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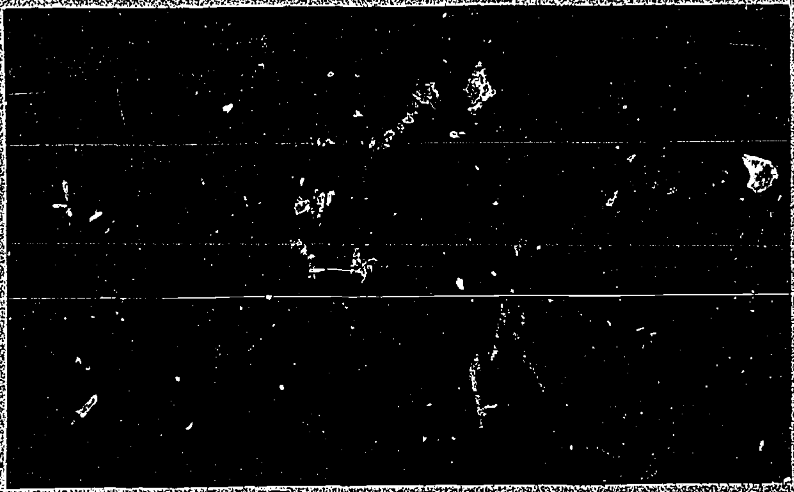
ABSTRACT

This document describes the Science Cluster College (SCC), a part of the Modular Achievement Program (MAP) at Bowling Green State University. The SCC offered a science seminar, survey courses, and laboratory work. The seminar emphasized creative aspects of scientific activity, the nature of scientific knowledge, inductive and deductive logic, science and values, and a historical analysis of concepts of space and time. The survey courses covered the principles or concepts of the six disciplines: Biology, Chemistry, Computer Science, Geology, Mathematics, and Physics. The laboratory work consisted of independent laboratory investigations. Grading, program evaluation, evaluation instruments, item classification categories, and student opinions of the program are included. Related documents concerning components of the MAP program are HE 005 102, 005 078, 005 082, 005 081, 005 080, 005 101, 005 077, and 005 079. (MJM)



Modular Achievement Program/Bowling Green State University

ED 087288

A Final Report On The First
Science Cluster College

Spring, 1973

A FINAL REPORT ON THE FIRST SCIENCE CLUSTER COLLEGE

Spring, 1973

The Students

Ninety students, all but four of whom were third quarter freshmen members of the Modular Achievement Program (MAP), participated in the Science Cluster College. Sixty percent were from the College of Arts & Sciences, 24% from Education and 15% from Business Administration. One student was from the School of Music. All were, at the time of enrollment, non-science majors with high school science and math backgrounds typical of a cross section of Bowling Green State University freshmen. The major motivation for participation was the desire to fill the science and math group requirements of the various colleges. Approximately 70% of the students lived in Prout Hall where most of the classroom sessions were conducted.

The Staff

Faculty members who participated were:

Full-time

Dr. William Baxter, Biology (Director)
Dr. Thomas Crumm, Chemistry
Dr. John Howe, Geology
Dr. Leland Miller, Computer Science
Dr. Charles Shirkey, Physics

One-half time

Dr. Charles Applebaum, Mathematics
Dr. Michael Bradie, Philosophy
Dr. Waldemar Weber, Mathematics

In addition there were six half-time graduate students from the various departments assisting in tutoring, grading tests, directing laboratory projects, etc.

The Program

A. Science Seminar (3 hrs. credit). The seminar, conducted by Dr. Michael Bradie, Philosophy, met in sessions of about 2 hours each, twice a week. A lecture presentation of approximately one hour was followed by small group discussions led by the other faculty. Emphasis was placed on the creative aspects of scientific activity, the nature of scientific knowledge and "proof," inductive and deductive logic, science and values and a historical analysis of concepts of space and time. Grading was based on four brief papers by the students on topics relevant to the major themes of the seminar.

