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School Learning Materials on Water Problems of New Mexico and the Southwest

**Technical Completion Report
Project No. A-031-NMEX**

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SCHOOL LEARNING MATERIALS ON WATER PROBLEMS
OF NEW MEXICO AND THE SOUTHWEST

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TECHNICAL COMPLETION REPORT

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ABSTRACT

The product of this study is a set of mediated learning packages based upon water problems of New Mexico and the dry regions of the Southwest. The learning materials were prepared and field tested for use at three levels: Elementary (grades 3-6), Secondary (grades 7-12), and Adult (teachers and mature students). Each learning package is composed of a set of color slides, an accompanying tape recording, a copy of the tape script, and suggestions for educational use.

The learning packages were based upon the results of school testing of both knowledge and attitudes concerning the most important water problems of New Mexico, as identified by the Citizens' Conference on Water, 1971. Learning gains and positive involvement of learners resulted from the utilization of the learning packages.

The New Mexico Water Resources Research Institute is the principal distributor of the learning materials produced.

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CHAPTER I

WATER PROBLEMS AND SCHOOL PROBLEMS

The future public support of constructive changes in water use policies will be based in part upon a general public awareness of water problems and some possible solutions to those problems. Pupils and teachers of New Mexico and Southwestern schools can become change agents when they have the opportunity to learn facts, principles, and appropriate attitudes toward water use and management.

At present, schools typically make no special efforts to prepare students to cope with present and anticipated water problems. Environmental learning materials that are used in schools tend to be general in nature and geared toward use in populous and industrially based regions. Water problems that are emphasized in school materials emphasize the evils of industrial pollution. Little appears to be available that can specifically influence young people toward the development of appropriate overall attitudes and knowledge of water problems of the relatively dry regions.

Except for efforts by a few conscientious teachers, the school curriculum lacks an organized or updated water emphasis. A gap exists between technical knowledge banks and pupil learning. Few schools have teachers who understand water problems sufficiently to develop their efforts. Since schools tend to change slowly, it is anticipated that future pupils will leave school with little knowledge of water problems and solutions unless outside agencies bring tested and easily adapted curriculum ideas and materials to the schools.

Principal Water Problems of New Mexico

In order to answer the question "What are the principal water problems of New Mexico?", the results of a recent State meeting were utilized. On May 24 and 25, 1971, sixteen elected area delegates representing

varied interests in water met with five county extension agents and members of the New Mexico Water Resources Research Institute Advisory Committee. The results of this meeting on water problems were selected as the most appropriate basis for school learning materials.

Delegates presented reports of prior meetings held in their home areas. After the presentations, participants were asked to rank the ten most important water problems. Results were summarized and produced the following overall statewide rankings.

THE STATE'S TEN MOST IMPORTANT WATER PROBLEMS

1. Declining ground-water table and diminishing surface water supply.
2. Need for improved irrigation systems and water-use management in irrigated agriculture.
3. Water pollution.
4. Need for knowledge of present and future supplies and demands of water.
5. Shortage of water for industrial, recreational, and municipal uses.
6. Adjudication of water rights.
7. Improvement of water laws.
8. Salinity of water and its effect on human and plant life.
9. Reuse of water, where practical, by recycling.
10. Land and water planning and zoning.

Additional water problems suggested by current literature in the field and by the technical advisor to the project were included.

CHAPTER II

BASES FOR DEVELOPING LEARNING MATERIALS

Early in the 1971-1972 school year, three "average" classroom groups of rural and urban pupils in grades four, six, and eight were tested by oral and written methods in the Deming and Las Cruces, New Mexico, schools and in the experimental classroom operated by the Teacher Corps at New Mexico State University. The purpose of the initial testing was to determine a general level of environmental awareness and literacy associated with water problems and related fields. Information gained became useful in the later writing and development of the learning materials.

Environmental Literacy

Half or more of the fourth grade students indicated that they had never heard of such terms as "recycle," "biodegradable," and "water rights." Neither sixth nor eighth graders indicated an awareness of "biodegradable," or "aeration." In addition, half or more of each group indicated a lack of knowledge of the meaning of "technology." A complete list of the unfamiliar environmental terms, most of which are related to water, is given in Table 1.

