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ABSTRACT

This report describes the model educational delivery system used by Ulster County Community College in its water quality monitoring program. The educational delivery system described in the report encompasses the use of behavioral objectives as its foundation and builds upon this foundation to form a complete system whose outcomes can be measured, evaluated, and readily modified. These characteristics enable the system to serve as an "academic cafeteria." Through it, the student can search for those objectives (as learning units) or series of objectives that, when properly selected, sequenced, and mastered, meet the student's specific needs and goals. This flexibility, in turn, provides the tools to release the teacher from the traditional role of lecturer and lab instructor to become a leader, motivator, and facilitator of learning. The model program describes the components of a complete educational delivery system for water quality monitoring, as well as serves as a blueprint for similar programs in a host of different areas. These areas might include the technologies, sciences, business, accounting, and many other disciplines. Under development is a computerized self-training/testing system, the Personal Testing and Interactive Evaluation system (PETITE), which is prescriptive, diagnostic, and self-generating, allowing the student to retest until the desired results are achieved. (Author/KC)

A PROTOTYPE EDUCATIONAL DELIVERY SYSTEM
USING WATER QUALITY MONITORING AS A MODEL

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FOREWORD

The Title III institutions of higher education and historically black colleges are particularly vulnerable to rapidly changing social and economic forces. They are frequently besieged by a series of problems that often appear insolvable.

While many Title III institutions and historically black colleges are fighting to survive, there are examples of successful vocational education programs in these institutions. The characteristics of these successful programs are not generally well known. Through this paper and four others in this series, the National Center provides institutional personnel with a description of programs and practices they can use to improve vocational education programs at their institution.

The National Center expresses its appreciation to Richard B. Glazer, the paper author. Mr. Glazer is Chairman, Division of Business and Human Resources, Ulster County Community College, Stone Ridge, New York.

In addition, the National Center expresses its appreciation to Dr. Shirley B. Cathie, the reviewer for Mr. Glazer's paper. Dr. Cathie is an education consultant from Plainfield, New Jersey.

Valuable assistance in selecting the programs and the paper authors was provided by Mr. Rayford L. Harris, Virginia State University; Dr. W. R. Miller, University of Missouri-Columbia; Dr. Delores M. Robinson, Florida State University; Dr. Bernardo Sandoval, Los Angeles Unified School District; and Dr. Steve Van Ausdle, Walla Walla Community College, Washington.

The National Center is indebted to the staff members who worked on the study. The study was conducted in the Information Systems Division, Dr. Joel Magisos, Associate Director. Dr. Floyd L. McKinney, Senior Research Specialist, served as Project Director and Oscar Potter as Graduate Research Associate. Dr. McKinney, a former secondary vocational education teacher, holds a Ph.D. in vocational education from Michigan State University. He has served as a university coordinator of graduate vocational education programs and as a division director in a state department of education. Mr. Potter is a doctoral candidate in agricultural education at The Ohio State University and has a M.A. in agricultural education from the University of Florida and a M.A. in administration and supervision from Florida Atlantic University. Patsy Slone served as project secretary and Janet Ray served as word processor operator. Roxi Liming provided technical editing, and final editorial review of the paper was provided by Ruth Morley of the National Center's Editorial Services area.

Other papers produced in this series are as follows:

- Local Area Networks of Microcomputers in Education

  Clifford D. Layton
  Rogers State College

- Promoting Industry Support in Developing a Computer Technology Program

  Albert Robinson
  Washtenaw Community College

- Systems Approach to Computer Literacy for Vocational Educators: A Professional Development Seminar for Faculty and Staff

  Mildred F. Johnson
  Cheyney University of Pennsylvania

- Vocational Education Programs at Virginia State University Successful Features

  W. Vincent Payne
  Virginia State University

Robert E. Taylor
Executive Director
The National Center for Research
in Vocational Education

EXECUTIVE SUMMARY

The Water Quality Monitoring program at Ulster County Community College has evolved slowly over the past nine years. From the beginning, the intent of the program developers was to show the education community that an educational delivery system could be developed that would meet the needs of students for comprehensive training, the needs of employers for skilled workers, and the need of faculty to deliver excellence in education without the painful and debilitating attrition rate normally associated with rigorous academic training programs.

This report describes the model educational delivery system utilized by the Ulster County Community College in its Water Quality Monitoring program. Vocational educators and administrators concerned with program improvement may find that adapting the model educational delivery system to their programs might better meet the needs of their students, employers, and faculty.

The educational delivery system at Ulster County Community College uses behavioral objectives as its foundation and from this base builds a total learning system. It is a system in the truest sense of the word as all components--students, instruction, resources, and performance--can be evaluated at every step. The result of a modification of any of the components can be measured, regardless of which component is altered. Because of the manner in which the system is structured, it is also highly flexible. Since the Water Quality Monitoring program faculty know where they are going, they also know how to change direction, when to change, and what the end result of that change will be.

The model program describes the components of a complete educational delivery system for water quality monitoring, as well as serves as a blueprint for similar programs in a host of different areas.

These areas might include the technologies, sciences, business, accounting, and a host of other disciplines. The educational delivery system is flexible, composed of many independent parts, self-pacing, easily evaluated, readily modified, and highly transportable. These characteristics enable the system to serve as an "academic cafeteria." Through it, the student can search for those objectives (as learning units) or series of objectives that when properly selected, sequenced, and mastered, meet the student's specific needs and goals. This flexibility, in turn, provides the tools to release the teacher from the traditional role of lecturer and lab instructor to become a leader, motivator, and facilitator of learning.

With the addition of the Personnel Testing and Interactive Training Evaluation (PETITE) system and the microcomputer training program, the testing of students becomes a nonpunitive, interacting, learning process.

With the completion of this program an educational delivery system is now no longer an idea whose time has come but rather a reality whose time is now.

CHAPTER 1

THE EDUCATIONAL DELIVERY SYSTEM

Introduction

This report describes the model educational delivery system utilized by the Ulster County Community College in its Water Quality Monitoring program. Vocational educators and administrators concerned with program improvement may find that the model educational delivery system as described, will serve as a blueprint for use in simillar programs. The educational delivery system can also be applied in other academic areas such as the health sciences, business, accounting, and biological sciences.

Historical Background

Recently, there has been an increasing awareness that the chemical and industrial products fueling technology and supporting industrial, economic, and population growth has been a double edged sword. These technological advances have provided a standard of living unique in the history of the United States. With this standard of living, however, has come the realization that the environment has become gravely polluted with billions of tons of sewage, and agricultural, household, mining, industrial, and commercial waste.

These wastes have permeated the soil and contaminated both the air. the soil, and surface waters. Across the country many bodies of water have become open sewers, chemical dumps, and toxic pools; some rivers have even caught fire and burned for days. Agricultural, industrial, and drinking water supplies have been imperiled.

To meet this threat and to begin to safeguard the environment and the public health, the U.S. Congress proposed and passed three complex and comprehensive sets of laws. These were intended to address the primary issues of water pollution and degradation.

The first of these laws was the National Environmental Policy Act of 1969. This law created the Council on Environmental Quality in the Executive Office of the President and established a national policy for the environment. The policy included the requirement that all federal agencies incorporate in proposals for actions affecting the environment a detailed statement of the impact of the proposed action.

This law was followed by the 1972 amendments to the Federal Water Pollution Control Act (The Clean Water Act) intended to "restore and maintain the chemical, physical, and biological integrity of the nation's waters." Its provisions included the elimination of all pollutants into navigable waters by 1985; a major national research development and demonstration program; the construction grant funds; the National Pollutant Discharge Elimination System (NPDES); and compliance monitoring.

In 1974 Congress passed the Safe Drinking Water Act providing for the safety of drinking water supplies throughout the United States. The act established and enforced national drinking water quality standards. It also qualified the states for primary enforcement responsibilities (primacy) if they met the following conditions:

- Adoption of regulations at least equal to the federal legislation
- Adoption and implementation of adequate surveillance and enforcement procedures
- Provision of variance and exemptions meeting federal requirements

- o Provision of an adequate plan for supplying safe drinking water under emergency circumstances
- o Provision of records and reports for keeping the United States Environmental Protection Agency (EPA) appraised of its activities

Further, the act stated that the U.S. Environmental Protection Agency may take direct Civil action in states without primacy and may impose a maximum penalty of five thousand dollars a day for willfull violation.