B. Survey courses (5 hrs. credit). During the first five weeks the students attended survey courses covering the principles or concepts of the six disciplines; Biology, Chemistry, Computer Science, Geology, Mathematics, and Physics. Each survey section met for a total of 12 hours of lecture and discussion. Objective tests over each area were the basis for grading. Students were required to demonstrate a minimum level of proficiency in each area to satisfy the group requirement. Those students who scored below a C on one or more of the area tests were given an opportunity to take another test to attempt to remedy the deficiency. The scores on the second test were used only to determine minimum proficiency and were not added to original scores. Students who remained below minimal standards following retesting were told by the Cluster faculty what science or math courses they should take to satisfy their group requirement.

C. Laboratory (7 hrs. credit). The last five weeks of the quarter were devoted to independent laboratory investigations. Students selected one of the six disciplines in which to work on projects relating to investigations of an aquatic ecosystem (pond) or of color. Students worked closely with faculty or graduate students on projects of their choosing. Students were expected to work at least 25 hours per week on the projects. Most worked in groups of two or three, but each student was required to write a report of his findings in acceptable scientific style. Prior to submission of the final lab reports, preliminary drafts were reviewed by the staff to ensure that the projects were judged on scientific merit and not simply on the style of the paper.

Grading was based on evaluation of the final reports by at least three members of the cluster faculty.

During the lab investigations students from the various disciplines who were working on the same major area met weekly to share their experiences and findings. These sessions also illustrated the integrated structure of science, in that on numerous occasions solutions to research problems were provided by students from another research team.

It should be emphasized that the majority of lab projects were developed "from scratch" by the students. Time and equipment availability placed limits on what could be attempted, but for the most part, students were able to design simple experiments or equipment to study a topic of interest to them.

This approach reduced the time available for gathering data, since a major effort was required to design and set up an experiment, but it had the advantage of forcing students to be creative and not simply follow a "recipe" for a laboratory exercise.

Special Events

A number of special lectures or activities were provided the Cluster students. A listing of the lectures may be found on the program calendar sheets included at the end of this report. Of special significance was a day-long trip to Chicago to visit the Museum of Science and Industry and the Field Museum of Natural History. Students spent several hours viewing the teaching exhibits at the museums and faculty conducted informal seminars on special topics of interest. Even though students paid a major portion of the cost and spent about 11 hours on a bus, their post-course evaluation comments consistantly rated the trip as a highlight of the program.

Grades

A. S-U option.

A total of 46 students (51%) elected to take at least one portion of the Cluster for S-U credit. Twenty-four chose S-U for one course only, 10 took two courses S-U and 12 took the entire program S-U. Of the 84 S or U grades given, 69 (82%) were S and 15 (18%) were U. A breakdown for each course shows: Science Seminar, S = 22 (100%) U = 0; Survey, S = 28 (70%), U = 12 (30%) and Laboratory S = 19 (84%), U = 3 (16%).

B. Letter Grades

1. Science Seminar. Letter grades were distributed as follows: A = 10 (14%); B = 30 (44%); C = 22 (34%); D = 1 (1%); F = 5 (7%). Grade average for the course, 2.57.

2. Survey. A = 9 (18%); B = 9 (18%); C = 23 (48%); D = 7 (14%); F = 1 (2%). Course grade average, 2.37.

3. Laboratory. A = 21 (29%); B = 26 (37%); C = 13 (19%); D = 6 (9%); F = 4 (6%). Course grade average, 2.77.

4. The overall grade point average, GPA, based on 2,663 quality points for 939 hours of credit, was 2.62. It is probable that this GPA is slightly higher than would have been the case if there had not been so many S-U options exercised, since students tend to select S-U for courses that they suspect they will have the most difficulty in.

C. Deficiency recommendations. Twenty four did not satisfy the group requirement owing to failure to achieve minimal standards in one or more areas. The Cluster faculty, acting as a committee of the whole, made recommendations of what courses each student needed to take to complete the group requirement. Copies of the recommendations are on file at the MAP Office.

