included the ability to: (1) focus a compound microscope, (2) distinguish observations from inferences (3) construct behavioral objectives, (4) apply Flander's Interaction Analysis, and (5) use set induction techniques. These competencies were selected as being representative of a larger domain of laboratory skills, science process usage abilities and teaching skills necessary for effective elementary school science teaching.

Competency in each of the science teaching skills was measured after the topic had been worked with in the science methods class. Minimal instruction was given prior to testing. The amount of this instruction varied from none in the use of the microscope skill to a basic training protocol in the use of the set induction skill. The performance level was specified at 100% accuracy for the construction of behavioral objectives and distinguishing observations from inferences. The ability to focus a compound microscope on high power within three minutes was used as a criterion for the microscope usage skill. Student performance on videotape and written materials was analyzed by the instructor for the set induction and interaction

analysis skills, respectively.

TABLE I

PERCENTAGE OF ATTAINMENT FOR EACH OF SELECTED ELEMENTARY SCIENCE TEACHER COMPETENCIES STUDIED (N-63)

SCIENCE TEACHING COMPETENCY	PERCENTAGE OF ATTAINMENT OF COMPETENCY
FOCUSING MICROSCOPE	60
DISTINGUISHING OBSERVATIONS FROM INFERENCES	59
CONSTRUCT BEHAVIORAL OBJECTIVES	75
FLANDERS INTERACTION ANALYSIS	75
USE SET INDUCTION TECHNIQUES	60

The academic and professional factors measured included: Education Course Grade Average, High School Science Units, University Science Grade Average, Over-all University Grade Average, Attitude toward Science, Degree of Participation in Science-Related Activities, Semester Hours of Life Science and Physical Science, Understanding of Science Processes and the Perceived Difficulty of Science Courses as compared with non-science courses.

The correlations were determined between the various academic and professional factors and the selected science teaching competencies by use of a multiple intercorrelation matrix. The significance of the correlation coefficients was determined for a two-tailed test at the five and one percent levels of significance. (4) A similar procedure was used to examine the intercorrelations among the factors. The intercorrelations among the five science teaching competencies were also studied.

SUBJECTS

The data was drawn from a population of pre-service elementary teachers enrolled in an undergraduate course in elementary science education. The subjects were primarily juniors or seniors. Most had completed their undergraduate science courses and substantive number of teacher education classes.

RESULTS

The mean scores and standard deviations for the academic characteristics of the population for preservice elementary school teachers are listed in Table II. The data for most of the characteristics was obtained from the students academic records. Their perceived difficulty of science courses as compared to non-science courses, attitude toward science and participation in science-related activities were collected by asking each preservice teacher to rate themselves in each of these three areas. The understanding of science processes was determined by use of the Welch Science Process Inventory (Form D).

The data suggests that the population has what might be termed an "average" background in science. While the science background is not exceptional, it seems to be representative of many preservice elementary science teachers. (10) Their perceived difficulty of science courses as compared to non-science courses indicated that they found the science courses among the most difficult in their undergraduate program. Their attitude toward science indicated a moderate interest in the field. The studies of Kane (5) and Wytiaz (12) support this finding. Participation in science related activities outside the normal undergraduate program was rated low by the preservice elementar science teachers. The Understanding of Science Processes indicated

a score in the same range of those reported for high school students enrolled in the newer physics curricula. (11)

TABLE II

MEAN SCORES FOR THE SELECTED ACADEMIC

CHARACTERISTICS OF THE PRE-SERVICE ELEMENTARY TEACHERS

ACADEMIC CHARACTERISTIC	MEAN SCORE	STANDARD DEVIATION
Education Course Grade Average	3.13	0.38
High School Science Units	2.73	0.33
High School Science Grade Average	2.75	0.77
Total College Science Hours	9.09	3.32
College Mathematics Grade Average	2.61	0.65
College Science Grade Average	2.41	0.70
Difficulty of Science Courses as compared to other courses(10 possible)	7.07	1.45
Overall College Grade Average	2.85	0.42
Attitude Toward Science (10 possible)	5.82	2.23
Participation in Science-related extra-curricular activities	3.04	1.86
Understanding of Science Processes	109.09	9.18

It is interesting to contrast these results with the data obtained from a group of science majors enrolled in the secondary science methods class. They also rated their science courses as more difficult than non-science courses, but they take almost a chauvinistic pride in this situation. They indicated a highly positive attitude toward science ($\bar{X}$=8.2) and reported an active participation in science-related activities ($\bar{X}$=7.5). They reported participation in environmental activitist groups, nature photography, and hiking and camping activities. The reasons for this sharp contrast between prospective elementary and secondary teachers in these affective areas could be a subject for further study.

