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ABSTRACT

Collaborative "research partnerships" between university researchers and classroom science teachers have been encouraged by recent efforts of both the National Association for Research in Science Teaching (NARST) and the National Science Teachers Association (NSTA). Key teachers in the Search for Excellence in Science Education (SESE) Exemplary Middle/Junior High Programs examined their students in three domains of science education: knowledge; attitudes; and applications/connections, using the Iowa Test of Basic Skills and National Assessment of Educational Progress (NAEP) items. Results indicate that for exemplary middle/junior high science programs: (1) teachers are highly experienced (average 18.5 years teaching); (2) students score far above the national norms on a standardized test of science knowledge (87% percentile rank); (3) students have strong positive attitudes toward science in most areas (science is the first or second favorite course for 48% compared to 29% for students generally); (4) students generally do not perform higher in the applications domain than students in general; and (5) boys show slightly higher scores than girls in most areas. (Author/TW)

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Symposium

SCIENCE TEACHERS AS RESEARCHERS: COLLABORATIVE ENDEAVORS DESIGNED TO IMPROVE SCIENCE TEACHING THROUGH RESEARCH

Student Outcomes and Teacher Characteristics in Exemplary Middle and Junior High Science Programs

A "Research Partnership" Research Project of
The University of Iowa and The National Science Teachers Association

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ABSTRACT

Collaborative "research partnerships" between university researchers and classroom science teachers have been encouraged by recent efforts of both the National Association for Research in Science Teaching (NARST) and the National Science Teachers Association (NSTA). The Middle and Junior High Division of NSTA and the University of Iowa recently carried out a research partners study (1987) to examine student outcomes and teacher characteristics in the NSTA/NSF identified middle/junior high exemplary programs.

Key teachers in the Search for Excellence in Science Education (SESE) Exemplary Middle/Junior High Programs examined their own student outcomes in three domains of science education: (1) knowledge, (2) attitudes, and (3) applications/ connections, using the Iowa Test of Basic Skills and National Assessment of Educational Progress (NAEP) items. Results were compared with national populations.

Teachers administered evaluation instruments assessing three domains of science education to one of their seventh or eight grade classes: The Iowa Tests of Basic Skills, Science Supplement for the knowledge domain, and two questionnaires using NAEP items for the affective and applications domains.

Teachers were surveyed using a questionnaire from the Report of the 1977 National Survey of Science, Mathematics and Social Studies Education, and one asking supplemental questions.

Results indicate that for exemplary middle/junior high science programs: 1) Teachers are highly experienced (average 18.5 years teaching). All feel well qualified, are highly enthusiastic about science teaching, use professional journals as resources, and find other teachers their greatest professional inspiration. All make presentations at professional meetings, ninety-one percent at national meetings. They use a rich mixture of teaching strategies allowing students active exploration of their natural world. 2) Students score far above the national norms on a standardized test of science knowledge (87% percentile rank). 3) Students have strong positive attitudes toward science in most areas. Science is the first or second favorite course for 48% compared to 29% for students generally. Compared with the national sample students report significantly higher attitudes toward science classes with regard to comfort, success, curiosity and preparation to make decisions. 4) Students generally do not perform higher in the applications domain than students in general. 5) Boys show slightly higher scores than girls in most areas.

This study has shown that in exemplary middle/junior high programs: 1) students can learn both science knowledge and maintain or develop positive attitudes toward science, 2) students need opportunities to make connections between what they learn in science and personal responsibility, 3) girls need specific assistance to enhance their involvement in science. A longitudinal research partnership study has been initiated in cooperation with the Middle/Junior High Division of NSTA to continue the study of student outcomes in outstanding science programs.