Program Evaluation

The designed program outputs of the Science Cluster, as defined in the original Statement of Objectives, Program and Evaluation, are presented below in outline form.

Objective evaluation data will be found following each major area.

I. Science Seminar

A. General Objective. Understanding the nature and methods of Science; a consideration of Science and Scientists.

Specific Objectives

1. Understand the nature of Science through the following:
    a. familiarity with the history of Natural Science.
    b. appreciation of the aims and limitations of Science.
    c. knowledge of the applications of Science (technology).
    d. practice in the manner in which Science resolves conflict involving competing ideas.
    e. appreciation of the possibilities of Science as an avocation.
    f. consideration of how Science and Scientists deal with value questions (Science and Society).
2. Understand the methods of scientific investigation through the following:
    a. familiarity with the elements of scientific logic (Induction and Deduction).
    b. consideration of the value and limitations of the "Scientific Method."

B. Evaluation Instruments

1. Evaluation of student progress. Students were graded on the basis of four papers required at two-week intervals. They were asked to select a topic from several suggested or develop their own topic of interest. Students were expected to critically evaluate a particular

scientific problem relating to topics discussed in class.

While most of the students completed the required assignments and many showed important insights, the general level of analysis tended to be superficial and rather poorly written in terms of style, grammar and spelling. Often these mechanical flaws obscured the possible significance of the students' analysis. Some formal testing of factual information given during the lecture presentations would have been helpful.

2. Program Evaluation. An objective pre and post test concerning Science and Scientists was used to evaluate this phase of the Cluster. The test consisted of 25 multiple choice items and was developed locally. The instrument was patterned to a small extent after a Test on Understanding Science (TOUS), distributed by Education Testing Service. Two preliminary forms of the test were given to students in Biology 439 and Physics 100 to identify items that were ambiguous, too hard or too easy. A copy of the revised test is attached.

The test was given to all Cluster students at an evening session at the start of the quarter. A control group of 38 Non-Cluster MAP students also took the test on the following evening. It should be kept in mind that the Non-Cluster group contained a high percentage (about 60%) of students who were majors in one of the physical sciences. Science majors were not included in the Cluster.

At the close of the quarter, the <u>same</u> test was given to both groups. The following results were obtained:

Pretest	Mean	S.D.	N
Cluster	12.9	3.6	90
Non-Cluster	15.2	3.1	38

Posttest	Mean	S.D.	N
Cluster	14.0	3.4	85
Non-Cluster	16.2	2.6	37

Calculation of a reliability coefficient, based on the correlation of the two sets of scores for the control group (retest method) yielded a value of r = .81. The time period between administrations of the test was believed great enough to eliminate the effect of memory of items. Significance testing (One-way Analysis of Variance) showed that:

a. The Non-Cluster group performed significantly higher ($P < .05$) than the Cluster students in both the pre and post tests.

b. Both groups improved significantly ($P < .05$) on the post-test when compared to the pre-test.

c. It was postulated that student attitudes, influenced by their success in the program, might alter their willingness to take the post-test seriously. To test this idea the Cluster students were divided into two groups on the basis of whether or not they were above or below minimal standards for the examinations given in the survey portion of the program. The performance

of the two groups was as follows:

Below Minimum	Mean	S.D.	N
Pre-Test	12.0	3.7	24
Post-Test	11.7	3.5	26

Above Minimum	Mean	S.D.	N
Pre-Test	13.3	3.6	67
Post-Test	15.1	2.9	59

It appears that those students who knew at the time of the post-testing session that they would receive a failing grade for the survey, probably didn't work as conscientiously as the others. Their performance on the other post-tests is likely to have been influenced in a similar fashion.

d. Conclusion: The significant improvement by Cluster students on the test suggests an increased knowledge of the terms, processes and methods of Science. The lecture portion of the seminar did not stress terms or definitions and no objective testing directed at determining a grade was conducted. The increased understanding of the students was thus a result of their learning in an informal way. It would seem desirable in any future seminar to deal with this body of information in a more direct manner during lecture/discussions and include objective testing during the quarter.