This legislation has brought about an unprecedented need for a host of new specialized personnel. These include trained technicians who can operate treatment plants; monitor municipal, industrial, and commercial waste discharges; test drinking water for purity; investigate aquatic and marine environments; prepare environmental impact and assessment statements; and write the reports required by the states and EPA.

To meet these needs, the Environmental Protection Agency recognized that it would be essential to develop a training program that would provide technicians capable of being productive immediately upon employment. To accomplish this goal, EPA proposed the development of a standardized two-year curriculum leading to an associate degree. This curriculum was to be clearly defined so that it could serve as a national standard. EPA further proposed the curriculum be written so that a sequence of courses, one course, or parts of a course could be extracted from the curriculum and recombined to provide workshops, short-training institutes, seminars, or diploma programs.

These requests provided the program developers with the unique opportunity to apply behavioral objectives to the development of an entire educational delivery system based on this objective format. The four-folc purposes of this project, therefore, were the following:

- To develop a two-year curriculum in water quality monitoring, leading to an associate in applied science degree, in which the graduate will be productive immediately upon employment.

- To use the format of behavioral objectives in which the curriculum has been so designed that the purpose, instructional objective, conditions, acceptable performance level, and course sequences are clearly defined. This format further provides the opportunity to describe in measurable terms the skills and knowledge to be learned while furnishing students with a clear definition of what they must know to complete the program successfully.

- To produce an educational delivery system in which the learning objectives are independent units that can be isolated and sequenced to provide a variety of instructional (critical) pathways for training technicians to do specific tasks. These pathways can be used to provide a host of workshops and training programs of varying lengths and types. These formats can be used in continuing education to provide retraining or additional training for water quality technicians.

- To design a system from which a series of modules can be produced, thereby allowing the instructor to develop, evaluate, and use a variety of instructional strategies for any given course or objective. Additionally, when the "critical pathways" are identified and approved, appropriate instructional materials (i.e., workbooks, audiovisual materials, simulations) can be produced and made available. These pathways then can be utilized with a minimal amount of participation by instructional or supervising staff.

The educational delivery system described in this report has all these attributes. Each course defines itself, as well as the terminal behavior the graduate will exhibit. The curriculum is designed to produce a technician who can be employed productively in many areas of water resources immediately upon job entry with a minimal amount of retraining. It is an educational delivery system that lends itself readily to evaluation and immediate revisions.

Water Quality Monitoring Program Educational Delivery System

This document describes an educational delivery system that, by utilizing the concepts of instructional objectives, offers the students, faculty and institution the following advantages

- Objectives that are clearly and specifically defined o Instructional pathways for the continuing education of the technician

o Modular programs that can be easily identified and produced

o A microcomputer training program that is instantly responsive, interactive, and non-punitive

o A curricular system in which the components of the total system can be readily evaluated

The prototype education delivery system described is continually evolving. It began with the development and writing of four books on water quality monitoring for the EPA (see appendix A). In 1975 the water quality monitoring curriculum at Ulster County Community College was implemented through a demonstration training program. The training program was funded through a joint contract with the U.S. Environmental Protection Agency and the New York State Department of Environmental Conservation. The intent of the program was to attract students from all areas of New York state and the n ion.

At the beginning of the program, it was decided the director of the Water Quality Monitoring program would be responsible to the dean of faculty, rather than merely heading a program within a department, which in turn would be responsible to a division. This arrangement provided the director with a great deal of flexibility allowing him to pursue new grants, remodel facilities, and to write three other water quality books. After the curriculum implementation, a classroom was remodeled into a water quality laboratory and equipped with the latest in instrumentation, including spectrophotometers, atomic absorption spectrophotometers, gas chromatographs, and all other necessary equipment and materials (see appendix B).

In 1979 the National Science Foundation supported the development of audiovisual materials to supplement the water quality monitoring objectives. This funding culminated in the development and production of twenty modules consisting of 35mm slides, an audiotape, and accompanying booklet (see appendix C). A microcomputer software program "The Personnel Testing, and Interactive Training Evaluation System" (PETITE), (see appendix D), and a "Local and Remote Access Training/Testing Microcomputer Progr m" are in the final stages of development. These were funded by the National Science Foundation and the U.S. Environmental Protection Agency, respectively.

The Curriculum

There are twenty defined courses in the Water Quality Monitoring program curriculum, plus six additional credits in general electives. Sixty-six total credits are required for graduation with thirty-one credits being in the environmental science area. These courses grouped by discipline are listed in table 1.

Table 2 denotes the semester arrangement of the courses in the sequence normally followed by an entering freshman. The six credit Social science courses and the electives necessary to meet the requirements of the New York State Education Department are not written in the objective format. These requirements can be fulfilled through a number of social sciences and elective courses, depending upon the needs and desires of the students.

The primary courses in the curriculum are clearly defined. These are introduced with a statement of purpose and then broken down into a number of units of instruction, each containing an objective (OBJ), the conditions (COND) under which the objectives will be learned, and the desired performance level (PL).

The statement of purpose serves as a summary of the course material and explains what the student will be studying. It deals with the relevance of the subject material and explains why the student is to master the skills

TABLE 1

COURSE GROUPING BY DISCIPLINE

Course	Title	Credits
Chem. 101	General Chemistry I	4
Chem. 102	General Chemistry II	4
Chem. 201	Instrumentation	4
	Total Chemistry Credits	12
Math. 101	College Algebra	3
Math. 102	Statistical Analysis	3
	Total Mathematics Credits	6
Bio. 101	Environment & Life	4
	Total Biology Credits	4
Env. Sci. 101	Water Quality Laboratory Techniques I	3
Env. Sci. 102	Water Quality Laboratory Techniques II	3
Env. Sci. 103	Water Quality Control Processes	3
Env. Sci. 104	Water Quality Summer Laboratory Exp.	3
Env. Sci. 201	Water Quality Laboratory Techniques III	3
Env. Sci. 202	Water Quality Laboratory Techniques IV	3
Env. Sci. 203	Water Quality Laboratory Management	3
Env. Sci. 204	Water Quality Laboratory Techniques II	3
Env. Sci. 205	Water Quality Laboratory Techniques V	3
	Total Environmental Science Credits	27
Eng. 101	Communication Skills	3
Eng. 102	Technical Report Writing	3
	Total English Credits	6
Soc. Sci. 101	Social Science I	3
Soc. Sci. 102	Social Science II	3
	Total Social Science Credits	6
Elective		6
(Optional)	Total Elective Credits	6
	Total Curriculum Credits	66

TABLE 2

COURSE ARRANGEMENT BY SEMESTER

Year	Semester	Course	Title	Credits
I	I	Chem. 101	General Chemistry I	4
		Bio. 101	Environment & Life	4
		Math. 101	College Algebra	3
		Env. Sci. 101	Water Quality Lab. Tech. I	3
		Eng. 101	Communication Skills	3
				17
I	II	Chem. 102	General Chemistry II	4
		Math. 102	Statistical Analysis	3
		Soc. Sci. 101	Social Science	3
		Env. Sci. 102	Water Quality Lab. Tech. I	3
		Env. Sci. 103	Water Quality Control Proc.	3
				16
Summer		Env. Sci. 104	Water Quality Lab. Exp.	3
				3
II	III	Eng. Sci. 201	Water Quality Lab. Tech. III	3
		Chem. 201	Instrumentation	4
		Env. Sci. 203	Water Quality Lab. Mgmt.	3
		Eng. 102	Technical Report Writing	2
		Elective (Optional)		3
				15
II	IV	Env. Sci. 202	Water Quality Lab. Tech. IV	3
		Env. Sci. 204	Water Quality Lab. Mgmt. II	3
		Env. Sci. 205	Water Quality Lab. Tech. V	3
		Elective (Optional)		6
				15

and knowledge covered in the course. Students should understand why they should master the learning objectives and how the course fits into the total sequence of their learning.

The <u>objective</u> describes to the students exactly what the task is that they are expected to master. The <u>condition</u> clearly defines the circumstances under which the students will perform the task and the objects, information, or assistance the students will have access to while performing the task. The students should perform the task under conditions as close to real situations as is practical in the instructional situation.