The correlation matrix for the selected academic and professional characteristics of the elementary teacher is indicated in Table III. The significant correlations indicate a pattern of the science education for this population of elementary teachers. While this pattern is not entirely clear or unidirectional, it does suggest two prominent trends. First, the college science grade average correlates significantly with a number of factors including high school science grade average, college mathematics grade average, attitude toward science and understanding of science processes. There may be clues in these relationships for individuals who prepare college science courses for the elementary teacher. Second, a positive attitude toward science correlated with an understanding of science processes and to a somewhat lesser degree with the overall College Grade Average and the College Science Grade Average. This finding seems to support a strong link between the cognitive and affective domains.

Participation in science-related activities was also positively related to attitude toward science, but the correlation was not highly significant. One implication is that many other personal and

TABLE III

CORRELATION MATRIX FOR THE SELECTED ACADEMIC CHARACTERISTICS OF PRE-SERVICE ELEMENTARY TEACHERS (N63)

	2	3	4	5	6	7	8	9	10	11
1	0.085	0.117	-0.043	0.275*	0.242	0.069	0.367**	0.055	-0.139	0.273
2		0.027	0.159	0.027	0.182	-0.35	0.073	-0.056	-0.044	0.149
3			0.013	0.269*	0.503*	0.224	0.261*	0.194	-0.195	0.362**
4				-0.187	0.072	0.212	-0.023	-0.004	-0.003	-0.001
5					0.336*	0.090	0.299	0.175	-0.061	0.448**
6						-0.186	0.532**	0.290*	0.090	0.472**
7							-0.056	-0.108	-0.266*	0.061
8								0.330	-0.018	0.553**
9									0.265*	0.364**
10										0.038

* Significant at the .05 level
** Significant at the .01 level

KEY:
1. Education Course Grade Average
2. High School Science Units
3. High School Science Grade Average
4. Total College Science Hours
5. College Mathematics Grade Average
6. College Science Grade Average
7. Difficulty of Science Courses as compared to other courses (10 possible)
8. Overall College Grade Average
9. Attitude Toward Science (10 possible)
10. Participation in Science-Related Extra-Curricular Activities
11. Understanding of Science Processes

social factors may interact in this process. Participation in science related activities was negatively correlated with the perceived difficulty of science courses. This result may indicate that non-academic factors or specialized interests may override a generalized difficulty with science courses. In any case, this particular population of elementary science teachers indicated a low level of participation in science-related activities.

A prime factor that suggests a definite direction in elementary science education is that of understanding of science processes. The analysis suggests that this factor interacts with many other professional and academic factors in the science education of the elementary teacher. The understanding of science processes as measured by the SPI correlates significantly with: high school grade average, college mathematics and science grade average, and attitude toward science. This finding suggested a renewed effort for the emphasis on thorough understanding and ability to use science processes in the preparation of elementary teachers for science teaching.

Table IV depicts the relationships between selected academic characteristics of the preservice elementary teacher and specific science teaching competencies. It is difficult to discern the exact relationship of a given factor to the acquisition of a specific competency. But, correlations suggest some factors that may contribute or retard the development of particular competencies.

The laboratory skill, focusing a compound microscope under high power, correlated with the high school science grade average, college mathematics, science grade, average and overall college grade average. A further analysis also indicated a higher positive correlation with the amount of life science courses taken. A review of the many other laboratory skills required in elementary school teaching would be

TABLE IV

CORRELATION COEFFECIENTS BETWEEN THE ACADEMIC CHARACTERISTICS OF THE PRE-SERVICE ELEMENTARY TEACHERS AND SELECTED ELEMENTARY SCHOOL SCIENCE TEACHING COMPETENCIES