II. Survey courses

A. General Objective. Introduce students to the subject matter of the Natural Sciences.

Specific Objectives

1. Understand the fundamental concepts and principles of the various disciplines.

2. Understand the interrelatedness of the various disciplines through demonstrated integration of principles and concepts.

3. Develop scientific literacy (vocabulary, terminology, conventions, symbols, etc.)

B. Evaluation Instruments

1. Evaluation of Student Progress. Two comprehensive, objective examinations, given at the conclusion of each survey cycle were used to determine grades. Four disciplines were tested on each occasion; Chemistry, Physics, Math and Computer Science on test 1; and Biology, Geology, Math and Computer Science on test 2. Each discipline had a total of 40 points with a score of 20 the lowest passing mark. Samples of the exams are available in the MAP Office.

2. Program Evaluation. Two types of Sequential Tests of Educational Progress (STEP) examinations developed by Educational Testing Service were the major instruments used to evaluate this portion of the program. Mathematics Basic Concepts, forms 1A and 1B, were used as pre and post tests for general math concepts. General Science, forms 1A and 1B, were used to evaluate general knowledge of the natural sciences. Forms 1A and 1B are appropriate for

testing of either fall-quarter freshmen or spring-quarter sophomores and National Norms for these groups are available. A brief description of each test and the results follows:

a. The STEP Mathematics Basic Concepts test measures the basic mathematical concepts, abilities, and skills that should be a part of the general mathematics education of all students. Each one-part test requires 40 minutes of working time and contains 50 items.

Item Classification Categories

Ability

Recall Facts and/or Perform Mathematical Manipulation: the ability to recall a definition, fact, or theorem or to apply a learned technique. A decision on how to approach the solution is not required (32% of items).

Demonstrate Comprehension of Mathematical Concepts: the ability to solve problems that require some understanding of the underlying concepts. The student must decide both what to do and how to do it. (64% of items)

Exercise Ingenuity or Higher Mental Processes: the ability to develop one's own technique for solving a problem or to generalize, evaluate, and make logical inferences or decisions about the sufficiency of data.(4% of items)

Content

Number and Operation. (24% of items)

Geometry, Measurement, Logic, and Proof. (18% of items)

Alegbraic relations, Sets, Equations, and Inequalities. (18% of items)

Application. (12% of items)

Probability and Statistics. (28% of items)

The information tested in the STEP Math test is of a very practical nature. The Math survey for Cluster students was designed to cover the concepts and principles of the whole spectrum of modern mathematics and thus the content of the survey did not emphasize material on the STEP test. It was of interest, however, to determine if exposure to the math concepts would increase the students' performance on the STEP test. It was also of interest to compare the Cluster students' performance on the post-test with that of the Non-Cluster group.

The results were as follows:

				Percentile Rank on National Norms*	
	Mean	S.D.	N	Freshmen	Ending Sophomores
Cluster pre-test	29.6	6.8	90	58	48
Cluster post-test	32.0	6.8	88	70	61
Non-Cluster (tested only at end of quarter)	33.0	9.7	42	72	63

*National Norms include students who were science majors.

Significance testing revealed that the Cluster students improved significantly during the quarter ($P < .001$), while there was no significant difference between the Cluster and Non-Cluster groups at the close of the term. Of further interest was the fact that the Cluster students were well above the national norm for 3rd quarter sophomores. Their Cluster experience appears to have markedly influenced their ability to manipulate mathematical material.

b. The STEP Science test measures knowledge and understanding of the fundamental concepts and processes of science, the comprehension and application of this knowledge, and the mastery of science skills. Major emphasis is placed on biology; physics and chemistry receive moderate emphasis; and the earth sciences, including astronomy, geology, and meteorology, receive the least emphasis.