The performance level defines mastery. It informs the student of the minimal level of performance acceptable in order to demonstrate mastery of the objective.

In writing these components of instruction, we found that there was no mystique in developing them. It was, in fact, a simple process that required an honest appraisal of what we wanted the students to do and how we wanted them to do it. We were careful to avoid words whose action or definition was unclear, such as buzz words, or jargon. Only statements with clearly measurable results were included in the objectives. Such clearly descriptive verbs as define, explain, discuss, predict, write, describe, illustrate, demonstrate, use, state, calculate, interpret, organize, set up, correlate, perform, classify, cross out, find, identify, complete, and draw were used extensively throughout the instructional components. If we could not test for the results of an objective, we did not use the objective.

A case in point would be objectives three and four in Chemistry 101. This course is the chemistry course intended to assist the student in learning the fundamental principles of chemistry and their application. Objectives three and four, "using a Bunsen Burner" and "cutting glass" are two of the many basic but essential tasks in the chemistry laboratory. They incorpoate all of the components of objectives as used in the water quality curriculum.

3
OBJ
Describe and demonstrate the proper use of a Bunsen burner (or an equivalent) to give a hot flame.

COND
Given an unlighted, unadjusted burner and a match or striker.

PL

A clear blue cone must be observable with no sustained yellow in the flame. A piece of soft glass must glow yellow in five seconds or less at the tip of the blue cone. Identify the cool, hot, and hottest regions of the flame.

4

OBJ

Describe and demonstrate the correct method for cutting, bending, and fire-polishing a piece of glass tubing. Explain why these steps are performed.

COND

Given a burner, wing tip, triangular file, ten inches of soft glass tubing and an asbestos pad.

PL

The glass tubing must be scratched with one firm stroke of the file, leaving a clearly visible scratch, then smoothly broken with thumbs placed opposite the scratch. Fire-polishing must leave no roughness or constrictions. A simple bend to 90° $\pm$ 10° with no visible constrictions, flattening, or dislocations from the plane of the bend. Also, neither student, instructor, nor table top must be burned with hot glass. The entire operation must require no more than fifteen minutes.

An example in the environmental technology area would be objective three in Environmental Science 101 (Water Quality Laboratory Techniques I) (Glazer, Austine, and Allen 1975, p. 49). A portion of this course assists the student in learning analytical techniques for microbiological sampling and analysis.

3

OBJ

Describe and perform aseptically the listed techniques using the proper safety precautions:

a. Serial dilution
b. Pouring agar plates
c. Streaking agar slants and plates
d. Making total counts
e. Aseptic transfers with loop
f. Preparing culture media
g. Counting colonies

COND
Given one of the following references

PL
Each technique must be performed successfully and free of outside contamination 90 percent of the time.

To follow through with the objective, students would now use the Learner's Guide to Water Quality Monitoring (Glazer, Austine, and Allen 1978). As an example, if the students were performing objective 3c, "Streaking Agar Slants and Plates," they would turn to that section (pp. 57-58) in the Guide and would proceed step by step through the objectives necessary to complete the task. To illustrate this procedure "Streaking agar slants and plates" is presented in figure 1. Figure 2 shows the equipment and supply matrix listing the materials needed to complete each objective for the "Streaking agar slants and plates" procedure.

In addition, each objective would be further supplemented by laboratory manuals and audiovisual materials from the EPA and other sources. These sources can be found in the Instructional Resources Inventory System (IRIS) produced by EPA and first published in 1980.

As can be seen, in the beginning of each course the purpose statement clearly explains to the student and the instructor exactly what the reasons are for taking the course and what they will have learned when they have successfully completed it.

After reading the course objectives, the student would normally then proceed through them in the order listed. To aid the students in the successful completion of each objective, the Learner's Guide would be used to supplement the objectives. As shown in the previous example, the student studying objective 3c, "Streaking agar slants and plates," would turn to that section in the

PURPOSE

This guide will assist you in learning to perform streaking techniques aseptically. The streak plate and streak slant techniques are useful methods for:

1. separating a pure culture from a mixed culture;
2. lowering the population density of an organism;
3. determining if more than one type of organism is present in a dense culture.

PREREQUISITES

Before beginning this module you should be able to prepare and pour culture media [Env Sci 101:3b and f(49)] and be able to perform an aseptic transfer [Env Sci 101:3e(49)].

RESOURCES

(To be provided by instructor.)

OBJECTIVES

OBJ 1: Aseptically prepare four agar pours and two agar slants.

COND: Given an equipped wastewater laboratory and resources.

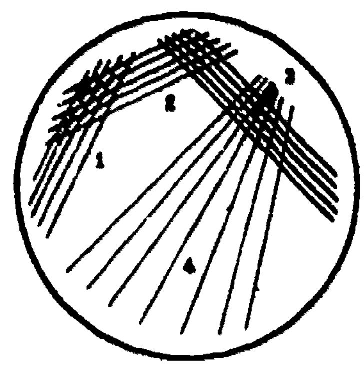
PL: Pours and slants should show no sign of growth after storage in the refrigerator for one day.

OBJ 2: Streak two pour plates using the Quadrant Streak Method.

COND: Given an equipped wastewater laboratory and resources.

PL: Include:

a. Agar surgace should not be gouged or broken.
b. Streaked plates should show isolated colonies which have been well separated.
c. Incubated culture should show only those organisms present in the original culture.
d. Pattern on the plates should appear as below:



OBJ 3: Streak two pour plates using the Radient Streak Method.

COND: Given an equipped wastewater laboratory and resources.

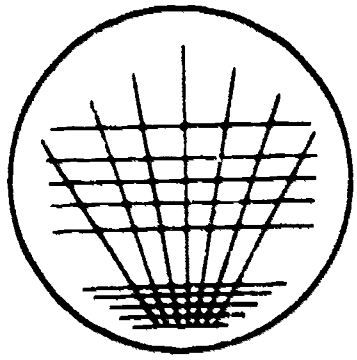
PL: Include:

a. Agar surface should not be gouged or broken.
b. Streaked plates should show isolated colonies which have been well separated.

Figure 1. Sample from the Learner's Guide, objective 3c, "Streaking agar slants and plates"

Figure 1--Continued

c. Incubated culture should show only those organisms present in the original culture.
d. Pattern on the plates should appear as below:



OBJ 4: Streak two slants.

COND: Given an equipped wastewater laboratory and resources.

PL: Include:
a. Agar surface should not be gouged or broken.
b. Streaked slant should show isolated colonies which have been well spearated.
c. Incubated culture should show only those organisms present in the original culture.
d. Zig-zag pattern should appear on the surface of the agar.

EQUIPMENT AND SUPPLIES

ITEM	OBJECTIVES 1	2	3	4	5	6	7	8
4 agar plates	X	X	X					
2 slants	X			X				
Inoculating loop		X	X	X				
Mixed culture broth		X	X	X				
Bunsen burner		X	X	X				
Test tube rack	X			X				
Incubator 37°C		X	X	X				
Refrigerator	X							

Figure 2. Sample from the Learner's Guide, equipment and supplies matrix for objective 3c, "Streaking agar slants and plates"

Learner's Guide. Here the student would work step by step through the objectives necessary to complete the task. In addition, the equipment and supplies matrix at the end of each task provide the student with the listing of materials needed to complete each objective.

Summer Laboratory Experience

All students participate in a summer cooperative internship between their freshman and sophomore years. This internship provides the student with actual work experience in a laboratory or treatment plant in the field of water or wastewater. The students are paid for this internship at a rate never less than the prevailing minimum wage. Upon successful completion of the internship, the student also receives three hours of college credit. Normally, the students work the entire summer, although only six weeks are required for credit.

The cooperative experience is well defined. The monitoring and grading system comprises an agreement between the student, the cooperator, and the college. A contract is then signed between the college and the cooperator to ensure further that the program is clearly understood and agreed upon by both parties.