Introduction

In 1982 the National Science Teachers Association's Search for Excellence in Science Education identified 50 programs judged to exemplify best the stated criteria of excellence in five focus areas: elementary science, physical science, biology, science as inquiry, and science/technology/society. In 1983 the Search for Excellence in Science Education (SESE) continued with three focus areas including **middle/junior high science.** Ten middle/junior high science programs were identified as national exemplars. Thirteen key teachers in ten exemplary middle/junior high programs were invited to participate in a study of student learning outcomes in their programs. Eleven teachers from eight programs administered three evaluation instruments assessing the domains of science education to one of their seventh or eighth grade classes: 1) The Iowa Tests of Basic Skills, Science Supplement, for the knowledge domain; 2) the Preferences and Understandings questionnaire, for the affective domain; and 3) the Science and Society questionnaire for the applications/connections domain. Each teacher was surveyed using two questionnaires: one from the Report of the 1977 National Survey of Science, Mathematics, and Social Studies Education and one asking specific supplementary questions related to the teachers exemplary programs.

Purpose

This study examines characteristics of key teachers in exemplary middle/junior high science programs and the learning outcomes of their students. The descriptive nature of the data is useful in creating a picture of the status of exemplary programs at this level. Four major hypotheses have been evaluated in this study.

1. Teachers associated with exemplary middle/junior high science programs have a different statistical profile in regard to characteristics, professional activity, and instructional practice than those in general.

2. Students enrolled in exemplary middle/junior high science programs perform at levels equal to or above national norms in the knowledge domain.

3. Students enrolled in exemplary middle/junior high science programs score significantly higher in the affective domain than students in national samples.

4. Students enrolled in exemplary middle/junior high science programs score significantly higher in the applications/connections domain than students in the national sample.

Design and Procedures

NSTA identified ten national exemplars in middle/junior high school science in 1983 as part of the NSF/NSTA Search for Excellence in Science Education (SESE) project. Criteria for selection were developed from the goals emerging from the NSF funded Project Synthesis study. In the present study the characteristics of teachers associated with middle/junior high exemplary programs were evaluated using the Weiss (1978) instrument with supplemental questions by Bonnstetter (1983). Data obtained were used to develop a profile of teacher characteristics and their instructional practice for comparison with national data (Weiss, 1978).

A description of student learning outcomes in exemplary middle/junior high programs was developed from data obtained using three instruments: 1) the Iowa Tests

of Basic Skills, (ITBS), Science Supplement, Levels 13 and 14 for the knowledge domain (content) and compared with national norms for grade equivalents, normal curve equivalents and percentile ranks; 2) the Preferences and Understandings instrument (Yager and Bonnstetter, 1984) drawn from NAEP items in the affective domain and 3) the Science and Society instrument (Dagher, 1986) developed from NAEP items in the applications/connections domain. Items on both the Preferences & Understandings and the Science & Society instruments were compared with NAEP items administered to general student populations in 1982, 1983, 1984.

This research provides a middle/junior high school science status study describing factors of teacher/instructional program and student outcomes in three domains of science education for exemplary programs with programs in general.

Figure 1 provides a representation of the research design. Exemplary program (Group I), teacher characteristics and instructional practices were described by percent responses on questionnaire items and compared with percent responses for programs in general (Group II). Student outcomes in the knowledge domain (ITBS instrument) were compared by the normal curve equivalent (national norm = 50) and by percentile rank (national norm = 50). Student achievement in the attitude and applications domains were reported by percent responding positively to questionnaire item statements and compared with percent responses from national samples. Tests for significant differences between national samples and middle/junior high exemplary program data were made using the Z proportion statistic. Significance was identified at the .01 level of confidence, occasionally at the .05 level of confidence. Achievement in the attitude and applications domains was compared by gender for students in the exemplary programs.

Results

This study provides an overview of the status of exemplary middle/junior high science programs in this country by describing and analyzing the teachers' characteristics and their student learning outcomes in three important domains.

Teacher Characteristics

The teachers in exemplary middle/junior high programs are exemplary themselves. They are experienced teachers, well prepared, enthusiastic about working with early adolescents, professionally involved,and use a multitude of resources and instructional strategies they have identified as appropriate for their active and rapidly maturing students. They consider science important for the education and lives of all of their students. They model enthusiasm, curiosity, and continuous learning. Their students perceive them as liking science, knowing a lot of science, yet willing to admit not knowing. Their students are encouraged to question and share ideas. Their students enjoy the science learning environment the teachers have created for them.