Environmental Concepts

The same pilot group of students who were examined for environmental literacy were also given a multiple choice test over environmental concepts. Each test was read aloud and discussed in order to reduce vocabulary problems. The results of the test indicated that each of the following misconceptions about water was held by 40% to 100% of the 79 students tested.

1. Rainmaking is usually accomplished by rain dances.
2. Homes and factories use most water in New Mexico.
3. Hogs pollute water more than people do.
4. The President or the Governor (as opposed to the individual) is the key person in stopping pollution.

TABLE I

ENVIRONMENTAL TERMS--NEVER HEARD OF OR MEANING NOT KNOWN BY 50%
OR MORE OF PUPILS*

	Deming Grade Four N=26	Teacher Corps Grade Six N=27	Las Cruces Grade Eight N=26
Additives	†	†	
Aeration	x	x	x
Algae	†		
Audubon	x	x	x
Biodegradable	x	x	x
Biosphere	x	x	
Cloud Seeding		x	
Conservation		†	
Decibel	†	x	
DDT		†	
Ecology		†	
Effluent		x	†
Emission	x	x	
Environment	x		
Fossil Fuel	x	x	
Hydrocarbons	x		x
Incinerator	x	x	
Legal	†		
Nuclear Energy	x	†	
Organic	x	†	
Organism	†	†	
Overpopulation	†		
Particulate	x	†	†
Phosphate		x	
Pollution	x		
Raw Sewage	x	†	
Reclamation	x	x	†
Recycle	x		
Refuse	x	†	
Reservoir	†		
Rural	x	x	
Scrubbers			x
Sonic Boom	†		
Standard	†	†	
Strip Mine		x	
Sulfur Dioxide	x		†
Technology	†	†	†
Thermal	x		†
Toxic	x		
Water Rights	x	†	
Total No. of Terms	40	40	40
Terms Never Heard of	22	14	5
Meaning Not Known	10	13	6

* Never Heard of Term = x
Meaning Not Known = †

5. Ecology means the same as "environment."
6. Waterfalls and rivers are more important than fuels in producing electrical energy for use in the Southwest.
7. To kill a single weed, it is best to poison it.
8. Poor soil rather than lack of water is the main deterrent to New Mexico growth.
9. To water a lawn in the desert, it is better to spray the lawn a little each day rather than soak the lawn each week.
10. Water that runs down the Rio Grande comes mainly from rain in Texas or Arizona.

Of the above, the most consistent misconception was an overfaith shared by all three groups of students tested, in hydroelectric energy generation. When asked why they thought as they did, students were often quick to locate rivers marked in blue upon maps and to associate these rivers with pictures of hydroelectric generating plants in texts and encyclopedias.

Attitudes and Feelings about Water

As an additional basis for developing learning materials about water problems, three groups, distinctly different from those in the initial testing phase on literacy and concepts, were given an attitude test over terms describing water.

Twenty-one terms were utilized in a semantic differential test. The test was prepared in both English and Spanish in an effort to enhance its regional validity. Each participant was asked to react to each water term, marking five continuums for each term. Results were indicative of feelings and attitudes about water concepts.

The three groups included 24 "average" fourth graders, 22 "above average" ninth graders, and 20 adult teachers. As was found with later testing, results with teachers were essentially similar to those of the ninth graders. A summary of the results of the attitude scales with the selected fourth and ninth grade students in the second phase of pilot testing is given in Figures I and II.