ACADEMIC CHARACTERISTICS	SELECTED ELEMENTARY SCHOOL SCIENCE TEACHING COMPETENCIES				
	FOCUS MICROSCOPE	DISTINGUISH INFERENCES	CONSTRUCT BEHAVIORAL OBJECTIVES	APPLY FLANDERS INTERACTION ANALYSIS	USE SET INDUCTION
EDUCATION COURSE GRADE AVERAGE	0.015	0.322*	0.317*	0.341*	0.269**
HIGH SCHOOL SCIENCE UNITS	0.159	0.146	0.095	0.073	0.095
HIGH SCHOOL SCIENCE GRADE AVERAGE	0.304*	0.458**	0.064	0.282	0.012
TOTAL COLLEGE SCIENCE HOURS	0.023	-0.151	-0.137	-0.093	-0.045
COLLEGE MATH GRADE AVERAGE	0.330**	0.358**	-0.200	0.230	0.144
COLLEGE SCIENCE GRADE AVERAGE	0.528**	0.579	0.099	0.243	0.173
DIFFICULTY OF SCIENCE COURSES	-0.045	0.046	0.057	-0.119	0.000
COLLEGE OVERALL GRADE AVERAGE	0.409**	0.602**	0.001	0.336**	0.206
ATTITUDE TOWARD SCIENCE	0.256*	0.237	0.020	0.215	0.357**
PARTICIPATION IN SCIENCE-RELATED ACTIVITIES	0.056	-0.117	0.132	-0.024	0.108

*significant at the .05 level
**significant at the .01 level

useful to determine if a similar pattern occurs in their acquisition.

The ability to distinguish observations from inferences is also positively correlated with the same variables listed above and also with the Education Course Grade Average. This intellectual process involves the use of an information processing component. This component may interact with an understanding of the science process skill. This consideration may account, in part, for the relationship between a number of general academic factors and the acquisition of this process skill.

The construction of behavioral objectives is specific to the teacher education classes. Therefore, it is expected that skill in its usage might correlate well with the Education Course Grade Average. It also may make considerable use of higher order cognitive functions. It is surprising, therefore, not to find a significant correlation with several general academic factors. A possible reason for this finding is that most of the behavioral objectives constructed were of a lower order type.

The teaching skill of the use of set induction correlated positively with the education course grade average and highly significant with the student's attitude toward science. This finding is particularly interesting. It may suggest pre-service teachers that have a positive attitude toward science are most effective in the development and use of set induction for science activities. This relationship is a useful area for further study. It has broad implications for the improvement of science teaching.

Table V summarizes the correlation between the selected elementary school science teaching competencies and the understanding of science processes. The understanding of science processes is significantly related to competencies in the laboratory skill,

TABLE V

CORRELATION MATRIX FOR SELECTED ELEMENTARY SCHOOL SCIENCE TEACHING COMPETENCIES AND THE UNDERSTANDING OF SCIENCE PROCESSES

	2	3	4	5	6
1	0.440**	0.620**	0.141	0.614**	0.114
2		0.374	0.123	0.347**	0.138
3			0.029	0.400**	0.045
4				0.246	0.272*
5					0.198

* significant at the .05 level

** significant at the .01 level

KEY:
1. Understanding Science Processes
2. Focus Microscope
3. Distinguish observation from inference
4. Construct behavioral objectives
5. Apply Flanders Interaction Analysis
6. Use set induction skills

science process skill and the application of Flanders Interaction Analysis. This situation may be explained, in part, by a concurrent ability in the use of higher cognitive processes, e.g., analysis and synthesis. It also may suggest a parallel development of only partially-related teaching competencies.

The significant correlation between the laboratory skill, science process usage and application of the Flanders' analysis reinforce this relationship. Conversely the other two teaching skills which seem to have a much less of a higher order cognitive ability component indicate a non-significant correlation with these three competencies. The interaction of cognitive ability, science education courses and related experience may contribute to the present level of development of these competencies in this population of preservice elementary teachers.

CONCLUSIONS

In summary, the analysis of the study suggests the following conclusions: (1) significant correlations between the laboratory skill, science process competencies and the understanding of science processes and university science grade average; (2) a significant intercorrelation between the science skill and science process usage and between these abilities and interaction analysis competency, however, the correlations of science laboratory skill and process usage with the other teaching skills were non-significant. (3) a significant correlation between set induction competency and the preservice teacher's attitude toward science; the correlations with other science-related factors were non-significant; (4) a significant correlation between the understanding of science processes and college science grade average and attitude toward science.

This study considers only in general terms the relationship between many academic and professional factors that may add to the

development of selected elementary science teaching competencies. These competencies were selected to be reflective of the larger domain of elementary science teaching rather only a single aspect, e.g., science process usage. The analysis was, therefore, limited to a generalized review of the data.

The findings of this limited pilot study may aid in the clarification of the role of some of the academic and professional factors that contribute to the development of selected elementary school science teaching competencies. This study may also be useful to science educators planning competency-based elementary science education programs for pre-service and in-service teachers. It should also generate a number of interesting research questions that will form a basis for other studies of the nature of the acquisition of basic elementary school science teaching competencies.

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