Student Knowledge

Each teacher administered the ITBS Science Supplement to each student in the class selected to participate in this study. Table 1 shows the results for each class by mean normal curve equivalent (NCE) for the class and by percentile rank (PR) derived from the mean NCE. Percentile rank represents that percentage of the distribution which falls below the given score. Therefore, using national norms, for test site 901, 94% of all students taking this test scored below the "average pupil" in the 901 class. NCE and PR scores were averaged to obtain the mean for the middle/junior high

exemplary program students. For 280 students a mean NCE of 73.9 was obtained, a result considerably higher than the national norm of 50. The exemplar group NCE equates to the 87th percentile rank. Comparison with the national norm of 50 indicates an "extremely high" (H. D. Hoover, 1987) performance for the exemplar students in the knowledge domain. Using the pupil percentile rank from the mean NCE for a class, it is possible to say that for class 902 the average pupil in the class scored at the 91st percentile rank. Therefore for the 280 students in the middle/junior high exemplary science programs, the average pupil scored at the 87th percentile rank. Likewise considering the "average pupil" in this group, 87% of the scores in the national distribution fall below the "average exemplar pupil's" score.

Student Attitudes Toward Science

This study has shown that in the learning environment exemplary middle/junior high teachers have created their students develop strong positive attitudes toward science (Tables 2, 3, 4, 5, 6, and 7) while demonstrating high levels of achievement in scientific knowledge. Knowledge is improved rather than sacrificed when students study science in a supportive and interesting environment. Correspondingly, the acquisition of scientific knowledge does not necessitate suffering and hardship. Fostering success in science courses does not require sacrificing all but the most academically inclined students.

It is also evident that the onset of adolescence does not automatically lead to negative attitudes toward science. There are science learning environments where a decline in attitudes is not experienced at the middle/junior high level. The students in the exemplary middle/junior high programs have demonstrated positive reactions toward science classes and their ability to function successfully in science.

Student Applications/Connections Abilities

Students in the exemplary middle and junior high programs demonstrated significant differences in regard to doing science related things (Table 8). Several items are significantly lower.

Tables 9 and 10 show student willingness to help solve world problems. As encouraging as the responses may seem it is interesting to note that the m/jh students are consistently less positive than those students in the national sample (Table 10). Three of the differences are not statistically significant; however four are significant (Table 11). In all but one case, separating trash, the girls are much more willing to help solve the problems indicated than are the boys (Table 10). Table 11 shows the surprisingly significant differences between the middle/junior high student sample and the general population sample in regard to personal willingness to address pervasive social problems related to technology. The m/jh students are much less willing to save electricity, clean up litter, separate trash, and/or ride in a small car.

The levels of social consciousness and responsibility demonstrated by our middle/junior high students in this study mirror those in adult society (Table 11). Our national political climate and social values have apparently influenced our youngsters. It is therefore especially important that responsibility be an experienced value in school science.

Sexual Equity

The gap in achievement between the boys and girls becomes evident as early as seventh and eighth grade even in exemplary science programs. It can be argued that

school experiences are not the cause. Data do not show the cause. However, as with the area of social responsibility in the applications domain, active intervention can be provided in school science experiences. Girls should receive encouragement and reinforcement. Their natural abilities need special attention in science programs.

Conclusion

This study has shown:

1. Teachers in exemplary middle/junior high science programs are highly professional and generally have the support systems requisite for their success.

2. In exemplary middle/junior high science programs students can learn both high levels of science knowledge and positive attitudes toward science.