Since its inception, the program has had more cooperative internships available to it than interns for placement. The preponderance of the cooperators have requested new students every year, often with expanded opportunities for them. Here are some of the cooperators in this program:

New York State Office of Parks and Recreation
New York State Department of Environmental Conservation
Northern Dutchess County Community Hospital
United States National Park Service
Ecological Analysts, Inc.
Ulster County Health Department
Republic Steel

City of Springfield, Massachussetts
Connecticut Department of Environmental Protection
City of Poughkeepsie, New York
Town of New Paltz
Town of Rosendale
CAMO Engineering
City of Kingston
Town of Ulster

This internship program has been so successful that the students working in the pollution abatement facilities of the New York State Department of Parks and Recreation were commended by the commissioner, Orin Lehman, and by Peter Buttner, director of environmental management of the Department of Parks and Recreation for the state of New York.

Facilities

To meet the needs of the Water Quality Monitoring Program, the water quality staff at Ulster County Community College designed a water quality wet-lab. It was then constructed by the college in the Algonquin Building.

The lab is a fully equipped and includes, glassware, chemicals, spectrophotometers, pH meters, autoanalyzers, dissolved oxygen meters, dissolved oxygen accessory kits, atomic absorbtion spectrophotometers, gas chromotographs, all necessary microbiological testing equipment, and much more.

The laboratory is available to and used by the students on a twenty-four hour basis, seven days a week.

Student Financial Support

During the tenure of the demonstration training program grant, approximately twenty students per semester were selected for 100 percent financial support for tuition, books, and fees. In 1978, this support began to be reduced in preparation for the program's eventual discontinuance as projected for the fall of 1980. Reduction was to 50 percent financial support for tuition, books and fees to the extent that budget limitations could support.

Table 3 notes the number of students receiving financial support each semester and the percentage of assistance during the demonstration training.

TABLE 3

STUDENT FUNDING SUPPORT

Year	Semester	No. of Students	% of Support
1975-76	Fall	22	100
	Spring	22	100
1976-77	Fall	37	100
	Spring	37	100
1977-78	Fall	34	100
	Spring	36	100
1978-79	Fall	14	100
	Fall	14	100
	Spring	29	100
1979-80	Fall	10	50
	Spring	10	50

Administration and Faculty Support

With the approval of the New York State Department of Environmental Conservation, Professor Richard B. Glazer was appointed project director by the Ulster County Community College because of his experience in curriculum development and his administrative experience in other training programs.

Professor Theodore Skaar was hired from Leicester Junior College to carry out the other responsibilities of the program. His prime responsibilities have been the recruitment, instruction, guidance and placement of students enrolled in the program. Professor Skaar also served as the assistant to the project director and involved himself in all facets of the program.

Student Recruitment

To facilitate the recruitment of students over a large geographical area, Ulster County Community College developed and printed a brochure explaining the intent of the program and the benefits that could be gained by the students. This brochure was included in a mass mailing announcing the program to every high school in the state of New York. Recruitment of students has continued to be a special effort within this state.

Of the 120 students to enroll in the Water Quality Monitoring program since 1975, 119 were surveyed to determine their sex, county of origin, (Ulster or other) and whether they had transferred from another college or from a different program within Ulster County Community College into the Water Quality Monitoring program. Table 4 presents this information in terms of percentages by year of enrollment during the demonstration training program.

As can be seen from table 4, the number of out-of-state and out-of-county students diminished significantly by 1980. This drop most probably is

TABLE 4

ENROLLMENT PERCENTAGES BY SEX, YEAR, AND ORIGIN

First	Sex		State of Origin		Counties in N.Y.		Transfer	
	M %	F %	N.Y. %	Others %	Ulster %	Others %	UCCC %	Others %
Fall 75	75	25	72	28	36	64	24	24
Fall 76	79	21	63	37	50	50	26	26
Fall 77	88	12	65	35	55	45	27	12
Fall 78	80	20	53	47	84	16	06	33
Fall 79	62	38	86	14	81	19	25	06
Fall 80	67	33	100	0	89	11	11	17
TOTAL	72	28	73	27	75	25	21	19

attributable to the decline in federal support which, in turn, required increases in out-of-state tuition.

The increase in the number of female students was unexpected but welcome. In our many trips to local high schools, we encouraged women students to enroll in the program, but did not expect the large number that registered. At this time, the ratio is approximately 60 percent men to 40 percent women.

CHAPTER 2

ALTERNATIVE APPROACHES TO CURRICULUM STUDY

One of the prime advantages of using the behavioral objectives format in this curriculum is that it provides instructors and curriculum developers the flexibility to develop a multitude of pathways. This approach enables instructors to meet varying or changing training and technician needs in a way that would not be possible using the classical course description approach. These pathways enable students to enter and proceed through the curriculum from different entry points, or to obtain partial skills which may not lead to a degree but will still make the individuals employable or more useful in their occupations. Some of these alternative approaches are discussed below.

Complete Curriculum

To explain adequately the relationship of the environmental courses to each other and to the other courses in the curriculum, the catalogue descriptions of the environment science courses are shown in figure 3.

The sequence in which each course in each subject area should be taken and the relationship of one subject area and course to another are noted in figure 4. The service courses in chemistry, biology, mathematics, and English are to be taken in the semester prior to the one in which mastery of the subject area is needed for the environmental science sequence. The social science course and the electives can be taken wherever it best fits into the student's two-year schedule.

ENV 101 WATER QUALITY LABORATORY TECHNIQUES I 3 s.h.

This course assists the student in learning the use of basic laboratory equipment instruments and glassware. The analytical techniques for microbiological sampling and analysis will also be studied. The student will elarn how to collect data, report 1 and interpret results, recognize abnormal conditions, and implement necessary changes. The student will also learn asepsis and safety considerations in sampling and laboratory analysis. 1 hour lecture, 5 hours lab.
Fa. '83

ENV 102 WATER QUALITY LABORATORY TECHNIQUES II 3 s.h.

The purpose of this course is to assist the student in learning the analytical techniques for the list of analyses necessary for monitoring in the National Pollutant Discharge Elimination System. The procedures for sampling, analyzing, interpreting and reporting results will be discussed. Safety in the laboratory will be stressed. The student will learn how to recognize abnormal results in procedures and how to remedy these situations. 1 hour lecture, 5 hours lab.
Sp. '84

ENV 103 WATER QUALITY CONTROL PROCESSES 3 s.h.

This course assists the student in learning to name and recognize the unit processes found in various types of municipal and industrial wastewater treatment plants in order to communicate with plant operating personnel. The student will learn why the unit processes are sequenced like they are and what change in the wastestream is brought about by each unit process and sequence of unit processes. The effects of the wastewater characteristics on the treatment process and receiving stream will be given and used for determining the type of sample to be taken to characterize the wastestream for process control or regulatory purposes. The student will be able to prepare flow diagrams of unit processes which would be needed to accomplish given effluent requirements. Prerequisite: ENV 102 and CHE 103 or permission of the instructor, 3 hours lecture.
Sp. '84

ENV 201 WATER QUALITY LABORATORY TECHNIQUES III 3 s.h.

A continuation of the practices and procedures developed in ENV 102. Prerequisite: CHE 103-104 and ENV 102 or permission of instructor. 1 hour lecture, 5 hours lab.
Fa. '83

ENV 202 WATER QUALITY LABORATORY TECHNIQUES IV 3 s.h.

Analysis of priority pollutants will be performed using such analytical tools as Atomic Absorption, Gass Chromatography, and Biossay. The student will, on

Figure 3. Catalogue description of environmental science courses

Figure 3--Continued

an individual basis, develop competence on those instruments which are currently being used to detect hazardous and toxic wastes. During the final week, an actual industrial sample will be completely categorized. Prerequisite: ENV 201 and 203 or permission of the instructor. 1 hour lecture, 5 hours laboratory.
Sp. '84

ENV 203 WATER QUALITY LABORATORY MANAGEMENT I 3 s.h.

This course assists the student in preparing an inventory of the supplies and equipment used for the laboratory control procedures. The student will learn how to: use chemical catalogues for ordering supplies and equipment, prepare daily, monthly and annual reports for laboratory and regulatory purposes, and make presentations on the laboratory operations and procedures to operators in the plant and visitors to the plant who have no technical background. The student will also practice instructional techniques to use in instructing new trainees who will work under his direction. Prerequisite: ENV 102-103. 3 hours lecture.
Fa. '83

ENV 204 WATER QUALITY LABORATORY MANAGEMENT II 3 s.h.