Part I of the two-part test consists largely of discrete items and emphasizes the important facts, principles and concepts selected from the major areas of science. Many of the items require the student to demonstrate his knowledge in a context somewhat different from that of the usual science tests. Part II of the Science test is composed largely of item sets, that is groups of items based on given information. These questions emphasize the use, rather than possession, of knowledge and ability. The individual items in the one-part tests reflect similar emphases.

Item Classification Categories

Skill

Knowledge, the ability to recall ideas, material, or phenomena. (15% of items)

Comprehension, the ability to translate ideas or material from one method of expression to another; to interpret material presented or to extrapolate from it. (25% of items).

Application, the ability to use learned information in answering an unfamiliar question or solving a new problem. (50% of items)

Higher level skills, analysis, the ability to break down material into its constituent parts and to detect the relationships among them and the way they are organized; synthesis, the ability to combine parts to produce a new pattern or structure; evaluation, the ability to make purposeful judgments of ideas and solutions. (10% of items)

Content

Biology, includes development, ecology, evolution, heredity, morphology, physiology, and taxonomy. (40% of items)

Chemistry, includes atomic structure and bonding, kinetic-molecular theory, the chemistry of particular substances, energy considerations, and fundamental terms and calculations. Some questions are laboratory oriented. (20% of items)

Physics, includes atomic and nuclear physics, electricity and magnetism, heat and kinetic theory, mechanics, optics, and waves. (25% of items)

Earth Sciences, includes astronomy, geology, and meteorology. (15% of items)

Results of the Science test were as follows:

	Mean	S.D.	N	Percentile Rank on National Norms* Freshmen	Ending Sophomores
Cluster pre-test	41.0	8.1	90	63	45
Cluster post-test	43.2	8.2	88	69	53

*National norms include students who were science majors.

The performance on the post-test was significantly improved over the pre-test. Analysis of the two parts of the exam showed that the students improved most in Part II which emphasized use of concepts and logical thinking.

c. Supplemental Questions concerning Geology and Computer Science. Owing to the fact that the STEP Science Exam had few questions on Geology and none on Computer Science, a test covering these areas was developed. It consisted of 12 multiple choice questions on Geology and 10 on Computer Science. Copies of the exam are available at the MAP office. The results of pre and post-testing, using the same exam, were as follows:

	Mean %	S.D.	N
Geology			
pre-test	45.4	12.3	90
post-test	60.6	11.7	87
Computer Science			
pre-test	30.1	11.4	90
post-test	56.0	10.9	87

Dramatic improvement was evident in both disciplines. Future Science Cluster programs probably should incorporate this type of pre and post-testing to more accurately evaluate student progress in learning specific information related to a particular discipline.

III. Laboratory

A. General Objective. Have students practice science through a series of coordinated laboratory investigations.

Specific Objectives

1. Become familiar with the specific manual skills required to perform basic laboratory operations.
2. Master the ability to communicate scientific information orally and in writing.
3. Participate in the investigation of a series of problems, the solutions of which can be seen to have significance to others conducting similar investigations.

B. Evaluation

The final reports of the students' projects constitute the best evaluation of this portion of the program. The range of investigations was quite broad; the following are some examples of project titles:

Color Perception in Crayfish

Activity of the Mongolian Gerbil (Meriones unguiculatus) Under Colored Lights

Color Perception in Drosophila

Midpoint Theory of Color Harmony

How and Why Different Solutions Affect Different Limestone Samples

Experiments in Color Discrimination in the Japanese Quail, Coturnix coturnix Uzura

Stomach Analysis of Fish

The Effect of Chemical Pollutants on Planaria

Synthetic Dyes

Memory and Color Perception in Goldfish

Chromatography: The Art of Separation

A Study of Chemical Effects on Fresh Water Microscopic Animals

A Computer Simulation of Living Species Within A Closed Ecosystem

Deficiencies in Color Vision

Mass Screening for Mosaic Color Blind Individuals

The Synthesis of Three Dyes

Spectral Analysis of Mud and Fish Samples Using Emission Spectroscopy

Aquatic Ecosystem of the Middle Devonian Period: Fauna of the Silica Shale

Those particularly interested in the evaluation of this phase of the Science Cluster are encouraged to look at the laboratory reports on file in the MAP office.