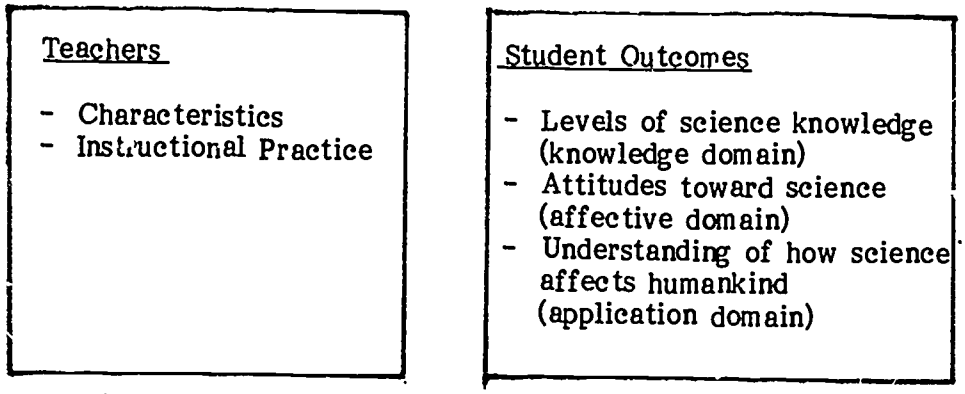
3. Students in exemplary middle/junior high science programs generally did not score higher on the applications/connections questionnaire than those in the national sample.

4. Gender differences in science learning begin to show up in the middle/junior high even in exemplary programs.

It is apparent that teachers in outstanding middle/junior high programs should begin to look at curriculum adjustments to address weaknesses in the applications/connections domain and in girls' involvement in science. These teachers are leaders and have credibility with their colleagues. If they can show success, implementation will spread. Those who provide support for middle/junior high classroom teachers should facilitate the exploration of strategies to address these areas.

Further research should follow to track the middle/junior high student outcomes in all five domains of science education. An attempt should be made to monitor the behaviors which result in measured student outcomes.

GROUP I: Exemplary Middle/Junior HIgh Science Programs



GROUP II: Standard Middle/Junior High Science Programs (from national norms and assessments)

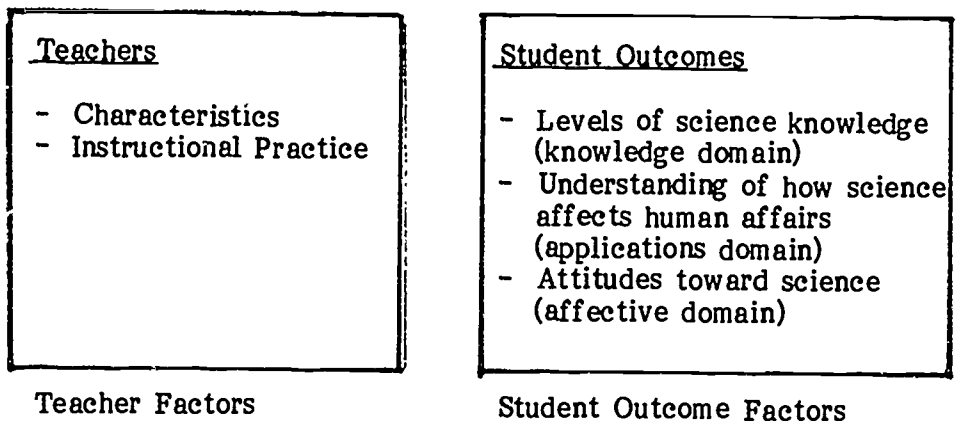


Figure 1 shows the factors evaluated in the study. Teacher and student factors for each group are described by data collected and analyzed for between group correlations. Comparisons of student outcomes between groups are made. STudent outcomes by gender are also described and compared.

Figure 1. Teacher and Student Research Factor Clusters

Table 1. Middle/Junior High Program Students Performance on the Iowa Tests of Basic Skills, Science Supplement, Levels 13 and 14 (N=280)

Class	Total			Male			Female		
	N=	NCE	PR	N=	NCE	PR	N=	NCE	PR
901	19	82.7	94	12	83.1	94	7	82.0	93
902	38	77.8	91	19	76.8	90	19	78.8	92
903	29	83.3	94	17	83.9	94	12	82.4	93
904	26	93.4	98	11	99.0	99	15	89.3	97
905	26	76.9	90	10	80.2	92	16	74.8	88
906	23	73.6	87	14	75.9	89	9	70.0	83
907	15	66.3	77	8	67.5	80	7	65.0	76
908	21	47.5	46	9	51.6	53	12	44.4	39
910	25	63.6	74	17	67.7	79	8	54.9	60
911	27	69.9	83	10	73.6	87	17	67.6	79
912	31	77.8	91	19	82.4	93	12	77.0	90
Exemplars	280	73.9	87	146	76.5	90	134	71.5	85
Nat'l Norms		50	50		50	50		50	50