This course aids the student in the design and implementation of a monitoring and surveillance program. This will include selecting sampling points, times of sampling and types of samples, collecting samples, transporting and preserving samples, preparing reports, interpreting data and suggesting actions to take. The student will learn how to select, fill out and submit reports required by local, state and federal legislation. Prerequisite: ENV 102, ENV 201, and ENV 203 or permission of the instructor. 3 hours lecture.

ENV 205 WATER QUALITY LABORATORY TECHNIQUES V 4 s.h.

The first section of the course presents the basic principles of bioassay as a monitoring procedure. The second part of the course assists the student in learning to make measurements for volume, quantity of flow, time of flow, cross sectional area of stream and velocity for bodies of water using such instruments as: pygmy current meter, price current meter, staff gauge, float recorder, weirs, venturi meter, parshall flume, and orifice meter. Prerequisite: MAT 105 and ENV 102. 5 1/4 hours lecture.
Sp. '84

ENV 281 COOPERATIVE EDUCATION 1 s.h.
ENV 282 COOPERATIVE EDUCATION 2 s.h.
ENV 283 COOPERATIVE EDUCATION 3 s.h.

Prerequisite: In order to participate in the work experience, the student must earn at least a 2.0 grade point average in the Water Quality Monitoring Program during the first year.

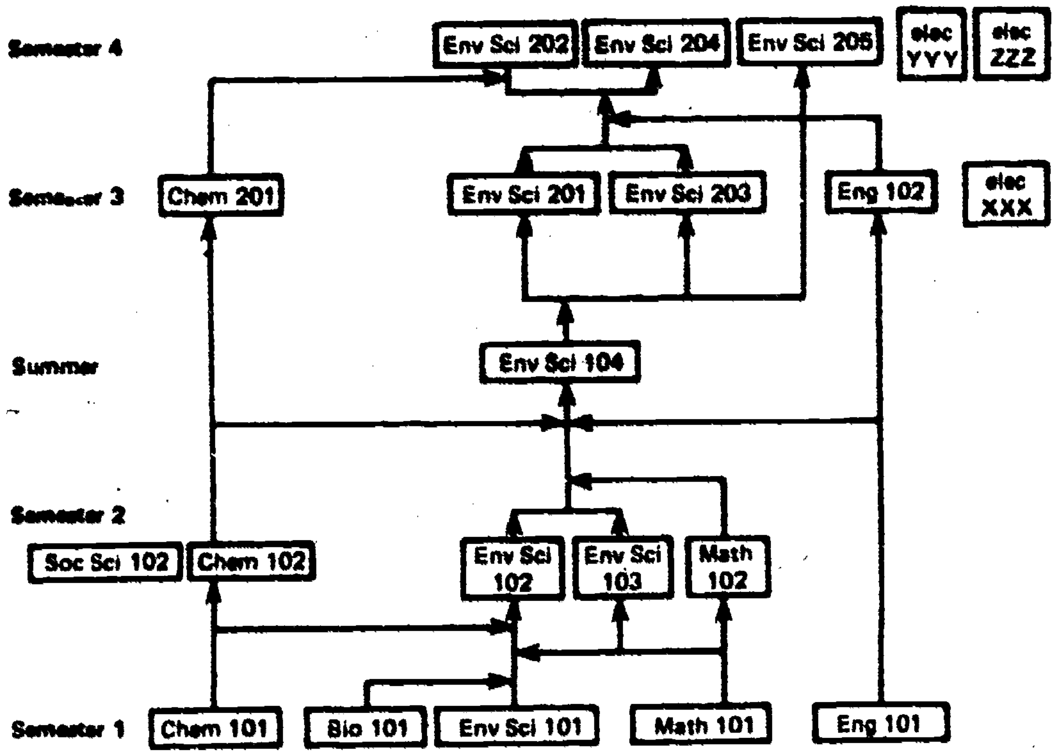
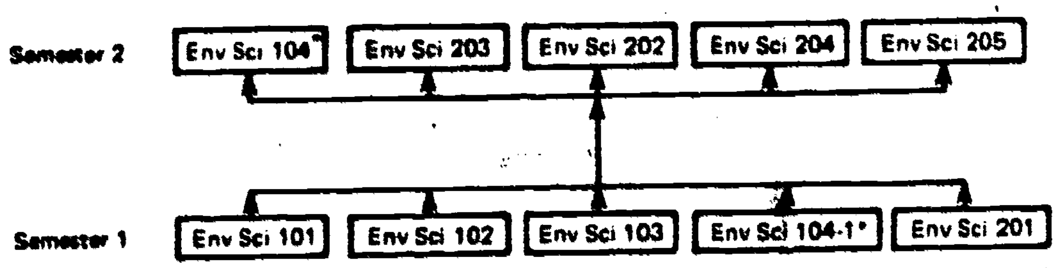


Figure 4. Sequence and subject area relationship

In all subsequent examples, the trainee must meet required prerequisites or demonstrate mastery of the skills at the performance level indicated in the individual curriculum courses.

Entry with Associate Degree in the Sciences or Related Fields

A trainee entering the program with an associate degree in the sciences or related fields is allowed credit for all courses successfully completed. An example of this would be a prior degree in the sciences as illustrated in figure 5. Thus a program can be designed to provide these trainees with the knowledge and skills necessary to complete the environmental science sequence in about one year.



*Env Sci 104 is divided so that 1 credit hour is taken the first semester and 2 credit hours the second semester. Alternatively, the course could be taken during the regular summer practicum at the end of the second semester, or it could be taken as an independent study course consisting of part-time work in a treatment plant during the school year.

Figure 5. Entry with associate degree

Entry for Treatment Plant Operator

The program offers treatment plant operators the opporunity to develop their knowledge and skills in the laboratory control area without having to complete the entire degree sequence. Figure 6 belows suggests a sequence for obtaining these skills.

The material in Environmental Science 104 could be mastered in the trainee's lab at any time during the traing program. The trainee can proceed through both stems simultaneously. Because of prior work experience, many treatment plant operators may be able to omit Environmental Science 103.

Entry for Specific Tasks

Since each unit is independent, each objective can be isolated and sequenced to provide a variety of instructional (critical) pathways for training technicians to do specific tasks. For instance, two of the major areas required in the NPDES monitoring program are the determination of indicator organisms (namely, fecal and total coliforms and fecal streptococci) and

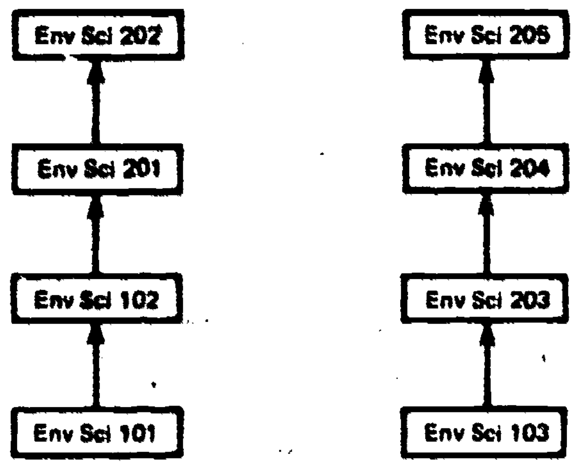


Figure 6. Entry for treatment plant operator

nutrient analysis of organic and Kjeldahl nitrogen, ammonia, nitrate, nitrite, orthophosphate, and total phosphorous. If it becomes necessary to train a technician to perform basic tests or, conversely, if technicians on their own desire to learn how to do these tasks, they can be prepared or can prepare themselves by selecting those objectives which pertain to mastering the techniques, as noted in figure 7. ("Math 101 12" indicates objective 12 of the course Mathematics 101, which can be found on page 44 of the Water Quality Monitoring program curriculum and Chem. 101 45 ajl" indicates objective 45, parts a, j, and l, of the course Chemistry 101, which can be found on page 29 of the Water Quality Monitoring program curriculum).

These pathways were put into book form and are available under the titles Nutrients: Learner's Guide for a Critical Path in Water Quality Monitoring (Glazer, Skaar, and Allen 1979a) and Indicator Organisms: Learner's Guide for a Critical Path in Water Quality Monitoring (Glazer, Skaar, and Allen 1979b).