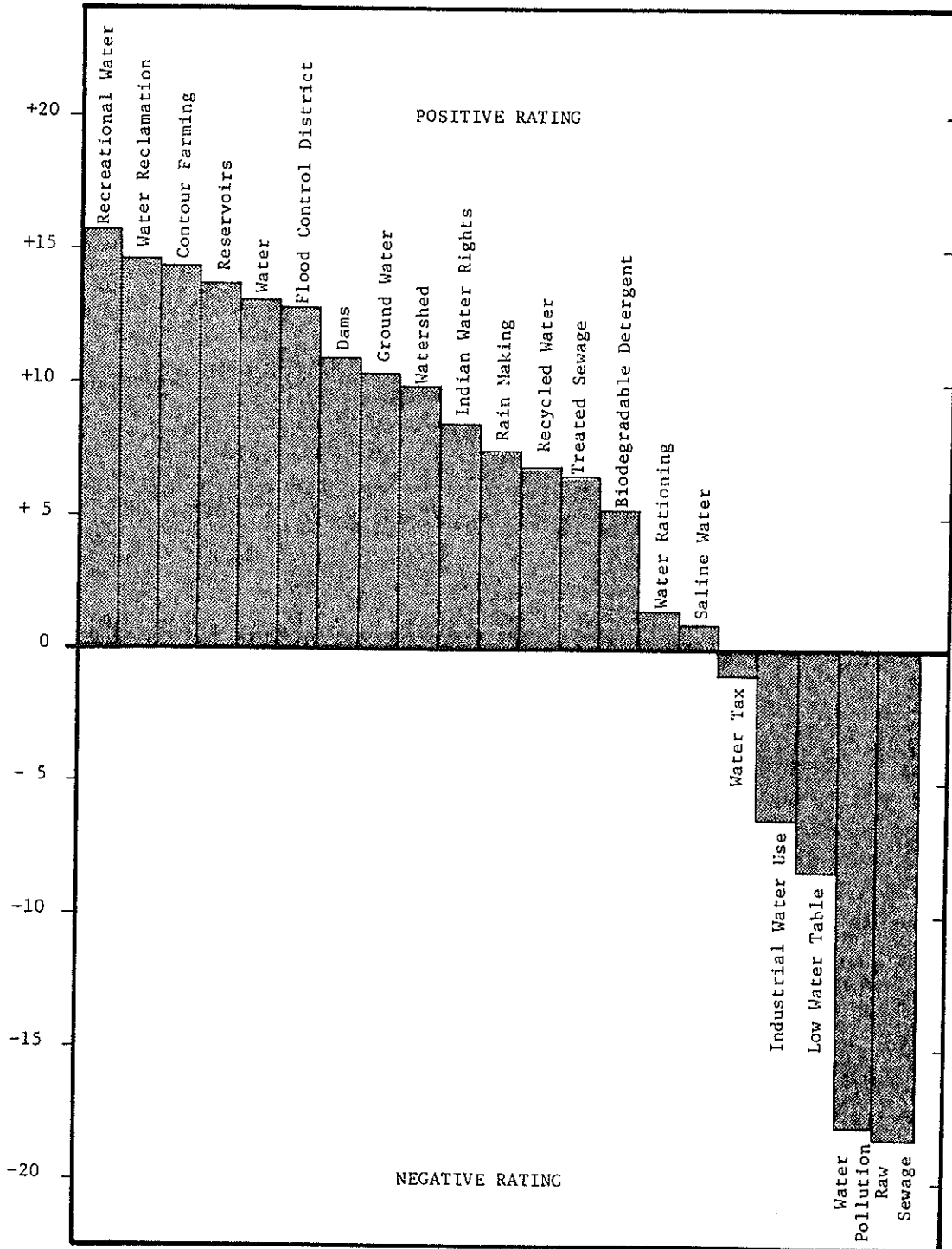


FIGURE 1
 RELATIVE SEMANTIC DIFFERENTIAL RATINGS OF WATER RELATED WORDS
 BY NINTH GRADERS IN SOUTH CENTRAL NEW MEXICO (N=22)