Evaluation of Student Attitudes Toward Science and Scientists

In order to evaluate changes in student attitudes toward Science and Scientists, an instrument was prepared which was given at the start and close of the quarter. Rather than sample simple opinion, the questionnaire was designed to evaluate the sophistication of the students' understanding of certain current "myths" relating to science and its conduct.

Students were instructed to state their opinions concerning a series of statements using the following scale:

A. Strongly agree

B. Agree in general

C. Uncertain

D. Disagree in general

E. Strongly disagree

The responses were scored by assigning a value of 5 to the response defined as "sophisticated" through a value of 1 for the response defined as "naive." Mean scores and their standard errors for each item were determined and the results analyzed by comparing the number of significant ($P < .05$) shifts in opinion for Cluster students and Non-Cluster students.

The nature of the questionnaire and the results may be seen in Table I.

All the increase in the number of significant, positive responses was recorded by the Cluster students. A G "likelihood ratio" test of independence for changes (three classes) gave a G statistic of 6.7, which when compared to X^2 for 2 df yielded a chance probability of 0.03. It thus seems appropriate to conclude that the Cluster students' understanding of the concepts explored on the questionnaire were changed toward increased sophistication.

Evaluation of Student Opinion of Their Cluster Experience

A questionnaire of student opinion of the program was given during the last week. The form was similar to that used by the Humanities Cluster. It allowed responses to specific statements on an agree-disagree scale and gave an opportunity for subjective appraisal of the various elements of the program including staff. A copy of the questionnaire with the average responses for the specific statements is attached as Table II.

In a fairly large number of cases (8) the student responses were not significantly different from a random pattern. It is likely that this is a reflection of the sharp dichotomy in student attitudes toward the program that developed during the survey portion. The failure of almost one third of the students to reach minimal standards in the math survey generated an atmosphere of hostility toward the total program that strongly influenced the responses on the student evaluation.

Inspection of the subjective comments also emphasized the extremes in student opinion. They ranged from unqualified approval to vigorous condemnation of the entire program. The students were perceptive of the contrasts in their appraisal, as evidenced by the following comment from one of the student responses.

> There are a few questions I feel should be seriously considered when evaluating this (or any) portion of the MAP program and the students comments about this quarter.
>
> How much will what a student has done in the program affect his evaluation of it? (i.e. will a student speak ill of the program because he has done poorly and praise it when he has done well?)
>
> How much does the success of any portion of the program depend upon the <u>students'</u> participating? that is -
>
> A. does MAP appeal to a certain type of student?
> B. could it be that students interested in the "informal" part of the program and its classes stay away from studies which demand more discipline?
> C. and could it be that these students might do poorly in a Science Cluster in comparison to Humanities Cluster for two reasons:
>
> 1. such students (those who dislike formal classes and disciplined study) would most likely <u>not</u> choose a major in or be interested greatly in the sciences
> 2. these students will not have disciplined themselves to work at something they dislike.
>
> Do math and science demand more discipline from the students than they are willing to give, causing them to do poorly?

Are criticisms of Science Cluster really an indication of the quality of the set up and teaching or a comment on the ability of certain kind of students (of which there may be a greater proportion in MAP because of the nature of the program) to discipline themselves to certain studies? I really don't have any answers. I'm just wondering and think you should, too.

Summary of Program Strengths and Weaknesses

A. Strengths

1. The laboratory experience proved to be the component that generated the most student enthusiasm and approval. The range and quality of the projects demonstrated student ability to work in areas in which they had had little or no previous experience. When compared to the structured laboratories, emphasizing simple exercises characteristic of regular 100-level courses for non-science majors, the Cluster experience clearly provided a unique opportunity for students to practice creative scientific investigation.