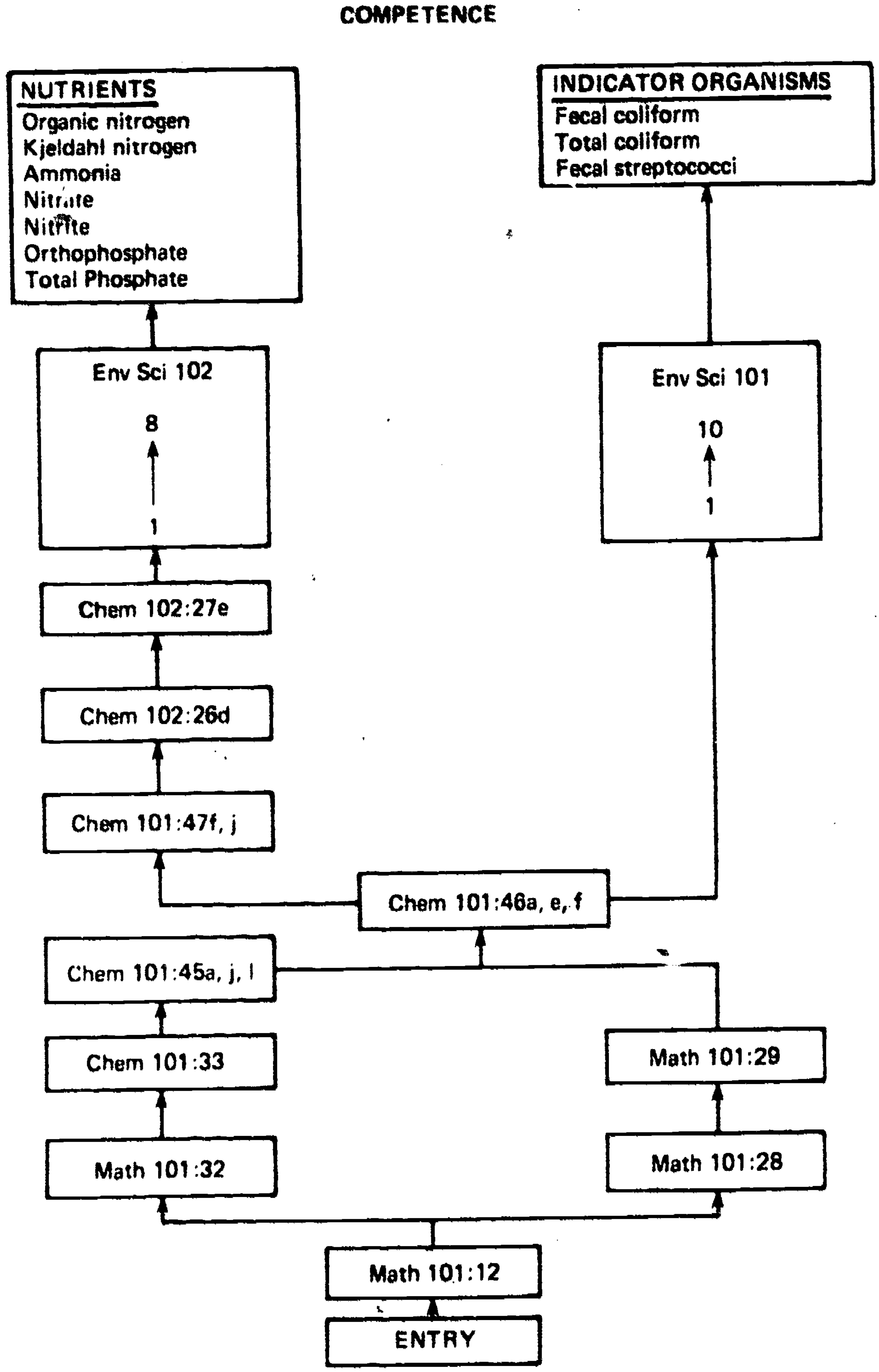


Figure 7. Critical paths

Student Success

It is difficult to measure academic success using graduation as an index. One reason for this is that a number of students who have successfully completed the program do not apply for graduation as they already hold an associate of arts and sciences or bachelor of science degree. This situation becomes even more difficult to assess when we recognize that there are at least five students who are part-time in the program and several others who will require three years of full-time study to graduate. These particular students are either taking a minimum load of twelve hours per semester or have failed courses that they must repeat in order to graduate.

Typical attrition during the freshman year is approximately four students. Normally, one student, possibly two, will fail during the second year. Attrition, then, runs no more than 24 percent. This is a low attrition rate for a rigorous, two-year science technicians program, and is well below the college norm.

Employment/Transfer

The Water Quality Monitoring program was designed to be a career program. At this time, there have continually been more jobs available than graduates to fill them. In January 1981, the Passaic Valley Sewer Commission notified Ulster County Community College that they were seeking to employ two hundred students graduating at the end of the spring 1981 semester.

Each year prior to graduation, a notice of graduation is mailed to over six hundred potential employers. This notice has consistently brought more job offers than graduates available. Some of these employers are shown in table 5.

TABLE 5

EMPLOYERS OF WATER QUALITY MONITORING PROGRAM GRADUATES

Company	City	No. Employed
International Business Machines	Kingston, NY	5
International Paper	Tuxedo, NY	4
Ecological Analyst	Middletown, NY	3
New York State DEC	New Paltz, NY	3
Sterns and Wheeler	Syracuse, NY	2
City of Kingston	Kingston, NY	2
County of Ulster	Kingston, NY	2
CAMEO Engineering	Poughkeepsie, NY	2
Star Industries	Newburgh, NY	2
Virginia, Department of Environ. Protect.	Richmond, VA	2
Municipal Wastewater Facility	Hopewell, VA	2
Wehran Engineering	Middletown, NY	2
Griswald and Foss Environmental Lab	(address unknown)	1
New & Used Water Specialis	Wappingers Falls, NY	1
Love Canal Project Consultants	Buffalo, NY	1
Stratmore Paper Company	Westfield, MA	1
PASNY - Indian Point Nuclear Plant	NY	1
New York State Gas and Electric	Binghamton, NY	1
Envirodyne Systems	Chicago, IL	1
City of Poughkeepsie	Poughkeepsie, NY	1
Northen Dutchess Community Hospital	Rhinebeck, NY	1
Saratoga County Sewer District	Saratoga, NY	1
Town of Rosendale	Rosendale, NY	1
City of Newburgh	Newburgh, NY	1
Cornell University	Highland, NY	1
Brinner and Larios	Kingston, NY	1
City of Portland, Maine	Portland, ME	1
Connecticut Department of Environ. Protect.	Hartford, CT	1
City of Amsterdam Municipal Wastewater Facility	Amsterdam NY	1
Town of Roscoe Wastewater Treatment Plant	Roscoe, NY	1

Approximately 50 percent of the Water Quality Monitoring students transfer to four-year institutions and 50 percent go directly to work. This upward mobility was ensured when through a cooperative effort, the bachelor's of engineering technology (BET) program in water resources was designed and implemented at the Pennsylvania State University, Capitol Campus in Middletown, Pennsylvania.

The Penn State program is a junior-senior-level program. In its design, it included the Ulster Water Quality Monitoring program as one of its transfer bases. This has allowed our students ready transfer to the university. Ten of the Ulster program's former students have graduated from Penn State and are employed as environmental engineers.

A formal transfer program is also in effect with the State University of New York (SUNY) college at Plattsburgh in the environmental science curriculum. Students have also transferred to SUNY Binghamton (environmental science), SUNY New Paltz (environmental geology), Clarkson College (environmental engineering), and Syracuse University (environmental science).

At this point in time, the transfer success and employment record of the program graduates are uniquely high. Indicators such as student success after transfer, student success upon employment, and employer requests for Water Quality Monitoring graduates from Ulster County Community College indicate that outside acceptance of the program has been achieved to a marked degree.

The average starting salary has now gone beyond the $13,500 mark. Many of the job opportunities for the 1983 class are starting at $17,000 per year.

