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Wastewater Management: a model in interdisciplinary studies

Frederick P. DeLuca
Iowa State University

Craig B. Davis
Iowa State University

Arnold van der Valk
Iowa State University, valk@iastate.edu

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Abstract

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An experimental program in waste water management that we at the Iowa State University helped to integrate into nine central Iowa high schools last year utilized a unique team approach which helped to alleviate many of the usual ob stacles. This article describes the project, in the belief that it may well become a model for others interested in promoting problem-centered interdisciplinary studies in high school science.

Disciplines

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Comments

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Author(s): Frederick P. DeLuca, Craig B. Davis and Arnold van der Valk
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WASTEWATER MANAGEMENT: a model in interdisciplinary studies

Frederick P. DeLuca
Craig B. Davis
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Interdisciplinary studies should be part of the high school curriculum. But the sheer difficulties presented to teachers of digesting new material in their free time and then implementing it in a system which tends to be rigid and highly structured, often combine to squelch any movement in the interdisciplinary direction.

An experimental program in waste-water management that we at the Iowa State University[1] helped to integrate into nine central Iowa high schools last year utilized a unique team approach which helped to alleviate many of the usual obstacles. This article describes the project, in the belief that it may well become a model for others interested in promoting problem-centered interdisciplinary studies in high school science.

Not for teachers only

The primary objective of the program was to assimilate concepts and principles of waste-water pollution and treatment into the science curricula of participating high schools. Early in the planning we decided that two factors would be essential to successfully achieving this aim. First, teachers would need a block of uninterrupted time in which (aided by university faculty) they would familiarize themselves with the waste-water problem and develop plans for implementing a learning unit into their respective schools. Second, teachers would need the opportunity to "pretest" the new material with selected students prior to any large-scale implementation.

We felt that a team approach involving both teachers and students would have a much greater chance of positive results, and that the procedure would have the added benefit of giving students a chance to experience science in a manner normally unavailable in high school programs.

Students in the "summer phase" concentrate a plankton sample.

An "uninterrupted block of time" in any teacher's life usually implies summer, so, not unexpectedly, we decided on a five-week *summer preparation phase* at the university, in which teachers, accompanied by high-ability students, would gain new knowledge and ideas, and perfect implementation plans. The summer phase was to be followed by an *inservice implementation phase* lasting throughout the 1975-76 school year, in which the same teachers, students, and professors would work together to incorporate the waste-water units into the curricula.

Accordingly, eight biology and chemistry teachers and 23 students from nine schools (two of the schools were represented by students only) were selected to participate. All of the students had completed at least one year of biology; some had also taken a year of chemistry.

Waste-water management was selected as the focus for the first program because it is a problem faced by every U.S. community. Increasing demand for and reuse of water in recent years has heightened public awareness of health and water quality factors, bringing water treatment facilities to even the smallest towns. These facilities range from complex tertiary treatment plants to easily operated lagoon systems.

It was decided that the major effort of the summer would be to give students and teachers access to a three-celled sewage treatment lagoon system. Such a system consists of shallow man-made ponds, called cells, in which sunlight, algae, and oxygen interact to restore water quality. Waste water, rich in raw sewage, enters the first cell, passes through the second and third cells, and is then released to a nearby river. The lagoon system was selected because of easy access and abundance, but other types of treatment facilities would provide similar opportunities for study.

The problem presented to the teachers and students was to develop a model of the operation of the lagoon, taking into account the material that enters the system, the biological and chemical processes that operate in each cell, and the quality of water leaving the system. Variables would have to be identified, measured, analyzed, and interpreted. It was essentially to be a study of the biological and related chemical activities of the system.

Summer preparation phase

The summer preparation phase began with a week of intensive study for teachers only, followed by four weeks of teacher/student collaboration. In the week they were without the students, teachers attended lectures and discussions, but devoted most of their time to field and laboratory work. They identified, counted, and isolated organisms from samples of lagoon waters, and became familiar with standard methods of water analysis for measuring pH, dissolved oxygen, biological oxygen demand, particulate matter, phosphate, ammonia, nitrate-N,

[1] The project operated out of the University's Environmental Studies Center, under a grant from the National Science Foundation.

carbon dioxide, and coliform content.

During the next four weeks, teachers refined their grasp of biological and chemical measurements, assisted students in the lab and in developing the lagoon model, and prepared implementation plans. Throughout, teachers were free to use the total resources of the university.