Table 2. Comparison of General Population Middle/Junior High Students With Exemplary Middle/Junior High Program Students With Regard to Their Perceptions of Their Science Teachers (Percent Responding Positively)

My Science Teacher:	NS	Ex M/JH	Z-Value	Significance
Asks Frequent Questions	55	88	9.58	*
Likes Student Questions	48	74	7.23	*
Likes Students to Share Own Ideas	52	84	9.104	*
Really Likes Science	76	75	-0.322	
Makes Science Exciting	58	70	3.418	*
Knows Much Science	65	86	6.431	*
Admits to Not Knowing	30	72	11.692	*

NS: (N=600), Ex M/JH: (N=280)
*Significant at the 0.01 level.

Table 3. Middle/Junior High Student Perceptions of Their Science Classes (Percent Responding YES)

Science Class is:	A	B	C	D	Ex M/JH	Male Ex M/JH	Female Ex M/JH
Interesting	42	52	51	85	83	83	83
Boring	36	27	29	14	15	16	14
Fun	36	41	40	81	77	75	78
Exciting	43	44	43	74	59	62	57

A: Information from the 1977 Third Assessment of Science by the National Assessment of Educational Progress (N=600) (NAEP, 1978)
B: Information from the 1982 national Science Supervisors Association Follow-Up Study (N=600) (Yager and Yager, 1984; Yager and Penick, 1986)
C: Information from the 1984 Study of Members of the National Science Teachers Association (N=750) (Vargas and Yager, 1986; Yager and Penick, 1986)
D: Information from students enrolled in four of NSTA's Exemplary Science Programs during 1986 (N=900)
Ex M/JH: Middle/Junior Exemplary Program Students, 1987 (N=280)
Ex (Male): Male Middle/Junior High Exemplary Program Students, 1987 (N=146)
Ex (Female): Female Middle/Junior High Exemplary Program Students, 1987 (N=134)

Table 4. Middle/Junior High Student Perceptions of Their Feelings About Science Classes (Percent Responding YES).

Science Class Makes Me Feel:	A	B	C	D	Ex M/JH	Male Ex M/JH	Female Ex M/JH
Successful	42	36	40	59	52	56	48
Uncomfortable	36	20	22	9	8	6	10
Curious	36	30	24	71	69	71	66
Prepared to Make Decisions	40	32	31	63	47	56	37

A: (=600), B: (N-600), C: (N=750), D: (N=900)
Ex M/JH: (N=280), Male Ex M/JH: (N=146), Female Ex M/JH: (N=134)

Table 5. Comparison of General Population Middle/Junior High Students with Exemplary Middle/Junior High Program Students with Regard to Their Perceptions of Their Feelings About Science Classes (Percent Responding Positively).

Science Class Makes Me Feel:	NS	Ex M/JH	Z-Value	Significance
Successful	42	52	2.772	*
Uncomfortable	36	8	-8.692	*
Curious	36	69	9.128	*
Prepared to Make Decisions	40	47	1.955	**

Ns: (N=600), Ex M/JH: (N=280)
* Significant at the 0.01 level.
** Significant at the 0.05 level.

Table 6. Comparison of General Population Middle/Junior High Students With Exemplary Middle/Junior High Program Students With Regard to Their Perceptions of the Value of Their Science Classes.

Things I Learn In Science Class	NS	Ex M/JH	Z-Value	Significance
Useful in Daily Living	78	69	-2.873	*
Useful in Future	74	68	-2.444	**
Useful in Making Choices	52	38	-3.868	*
Useful in Future Living	74	80	1.936	

NS: (N=600), Ex M/JH (N=280)
*Significant at the 0.01 level.
**Significant at the 0.05 level.