CHAPTER 3

THE FUTURE

The future of the program looks healthy and promising. The lowest enrollments were in 1981 and 1982 during the deemphasis of national environmental programs and concerns which had been building steadily since 1970. During this period, although jobs remained plentiful, students shied away from environmental programs and appeared to be under heavy pressure to remain aloof from the environmental problems that face us. Since the spring of 1983, however, the public has apparently recovered from the Anne Burford debate at EPA and interest and enrollment in the Water Quality Monitoring Program is once again on the rise.

The curriculum and training program were designed using instructional objectives and independent, modular materials. They have lent themselves to the development of supplemental programs which, although geared toward the water quality curriculum, would serve equally as well in many other technical and liberal arts curricula. The PETITE and Micro Computer Training Program in particular are being designed to meet the training needs of a host of other courses and disciplines ranging from the health sciences, business, accounting, biological and general sciences and certain liberal arts courses.

Personal Testing and Interactive Evaluation System (PETITE)

A major step in the completion of the Educational Delivery System is the Personnel Testing and Interactive Training Evaluation system (PETITE) being developed through a National Science Foundation (LOCI) grant awarded to Ulster

County Community College in 1982. The objective of the training system is to, complete the educational delivery system by developing an automated feedback training/testing system, which is prescriptive, diagnostic, self-generating, and allows the students to retest until they achieve the grade they desire. Rather than being punitive, a test now becomes a learning tool to complement the training program or course work. While the basic approach is not new--it is used to train technicians on the Trident submarine and Polaris missile system--it has never been applied as thoroughly in a two-year educational program.

Further, the Water Quality Monitoring program, like all responsible instructional systems, requires mechanisms for evaluating student performance, as well as performance of the instruction itself. This evaluation is principally accomplished by oral or written testing and observation. Valuable time is spent in routine development, administration, and assessment of the test materials. This time spent could be much more productive with the proper support of intelligent computer assistance.

The Automatic Feedback System

The PETITE system consists of the following basic subsystems.

1. Student Information
2. Test Generation
3. Test Administration
4. Test Student Interaction
5. Test Evaluation
6. General Inquiry

The system will operate with a small, yet powerful microcomputer to be programmed to accomplish selected parts of the subsystems. Once the prototype has been developed and evaluated, these microsystems can and will be extended to serve numerous other instructional programs. This extension has the potential for significant labor saving and improved instructional assessment in which the test now becomes another learning tool interacting directly with the student.

To minimize software development costs prior to program demonstration, selected modules have been identified which have the greatest labor-savings impact. The following functions are proposed to be automated in the prototype.

A. Student Information Subsystem

1. Software will be developed to the point where the capability can be demonstrated. The design will anticipate subsequent additions.

B. Test Generation Subsystem

1. Will provide automated assistance in maintaining discrete test instrument (question) files. Approximately two hundred multiplechoice items will be electronically stored and updated into each floppy disk as needed for the instructional program. The test instrument files will contain data on how the question has performed, in addition to reference and textual data.

   a. Initially, the system will include: upper-case, alpha, and numeric characters with a forty character display width and fifteen line question length.

2. Will provide automatic assistance in constructing individualized tests. The instructor may serially scan and flag for selection those items which are to be used on a specific test. Individualized tests or series of tests will be automatically assembled on a separate floppy disk to be used by the students for on-line testing. A hard copy listing of the test may be printed.

   a. The subsystem will serve as the base for developing subsequent modules. These will feature totally automated test generation based on a predetermined objective weighting scheme, treating as many test versions as desired.

C. Test Administration Subsystems

1. Will provide automated presentation of individualized tests. Interactive testing will feature immediate feedback of the

correct answer as well as additional training necessary and objectives and modules to be used. Student response data will be stored for the test analysis module. A student hard copy grading report will be provided.

a. Subsequent modules may be developed which will provide on-line graphical presentation and extensive training prescriptive data for those items that were incorrect.

D. Test Evaluation

1. Will provide automated update of the test item statistics to the test instruments file (e.g., percentages of responses chosen) for every test administered.

2. Will provide extensive data on various modules of instruction.

3. Will provide extensive data on the characteristics of the student and there relationship of these characteristics to student success.

The primary PETITE software system will be menu-driven, placing the operator into a menu after signing-on to the computer and typing PETITE. This will display a menu of processing items from which to choose. In addition, an on-line "Help" will be built into the system. If operators are unsure about a process or option, they may type, "HELP." They will then be provided with an explanatory text on the actions they see to perform. (Appendix D shows the system specifications.)

The Local and Remote Access Microcomputer Testing-Training System

The Water Quality Monitoring program at Ulster County Community College proposed to EPA to design, develop, and implement a prototype of a microcomputer training-testing system. This system would use both a local area network and a remote communication network to support test generation, training and achievement testing, a user-based database management system, and an interactive training evaluation system. The project was funded in 1983 and is halfway to completion.

Upon completion of the system it will be used nationwide, both regionally and locally to test the knowledge of wastewater technicians, hazardous waste and enforcement personnel, and other pollution control practitioners. Testing will be in the areas of certification, monitoring, laboratory and field testing, operations, new procedures, new laws and regulations, and a host of other areas. Printed materials such as EPA's Effluent Monitoring Procedures, Operation of Wastewater Treatment Plants, Critical Paths in Indicator Organisms and Nutrients, Water Quality Audio-Visual Modules, and other job training materials will supplement the testing-training system.

The microcomputer program will be based on the Personnel Testing and Interactive Training Evaluation System (PETITE) described in the previous section.

The developed software package will run on a high-speed microcomputer with two to five hundred K-bytes of memory, one megabyte 5 1/4" floppy disk storage, and twenty to sixty megabytes of hard disk storage. The microcomputer will support up to ten workstations working independently and simultaneously using the multi-user Oasis Basic Operating System.

The host microcomputer will service a remote communication network that will communicate with intelligent terminals in any wastewater facility, laboratory, or training center in the country. A local area network, through a dedicated line, will link the host microcomputer to the water quality offices, training rooms, or laboratories within two thousand feet. This will provide the opportunity for in-house training within the college. A cluster of three terminals will link directly to the microcomputer for direct student training and testing. This prototype can be used in any facility or region in which EPA desires a similar training-testing system.

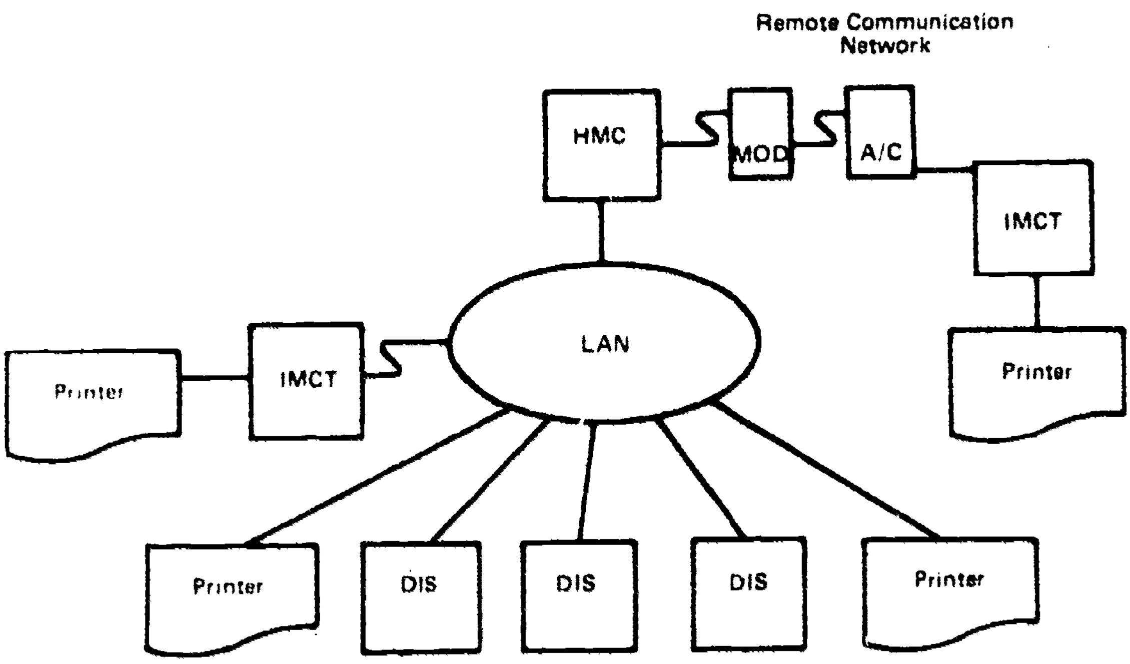
The objectives based learning materials produced for EPA by the Water Quality Monitoring program at Ulster County Community College and other colleges, universities, and training centers, will be used to integrate the training process, making it a self-pacing, interacting, user-based, training-testing system.