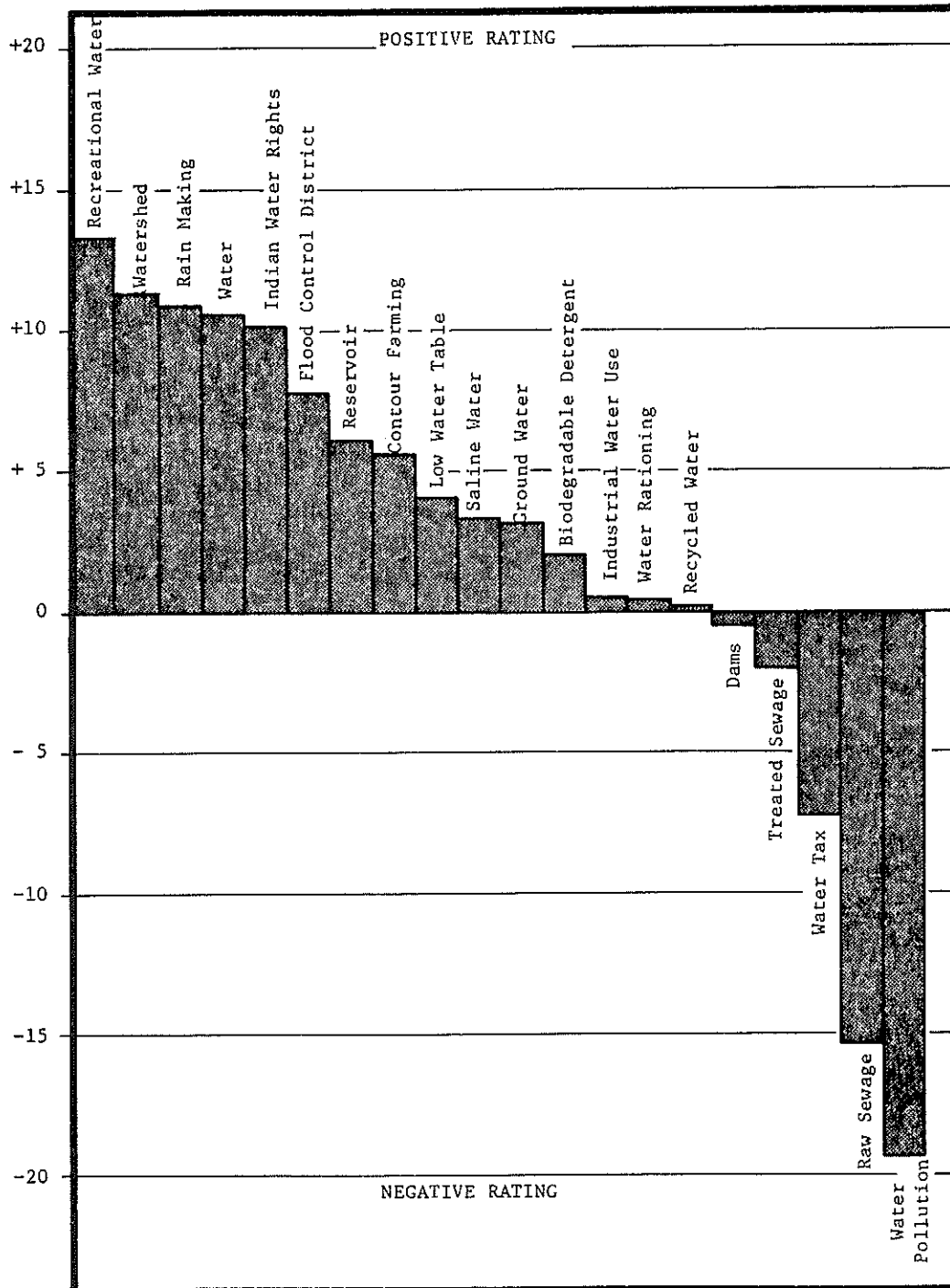


FIGURE 2

RELATIVE SEMANTIC DIFFERENTIAL RATINGS OF WATER RELATED WORDS
 BY FOURTH GRADERS IN SOUTH CENTRAL NEW MEXICO (N=24)

The semantic differential scale used was developed for this study. The words were selected by educators through a process of reviewing the portions that deal with water of all general science texts on the New Mexico approved textbook list. From this list of approximately 50 terms, 21 terms considered most appropriate for general public awareness were selected with the assistance of water researchers.

Each word was rated on a five-place scale for each of five pairs of bipolar adjectives. An exponential rating was applied, with zero as the center of the scale. For each bipolar pair, ratings of +4, +1, 0, -1, and -4 were possible. A summation of the five pairs for each word-rating could range from +20, most positive, to -20, most negative.