Table 7. Comparison of General Population Middle/Junior High Students With Exemplary Middle/Junior High Program Students With Regard to Their Perceptions of What it Would be Like to be a Scientist (Percentage Responding YES)

Being A Scientist Would:	NS	Ex N/JH	Z-Value	Significance
Be fun	49	44	1.385	
Be boring	52	29	6.598	*
Make me feel important	42	55	-3.588	*
Be lonely	59	12	14.613	*
N=	2500	280		

*Significant at the 0.01 level

Table 8. Comparison of General Population Middle/Junior High Students With Exemplary Middle/Junior High Program Students With Regard to Doing Science Related Things (Percentage Responding Positively+)

How Often Do You:	NS	Ex M/JH	Z-Value	Significance
Try Your Ideas	40	46	1.678	
Believe What You Read About Science	64	64	0.000	
Check School Work for Accuracy	50	48	-0.552	
Read Labels Before Buying	62	38	-6.648	*
Look at all Sides of a Question Before Deciding	78	65	-4.082	*
Believe Events Have Logical Explanations	60	66	1.705	
Prefer Being Told an Answer	69	35	-9.510	*
Like to Figure Out How Thinks Work	69	56	3.757	*
Change Your Mind When Ideas Don't Fit Facts	45	57	3.312	*
Keep Working When Unexpected Problems Occur	52	52	0.000	
Feel Time Wasted When Idea Doesn't Work	58	30	-7.727	*
Gather Variety of Information Before Deciding	46	42	-1.110	

+Positive = Always or Often NS (N=2500), Ex M/JH (N=280)
*Significant at the 0.01 level.

Table 9. Middle/Junior High Exemplary Program Student Perception, by Class, With Regard to Their Willingness to Solve World Problems (Percentage Responding Positively)

Class	Use Less Electri-city	Bike & Walk More	Clean Up Litter	Separate Trash	Ride a Small Car	Use Less Heat	Use Returnable Bottles
901	78.9	89.5	68.4	73.7	78.9	52.6	94.7
902	73.0	70.3	48.6	40.5	59.5	56.8	89.2
903	86.7	73.3	33.3	43.3	63.3	33.3	86.7
904	84.6	92.3	46.2	53.8	76.9	42.3	88.5
905	69.2	76.9	38.5	46.2	88.5	42.3	69.2
906	69.6	73.9	56.5	43.5	60.9	30.4	91.3
907	73.3	80.0	40.0	40.0	53.3	40.0	80.0
908	90.5	71.4	42.9	61.9	66.7	66.7	90.5
910	80.0	96.0	48.0	60.0	60.0	40.0	76.0
911	81.5	85.2	51.9	37.0	66.7	55.6	70.4
912	83.9	93.5	74.2	45.2	80.6	71.0	83.5
Total Sample	79.3	81.8	50.0	48.6	68.9	48.9	84.6

(N=280)

Table 10. Middle/Junior High Student Perceptions With Regard to Their Willingness to Solve World Problems (Percentage Responding Positively)

I Am Willing To, Even If Inconvenient:	NS	Ex M/JH	Male Ex M/JH	Female Ex M/JH
Use less electricity	87	79	76.7	82.1
Use bikes or walk more often	87	82	77.4	86.6
Clean up litter	69	50	47.3	53.0
Separate trash	65	49	50.7	46.3
Ride in small economy car	78	69	59.6	79.1
Use less heat to save fuel	56	49	47.9	50.0
Use returnable bottles	88	85	78.8	91.0

NS (N=2500), Ex M/JH (N=280), Male Ex M/JH (N=146), Female Ex M/JH (N=234)

Table 11. Comparison of General Population Middle/Junior High Students With Exemplary Middle/Junior HIgh Program Students With Regard to Their Willingness to Solve World Problems (Percentage Responding Positively)

I Am Willing To, Even If Inconvenient:	NS	M/JH	Z-Value	Significance
Use less electricity	87	79	-3.046	*
Use bikes or walk more often	87	82	-1.954	
Clean up litter	69	50	-5.428	*
Separate trash	65	49	-4.504	*
Ride in small economy car	78	69	-2.873	*
Use less heat to save fuel	56	49	-1.937	
Use returnable bottles	88	85	-1.233	

NS (N=2500), Ex M/JH (N=280)
*Significant at the 0.01 Level

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