To ensure that the operating system has the speed, portability, and expandability desired of a multi-user microcomputer, the operating system selected for development of PETITE was Oasis, manufactured by Phase I Systems, Inc. Oasis provided a microcomputer operating system with features traditionally associated with large, mainframe computer systems. Oasis is capable of multi-user processing with upward compatible growth to the newer, more powerful sixteen bit processors. Using Oasis has provided the system with a powerful, planned growth environment. In addition, the recent advent of inexpensive, rapid access, hard disk systems (winchester disks) coupled with operating systems such as Oasis, have resulted in microcomputers that approach the performance of much larger systems at a fraction of the cost.

The training-testing system will include as hardware the host high speed multi-user microcomputer with no less then two hundred K-bytes of memory, one megabyte 5 1/4" floppy disk storage, and twenty to sixty megabytes of hard disk storage. The microcomputer will support up to ten work stations working independently and simultaneously, using the multi-user Oasis Operating System. This microcomputer system will service a local area network, a remote communication network, and on-line central terminals and printers. The system can be readily adapted to operate with remote Apple computers (or equivalent) serving as intelligent terminals into the multi-user microcomputer (see figure 8).

The staff to develop and implement the training-testing system will be drawn from the faculty and staff of Ulster County Community College, presently involved in the development of the PETITE system.

The system will be housed at Ulster County Community College. The remote communication network will support an intelligent microcomputer terminal (Apple or equivalent) in a waste treatment plant within driving distance from the college. The local area network will connect to an Apple II microcomputer in a separate building on the college campus. Three CRTs with two printers will be housed in the Water Quality lab and connected directly to the host microcomputer.



HMC	Host Microcomputer
MOD	Modem
A/C	Acoustical Coupler
IMCT	Intelligent Microcomputer Terminal
LAN	Local Area Network
DIS	Display

Figure 8. Diagram of the local and remote microcomputer network

CHAPTER 4

CONCLUSION

The educational delivery system presented here encompasses the use of behavioral objectives as its foundation and builds upon this foundation to form a complete system whose outcome can be measured, evaluated, and readily modified. Because of the manner in which the system is structured, it is also highly flexible and transportable. With the addition of the Learner's Guide, audiovisual materials, and the personal Testing and Interactive Training Evaluation System designed for microcomputers, along with the microcomputer automated feedback testing-training system, the education delivery system becomes a nonpunitive, interacting learning process.

The system is a prototype for a host of other disciplines. It enables the educator to develop an "academic cafeteria." Through it, the student can search and select those objectives (learning units) that meet their specific needs and goals and that ensures a much greater degree of success for them in their studies or training.

APPENDICES

APPENDIX A

FOUR WATER QUALITY BOOKS by
ULSTER COUNTY COMMUNITY COLLEGE FACULTY

Glazer, R. B.; Austine, J. H.; and Allen, J. F. A Two-Year Water Quality Monitoring Curriculum. Washington, DC: EPA, 1975.

Glazer, R. B.; Austine, J. H.; Allen, J. F.; and Skaar, T. J. Learner's Guide to Water Quality Monitoring. Washington, DC: EPA, 1978.

Glazer, R. B.; Skaar, T. J.; and Allen, J. F. Indicator Organisms: Learner's Guide for a Critical Path in Water Quality Monitoring. Washington, DC: EPA, 1979.

Glazer, R. B.; Skaar, T. J.; and Allen, J. F. Nutrients: Learner's Guide for a Critical Patin in Water Quality Monitoring. Washington, DC: EPA 1979.

APPENDIX B

EQUIPMENT AND SUPPLIES FOR A WASTEWATER LABORATORY

A. Equipment

1. Clock, interval timer
2. Deionizer
3. Refrigerator, at least 10 cubic-foot capacity
4. BOD incubator
5. Water still
6. pH meter
7. Balance, triple beam
8. Balance, analytical
9. Desiccator
10. Drying Oven
11. Muffle furnace
12. Pressure-vacuum pump
13. Bunsen burner
14. Hot plate
15. Water bath
16. Spectrophotometer
17. Kjeldahl apparatus, digestion
18. Kjeldahl apparatus, distillation
19. Gas analysis (CO_2)
20. Wastewater sampler
21. Chlorine colorimeter
22. Amperometric titrater
23. Condenser
24. Microscope and light
25. Sterilizer
26. 44.5°C incubator

B. General Supplies

1. Apron
2. Brushes
3. Funnels
4. Spatula
5. Wax pencils
6. Lubricants
7. Glassware cleaner
8. Face shield
9. Neoprene gloves
10. Graph paper

C. Analytical Supplies

1. Sample bottles
2. BOD bottles
3. Wash bottles
4. Dropping bottles
5. Test tubes
6. Nessler tube

This list of equipment and supplies is for a "typical" wastewater or water quality control laboratory. However, the instructor should select from the list those items that apply to the NPDES tests and should not expect to have all the equipment and supplies. The instructor may also have to obtain materials not found on the list but which are necessary for NPDES tests.

7. Erlenmeyer flask
8. Volumetric flask
9. Filtering Flask
10. Kjeldahl flask
11. Round bottom flask
12. Separatory funnel
13. Buchner funnel
14. Funnel support
15. Buret and caps
16. Buret clamp
17. Buret support
18. Gooch crucible
19. Crucible holder
20. Crucible tongs
21. Pipets
22. Safety pipet filler
23. Beakers
24. Graduated cylinder
25. Evaporating dish
26. Petri dish
27. Opal glass plate
28. Glass fiber filter disc
29. Glass beads
30. Rubber stoppers
31. Rubber tubins
32. Utility clamp
33. Tripod
34. Filter paper
35. Thermometer

D. Chemical Suplies

1. Methylene blue solution
2. Buffer solution
3. Phenolphthalein indicator
4. Thymol blue indicator
5. Methyl orange indicator
6. Manganous sulfate
7. Sodium thiosulfate
8. Starch
9. Calcium chloride
10. Ferric chloride
11. Magnesium sulfate
12. Phosphate buffer
13. Ferrous ammonium sulfate
14. Potassium dichromate
15. Sulfuric acid-silver sulfate
16. Ammonium chloride
17. Nessler reagent
18. Rochelle salt
19. Zinc sulfate
20. Sodium arsenite
21. Standard nitrate solution
22. Boric acid
23. Sodium hydroxide
24. Sodium thiosulfate
25. Sulfuric acid-mercuric sulfate-potassium sultate
26. N-Butanol reagent
27. Chloroform
28. Alkaline iodide azide
29. Potassium iodide
30. Arsenite
31. Sodium sulfate
32. Brucine-sulfanilic acid
33. Mercuric sulfate
34. Sodium hydroxide-sodium thiosulfate
35. Calcium chloride
36. Silicic acid
37. Sulfuric acid
38. Ferrion indicator solution
39. Zonite
40. Potassium chromate
41. Silver nitrate

APPENDIX C

AUDIOVISUAL SELF-PACING MODULES

1. Nitrate
2. Orthophosphate
3. Fluoride
4. Sulfide
5. Sludge Filterability
6. Sulfate
7. Grit Analysis
8. Bromide
9. Copper by Atomic Absorption
10. Sludge Age
11. Operation of the Spectronic 70
12. Determining the Optimum Wavelength of a Colored Solution Using the Spectronic 70
13. Color and Odor
14. Suspended Solids
15. Specific Conductance
16. Hardness
17. Acidity and Alkalinity
18. Grab Sampling and Composite Sampling
19. How to Dry to Constant Weight
20. Coliform by MPN

APPENDIX D

PETITE SPECIFICATIONS

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REFERENCES

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