The students' schedule during their four-week summer phase was more structured. Approximately one-fourth of their time was devoted to lectures and seminars relating to pollution, water chemistry, basic ecology, aquatic biology, and waste-water treatment. Another fourth was given to field trips, guest speakers, library research, informal discussion, films, and special topics such as electron microscopy. The remainder of the time was given to field and laboratory activities related to development of the lagoon model. This main effort culminated during the last week with a 24-hour sampling and measurement project at the lagoon. Three groups, each composed of students, teachers, and professors, worked consecutive eight-hour shifts to collect data that could lead to insights into the operation of the lagoon over a 24-hour period.

Student and teacher responses to items on Semantic Differential Test (summer phase)[a]

Student rating of program elements (in order, 1-24)	Student Average	Teacher Average	Teacher rating of program elements (1-24)
1 Overall program	6.50	6.37	1
2 Field work at the lagoon	6.39	6.00	5
3 Iowa State University	6.33	5.68	11
4 Instruction by college professors	6.26	5.75	9
5 Informal discussion with students	6.20	6.34	3
6 Interaction between students, teachers and professors	6.19	6.28	4
7 Informal discussion with college professors	6.14	5.75	8
8 Chemical analyses	6.11	5.93	7
9 Photography	6.10	5.40	15
10 Informal discussion with high school teachers	6.03	6.37	2
11 Lectures	5.84	5.65	12
12 Field trip to Ames' sewage treatment plant	5.65	5.96	6
13 Instruction by high school teachers	5.57	5.68	10
14 Library search	5.38	5.21	17
15 Daily schedule	5.32	4.56	24
16 Movies	5.20	4.87	21
17 Student seminars	5.14	5.46	14
18 Identification of organisms	5.08	5.06	19
19 Textbook	4.88	5.40	16
20 Exams	4.80	4.68	23
21 Organism count	4.71	5.09	18
22 Reading assignments	4.21	4.71	22
23 Isolation of organisms	4.21	5.50	13
24 Field trip to nuclear reactor	4.10	5.03	20
AVERAGE OF ALL RESPONSES	5.30	5.41	

[a]Possible responses ranged from one to seven. Above four was considered positive; four was neutral; and below four, negative.

Was it worth it?

We used two techniques to evaluate the summer preparation phase. One involved informal collection of observations and comments from students, teachers, and professors; the second measured teacher and student attitudes toward the program as indicated by responses to a semantic differential test.

The informal collection of observations and comments took place all summer and was invaluable as an ongoing means of evaluation. At first, teachers were reluctant to offer criticisms and suggestions, but when they realized we were sincere in our quest for feedback, suggestions ensued, and we were able in many instances to make immediate and positive changes. This was much more effective than waiting until the end of the summer for evaluation. Moreover, our openness toward feedback helped to foster a valuable spirit of cooperation and common goals.

The second tool for evaluation—a semantic differential test—was constructed and administered at the end of the summer phase. The test asked for responses to 24 items, each of which formed a part of the program. Evaluative scales assigned to each factor were: *trivial to important, slow to fast, boring to interesting, unsuccessful to successful,* and *meaningless to meaningful*. Possible responses for each polarized adjective pair ranged from one to seven. Responses above four were considered positive; four was neutral; and below four was considered negative. The Table (see above) lists average responses from teachers and students to each factor, supporting the following findings:

1. Both teachers and students rated the overall program as good to excellent; however, the students rated the program higher than did teachers.

2. The informal discussions and interaction between students, teachers, and professors received high ratings from both teachers and students.

3. With some exceptions, there was high agreement among both teachers and students in the ranking of the 24 factors.[2]

[2] Kendall's coefficient of rank correlation between students' and teachers' responses was significant at the 0.1 level of confidence.

4. It is interesting to note that traditional factors such as textbook, reading assignments, exams, movies, and student seminars (formal presentations) were ranked in the lower half of the responses by both teachers and students.

Implementation phase

Our guiding philosophy throughout the implementation phase was that the teachers, because of their closeness to their school and community, were in the best position to make wise decisions concerning design and implementation of their respective programs. Each teacher, therefore, had full control of his or her program. We maintained an open line of communication and we did visit the teachers at school, but each meeting was of a purely consultative nature, and no attempt was made to superimpose any preconceived scheme onto the schools.