Comparison of Results on Semantic Differential Scales

In the relative ranking of the terms by both fourth and ninth graders, "recreational water" was rated the most positive, while "water pollution" and "raw sewage" were the words rated most negative. A discussion with those who rated the words revealed that a few of them had interpreted "saline water" as "water for sailing on." Others recalled pleasant seaside visits. As a result of this misunderstanding, "saline water" received a slightly positive rating.

The similarity of the affective responses or feelings of the fourth and ninth graders toward water related words and concepts was measured using Kendall's coefficient of rank order correlation (Tau). The correlation coefficient between the responses of fourth and ninth graders was 0.465, showing a statistical significance ($P = 0.04$).

The implications of the semantic differential indicate the need for wider dissemination of water and environmental facts. Because of the current relative development of the technologies, "recycled water" would be expected to have a higher positive value than "rainmaking": such was not the case with either group. The fourth graders gave "recycled water" a negative rating. Both groups rated "saline water" positively. Their ratings, similar to those of a small group of teachers tested, may reflect those of the electorate in general. This small sample gives little encouragement to those who would pass bond issues for the reduction of water salinity at some future date. The results with the semantic differential scale underscore the need for non-technical communication about water problems.

CHAPTER III
RESEARCH DESIGN AND PROCEDURES

In order to produce and field test school learning materials about water problems of New Mexico and the Southwest, a sequential procedure and research design was used.

Sequential Steps

1. Through a search of printed materials on water problems available through the New Mexico Water Resources Research Institute and Government agencies, and with the assistance of qualified water experts, a hierarchy of key water problems of the region was established. An emphasis was placed upon the causes of and possible solutions to water problems.
2. A search of Educational Resources Information Centers, State Departments of Education, and Educational Products Information Exchange was made to determine the present availability of useful educational materials on water problems.
3. Based upon 1 and 2 above, a test was developed to determine in part the present state of students' knowledge about the identified key water concepts.
4. Based upon 1, 2, and 3, a test of feelings and attitudes about water problems was developed. The test utilized a semantic differential scale written in both English and Spanish in order to have regional cultural validity.
5. Both instruments described above were administered to pilot groups of students in grades 4 through 9 who were judged by their teachers to be representative of their South-Central New Mexico communities (N = 125). Some teachers were also tested (N = 20).

6. Pilot-test results were analyzed, and a "final" test in English and Spanish of water problems and concepts was developed with the assistance of a linguist and the technical advisor to the project.
7. Learning packages for use at three levels were developed by writing teams per an analysis of apparent needs. Target groups of Grade 4, Grade 9, and Adult (teachers) were chosen. Each learning package included 149 to 225 color 2" x 2" slides based principally upon New Mexico scenes illustrating water problems and supplemented by sketches and cartoons; a professional tape recording; a script copy; and a set of instructions for educational use. Script writers, principally teachers from the Las Cruces schools, used reference copies of 72 facts and principles about water that had been summarized from the literature, and were asked to emphasize the ten key water problem areas noted elsewhere in this report.
8. After extensive revisions of technical accuracy, language level, and student reaction, the prototype learning packages were tested in educational settings comparable to those in which the materials are expected to have general use.
9. A statistical analysis of test results from learners who had or had not utilized the learning packages was completed. Table II is the data matrix used where applicable in the field testing.
10. Each of the three prototype learning packages was revised into a final form for duplication and publication, based upon field results, technical corrections, and updating.
11. Copies of the learning package are being made available for school use through the New Mexico Water Resources Research Institute. The elementary level learning package is being evaluated for its commercial value by two publishing firms.

TABLE II

DATA MATRIX FOR EVALUATION OF MATERIALS*

	Elementary School	Secondary School	Adult Teachers
Group 1			
<u>Experimental</u>		(Low Science Achievers)	
Use of Learning Package on Water	44 subjects	28 subjects	18 subjects
Group 2		(Middle Science Achievers)	
<u>Limited</u>			
Use of Library Materials on Water	38 subjects	26 subjects	19 subjects
Group 3		(High Science Achievers)	
<u>Control</u>			
No Planned Treatment	41 subjects	28 subjects	18 subjects

*Random assignment used except where noted.