2. The computer science survey, while judged by students to be difficult, nevertheless allowed them to develop a working knowledge that most found to be valuable. Student progress in learning the BASIC language was judged to be remarkable, given their backgrounds and interests.

3. The ideas and problems explored in the Science Seminar generated a high level of interest. Students were especially concerned with relating the nature of scientific "knowledge" to their experiences in the Humanities Cluster or the Coordinated Humanities Quarter.

4. The Chicago trip was, as previously mentioned, a quarter highpoint.

5. The graduate assistants proved invaluable for the many tasks assigned them. During the laboratory experience they worked many extra hours with students. The assistants reported that they were stimulated by the opportunity to work with small groups of students on original projects.

6. Staff offices in Prout allowed maximum interaction between students and staff. The staff reported positive experiences in counseling and tutoring.

B. Weaknesses

1. Lack of adequate integration of disciplines in the surveys. Individual survey courses tended to center on the subject matter of the area and the interrelationships of concepts and ideas were left largely to the students.
2. The requirement by the Science Council of the College of Arts & Sciences that students achieve minimal standards of performance in all six survey disciplines created many unique problems. Those students who didn't meet minimal standards in a single area were distressed that failure in one-sixth of the survey resulted in a failing grade, regardless of how well they had done in the other areas. Stress on the content of the disciplines, treated in individual "mini-courses," again tended to emphasize the differences between areas rather than their integration.
3. The large-lecture format used for the Science Seminar did not allow for enough student participation in discussing concepts as they were presented. The small discussion groups following the lecture were often not well attended or the discussion was too general to be of much value.
4. Interaction of "research teams" could have been increased through more meetings of students working in a particular area.
5. More formal time-structuring of the laboratory work would have prevented some of the last-minute rush to complete projects.

6. The main lounge in Prout was not suitable for large lecture meetings. Numerous outside distractions, lack of enough chairs and difficulty in darkening it enough for movies, were the major sources of concern.
7. Inability of the staff to define exact grading policies at the start of the program caused students to not know until late in the program where they stood relative to grades. The reliance on two major examinations for the survey, coupled with the rapidity with which the material was covered, created a "make it or break it" atmosphere. A series of short quizzes and a slower pace would have allowed the students time to "digest" the material.
8. Owing to the fact that the Science Cluster followed so closely the Humanities Cluster, certain comparisons by students were inevitable and strongly influenced their early attitudes toward the new experience. Specifically, many students were surprised and confused by the highly structured pattern of the discipline surveys. Anticipation of this problem would have allowed a smoother transition between programs.

Recommendations

The following recommendations represent a synthesis of suggestions from staff and students concerning the structure of a future Science Cluster.

1. Eliminate the discipline survey and integrate the different areas into an investigation of some common theme. One possibility would be to treat the subject of "Energy" from the points of view of the participating disciplines. Each class session would involve input from the several staff members.
2. Reduce the program credit to 12 hours distributed as follows: Science Seminar, 3 hours; Survey, 5 hours; and Laboratory, 4 hours.

3. Have students meet the mathematics group requirement through enrollment in regular math courses if their high school math were insufficient. They could concurrently enroll in a 5 hour math course or take any other course that didn't conflict with the Cluster schedule.
4. Lengthen the time span over which both the survey and laboratory are conducted; that is, terminate the survey in about the eighth week and start the laboratory experience about the third week.
5. Treat special topics like computer language and programming, statistical methodology and laboratory techniques in short workshops.
6. Provide for more effective group discussion in the Science Seminar. Include objective testing in this portion. Have students critically evaluate the "evidence" supporting some controversial topic like ESP.
7. Obtain the full-time participation of the staff member from the Philosophy department.
8. Evaluate student progress in the survey through a series of brief objective examinations.
9. Conduct a series of informal seminars where staff and graduate assistants talk to students about their respective scientific specialties.