The common form of implementation was through established courses. Four of the schools had ecology courses (or an ecology section within a regular biology class), so most of the newly acquired knowledge was readily assimilated either as new units or as supporting information and activities for established units. Special units were implemented in chemistry classes and in one earth science class.

Programs related to ecology, advanced biology, and chemistry were implemented at the junior and senior levels; those relating to introductory biology were implemented at the sophomore level.

In large classes (as well as in science clubs), special projects were also initiated, in which small groups of students were selected to work with teachers during free periods, after school, and weekends to collect data from rivers, ponds, lagoons, and sewage treatment plants. The students were then responsible for reporting the data to the entire class.

Three projects in particular deserve mention: After one teacher's new course in environmental analysis was canceled due to scheduling difficulties, he decided to conduct it as a special project for six students. Meeting every day for one semester, they made an excellent study of the effects of chemicals introduced into a lake to reduce the small pan fish population. Another teacher took advantage of the fact that his school was located next to a river and "dunked" the entire ecology class into a nine-week unit on freshwater ecology and pollution. Working with a small advanced chemistry class of nine students, a third teacher took his class to a nearby sewage lagoon to duplicate the field and lab activities of the summer phase. At one point they noticed that their data looked somewhat unusual. They checked with the lagoon supervisor, who appeared unconcerned, despite the fact that he had logged similar data. Investigation by the class led to discovery of a clogged control gate, causing malfunction in one cell of the lagoon.

The students who had participated in the summer preparation phase helped teachers tremendously during the implementation year, serving as group leaders, instructors, and lab assistants. One teacher commented, "I would not have attempted this project on an independent study basis had I not had those students available." Another said: "If the program had not included students, the results would not have been nearly as successful."

Some of the summer phase students also undertook special projects; one interned with a local waste management planning group. Another student, one of four who were unaccompanied by their teachers during the summer phase, received considerable support from her teacher in conducting a pond study and went on to receive a prize for her paper at last year's Iowa Junior Academy of Science conference.

"If activity-centered interdisciplinary studies are to make significant inroads in school curricula, the entire educational community must continue to work for lower student-to-teacher ratios."

Final evaluation

As with the summer phase, we used both informal discussions (largely at an end-of-the-school-year meeting between students, teachers, and professors) and formal questionnaires to evaluate the implementation phase. Teacher ratings of the total program ranged from "good" to "very good +." Their general feelings are reflected in comments like the following: "If it had not been for this program my unit on freshwater ecology and water pollution would not have been as good"; "This type of program has provided more practical material for implementing into a high school curriculum than other institutes I have attended."

Student reactions to the program are reflected in their responses to a questionnaire. Responses indicated that: (a) Knowledge gained in the summer phase was used during the school year; (b) They assisted other students; (c) They gained a better feel for how scientists work; and (d) They would encourage other students to participate in similar programs. When asked to indicate the primary forms of their participation in the implementation phase, they indicated (most frequent to least frequent): outdoor activities, assisting with teaching, regular classes, research, independent study, after-school activities, and special classes.

Some of their comments were quite insightful: "Our teacher had the interest to go back and implement the program into his course, and we students who attended last summer were a big part of that." "I enjoyed working on the projects with other students, but I don't think I would want to study science in college." "You don't realize how much research is needed to do a project until you try it."

Like any other pilot project, ours was not without snags that tended to retard implementation, but at no time proved insurmountable. Time, for one, was not always on our side. The average teacher spent 31 class hours on the program, reaching an average of 93 students and involving one other colleague. In the end, it was the willingness of teachers and students to devote after-school and weekend hours to their projects that contributed to their success.

Lack of money for chemicals and measuring apparatus was also worrisome. All teachers had to improvise, but as one student said, "You don't need an electron microscope to do something you really want to do."

Large class enrollments and lower-ability students also made in-depth lab and field-work very difficult. (This problem was often alleviated by a special projects group trip to collect data.) Smaller classes would benefit both the brightest and dullest students.

Our experience with this program leads us to believe that a team approach involving teachers, students and professors offers many advantages that cannot be provided in programs for teachers or students alone. Although we are very pleased with the project's outcome (and nearly all of the teachers have made plans to repeat the unit next year) feedback seems to indicate that teachers need more support during the implementation phase, especially in areas where the high school curriculum tends to be somewhat inflexible. Future plans should include additional funds for science materials and released time for teachers. If activity-centered interdisciplinary studies are to make significant inroads in school curricula, the entire educational community must continue to work for lower student-to-teacher ratios. ■

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