CHAPTER IV
RESULTS, SUMMARY AND RECOMMENDATIONS

The learning packages developed in this project were used by three different levels: Elementary, Secondary, and Adult. Results of their use were evaluated two different ways.

- (1) An objective pencil-test with 57 true-false and four-option multiple choice questions yielded comparative data on water concept knowledge.
- (2) Open-ended essay questions allowed the responses of those tested to be compared with the more definitive statements of water problems noted by lay citizens and by experts in the field.

Objective Test Results

For all groups, the mean scores for those who used the learning packages were highest on the objective test of knowledge of water problems; however, there was no statistical significance in the difference between sets of scores. The group closest to statistical significance was the elementary learning package group where the probability indicated by a one-tailed t-test was 0.15 that the group's scores were distinctly different from the scores of other elementary groups. Mean values of scores, standard deviations, and the numbers in each group are presented in Table III.

It should be noted that, because of facilities constraints, secondary students could not be assigned random treatment within classrooms in the manner used with the elementary and adult groups. Instead, the students with the highest average science grades (2.00) were placed in the control (no treatment) group, the middle group (GPA = 1.88) had the limited (reading) treatment, and the group with the lowest average science grades (1.66) was given the prepared learning package on water problems. Therefore, while the secondary groups were biased, they were biased against the

TABLE III

RESULTS OF WATER CONCEPT OBJECTIVE TEST AS A FUNCTION
OF GRADE LEVEL AND TREATMENT

	<u>Experimental</u> Used Learning Package	<u>Limited</u> Used Library Materials	<u>Control</u> No Planned Treatment
ELEMENTARY			
Mean	51.36	45.75	45.61
S.D.	10.22	11.09	13.40
N	44	38	41
SECONDARY			
Mean	60.65	59.72	56.55
S.D.	12.03	11.00	16.90
N	28	26	28
ADULT			
Mean	72.32	68.88	70.96
S.D.	8.02	8.27	9.71
N	18	19	18

Although some possible curricular significance can be inferred from the above consistency of higher scores associated with the use of the learning packages, no evidence exists that the learning packages increased cognitive knowledge of water problems to a statistically significant level.

success of the learning packages. Despite that, the highest marks on both the objective and essay examinations were achieved by pupils who used the learning package.

When given the opportunity to choose tests written in English or Spanish, over 95% of the students chose the English version. Apparently, school success associated with English language development weighed as a selective factor in the samples of students chosen for this study.

Essay Test Results

The second portion of the test had three parts. Learners were asked to state three or more water problems of New Mexico and the Southwest, what to do about each problem, and who should do it. Answers to the first part were categorizable for all groups. However, the answers to "what to do" and "who should do it" were too general to be meaningful for any group, including the adult teachers. Typical answers to "what to do" and "who should do it" included the following pairs of remarks from the adult teachers:

<u>"What to do"</u>	<u>"Who to do it"</u>
Pitch in and help	All of us
Dig more wells	Federal Government
Provide measures for water clean-up and for prevention of future pollution	Quality industry (sic) with State and Federal Government guidelines
Alert citizens of the State to the problem and educate same on methods of water conservation in the home	Educational agencies, news media
Encourage a needed amount only to all citizens	The Government along with the people of the town
Reduce sewers	Everyone
Lose (sic) of water due to uncare of forests--better forest management	Everyone

The responses of the elementary and secondary school children regarding "what to do" were even more general.

A tabulation of the essay responses appears in Table IV.

As indicated in Table IV, the control group of elementary students listed 1.85 problems per child, with a 33% categorical agreement with citizen-experts in the referral group. Elementary pupils who read about water in traditionally available library materials produced 1.74 problems per child, with a 36% agreement with experts by categories. Elementary pupils who used the learning package produced 1.65 problems per child with an agreement of 59% in the referral group.

Secondary students in the control group gave the least number of problems, 1.36 per student, and had the lowest agreement at their level with the citizen-experts, 68.4%. Those who used library materials listed more problems, 1.88 per student, and had a higher percentage agreement with the referral group, 77.5%. Those who used the learning package listed the greatest number of problems per student, 2.11, and had the highest agreement with the experts regarding serious water problems, 78.1%.

Of the problems listed by adult learners, the control group has 84% of its responses in the same categories as the citizen-experts, readers of library materials had 82% of their responses in those categories, and those adults who used the learning packages listed 96% of their water problems in the ten categories judged most serious by the referral group of experts.

The results show that the learning packages for both adults and children helped to focus the learners' attention upon the serious water problems in New Mexico. For the secondary students, both reading about water problems and using the learning packages resulted in almost the same 10% increase in agreement with legitimate water problems over that of the control group. Again, it should be stressed that while the secondary groups were biased, they were biased against the success of the learning package. In view of this, the results were most encouraging.

TABLE IV
 A COMPARISON WITH CITIZEN-EXPERTS' LISTING OF THE TEN MOST CRITICAL
 WATER PROBLEMS OF NEW MEXICO AND THE FREQUENCY OF THOSE PROBLEMS
 LISTED BY LEARNERS AS A FUNCTION OF LEVEL AND EXPERIMENTAL TREATMENT GROUP
 (Group 1 = experimental, used learning package; Group 2 = limited; Group 3 = control)

PROBLEMS AS RANKED BY EXPERTS	ELEMENTARY (N=123) Group			SECONDARY (N=82) Group			ADULT (N=55) Group		
	<u>1</u>	<u>2</u>	<u>3</u>	<u>1</u>	<u>2</u>	<u>3</u>	<u>1</u>	<u>2</u>	<u>3</u>
1. Declining water supply, ground & surface.	3	4	5	4	3	5	7	5	1
2. Need to improve irrigation.	11	6	3	4	5	0	5	3	2
3. Water Pollution.	23	13	16	20	21	12	16	17	12
4. Need to know present and future supply-demand of water.	0	0	0	0	0	0	1	0	1
5. Industrial, recreational, & municipal water shortage.	1	0	0	14	9	9	6	8	7
6. Adjudication of water rights.	0	0	0	0	0	0	0	0	0
7. Improvement of water laws.	0	0	0	1	0	0	1	1	3
8. Water salinity effect on human & plant life.	2	1	1	0	0	0	4	1	0
9. Reuse of water by recycling.	1	0	0	3	0	0	3	2	4
10. Land & water planning and zoning.	2	0	0	0	0	0	1	0	0
Other Problems Listed by Learners:									
Air pollution	6	1	2	1	0	0	0	0	0
Detergents	1	1	2	0	0	0	0	0	0
Drought	4	5	4	0	1	1	0	0	0
Mercury poison	0	4	5	1	0	0	0	1	0
Pollution (general)	6	9	13	0	0	1	0	1	1
Trash	6	12	13	1	2	2	1	0	0
Other or Not Categorizable	7	11	12	10	8	8	1	6	8
TOTALS.. .. .	75	67	76	59	49	38	46	45	29

Summary of Results

Groups of learners using the learning packages on water problems of New Mexico and the Southwest at all three levels of elementary, secondary, and adult, showed a more accurate reflection of valid water problems than did those learners who used available library materials or no special learning materials. However, no group, including teachers, could give accurate information on solutions to water problems or on the appropriate solvers of water problems.

All three groups using learning packages scored higher on objective tests over factual water concepts than did other groups, though not at a statistically significant level.

Recommendations

It is apparent that many New Mexico students and teachers have little understanding of water problems and their solutions. The wide use of the learning packages produced in this project can introduce them to the most serious problems of New Mexico and the Southwest, and may serve as a beginning for further examination of possible solutions to these problems.

In the judgment of the investigators, the learning packages produced in this project are most useful under the following circumstances:

1. Elementary (Grades 3 through 6) Bernard Beaver and Wendell Waterdrop, the cartoon narrators of the 22-minute tape and script appeal to young students. Use whole in two or three parts.
2. Secondary (Grades 7 through 12) A section of tape recording made by junior high school students who discuss their solutions to water problems is included. This package should be used in three parts over a three-day school span for best results.
3. Adult (Teachers and others) Although designed and tested principally with teachers, this extensive learning package

should be effective with mature secondary students. For example, it is likely that high school biology students will be able to learn readily from this straight-forward, high-content learning package that is designed for use within as little time as half an hour.

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