Conclusion

On balance, the Science Cluster was judged by its participants to have been a valuable educational venture. The scope of information about the sciences, the creativity and industry exhibited in the laboratory and

the insights gained by non-science majors into the philosophy, aims and limitations of science were dramatic when compared to the experiences of those students who fulfill their science and math group requirement in the normal fashion. It is our conviction that this type of program is truly attempting to deal with a major objective of general education: development of critical thinking and problem-solving skills on the part of the individual student. The Science Cluster's contribution to this developmental process consists in providing the student with a broad understanding of and exposure to a well-defined area of academic endeavor other than the one in which they will eventually specialize.

Survey of Student "Opinions" Concerning Science & Scientists

	Statement	"Sophisticated" Response	Probable meaning of "naive" response	Average Responses on a 5-Point Scale: Cluster Pre-test N = 90	Cluster Post-test N = 85	Non-Cluster Pre-test N = 38	Non-Cluster Post-test N = 37
1.	Science is exact, and unlike the humanities, deals with absolutes.	Disagree	Misunderstanding of the nature of scientific data & provisional nature of knowledge.	2.71*-	3.25*	2.89	2.89
2.	Scientific theories which seem to contradict accepted social values should not be taught in grade school.	Disagree	Dogmatism concerning conflict of ideas.	3.89*	3.86*	4.10*	4.03*
3.	Creative individuals may be as attracted to careers in science as to careers in the "arts."	Agree	Failure to see scientists as "creative."	3.70*	3.83*	3.97*	4.05*
4.	Scientists sometimes allow their personal views to influence their work.	Agree	Acceptance of myth of absolute scientific objectivity.	3.48*	3.37*	3.13	3.08
5.	Greater scientific control over life & death processes is ultimately dehumanizing.	Disagree	Failure to recognize view that "control" may be a humanizing activity.	2.91	2.68*-	2.95	3.43*
6.	In the absence of modern scientific & technological advances we would not be experiencing our present population crisis.	Agree	Failure to recognize impact of technology (death control, agriculture, prevention of infant death) on population growth.	2.98	3.17*	2.10*-	2.62*-

	Statement	"Sophisticated" Response	Probable meaning of "naive" response	Cluster Pre-test N = 90	Cluster Post-test N = 85	Non-Cluster Pre-test N = 38	Non-Cluster Post-test N = 37
7.	Scientific methodology should be used to prove or disprove religious "truths."	Disagree	Failure to recognize inappropriateness of scientific method for testing religious "truths."	3.71*	4.01*	3.89*	4.00*
8.	Scientists, in an effort to maintain their unique status, have surrounded their work with highly technical terms understandable only to other scientists.	Disagree	Failure to appreciate need for precise communication among scientists.	3.11	3.23*	3.54*	3.89*
9.	Scientists, because of their training in the scientific method, are more likely to be good politicians.	Disagree	Simplistic belief in transfer of expertise.	3.62*	3.66*	3.81*	3.76*
10.	It may be harmful to the progress of science for governments to label certain research "top secret."	Agree	Failure to recognize that findings must be communicated widely for science to progress. Also belief that the question relates directly to national security.	3.05	3.36*	3.24*	3.14
11.	Compared to men, women have fewer of the traits associated with highly successful scientists.	Disagree	Stereotyped understanding of male-female roles.	4.12*	4.06*	4.05*	4.16*

	Statement	"Sophisticated" Response	Probable meaning of "naive" response	Cluster Pre-test N = 90	Cluster Post-test N = 85	Non-Cluster Pre-test N = 38	Non-Cluster Post-test N = 37
12.	Scientists as a group have about the same average I.Q. as members of other professions.	Agree	"Egghead" stereotype of scientists.	3.02	3.23*	2.89	3.11
13.	A career in science demands greater discipline & dedication than a career in the humanities.	Disagree	Belief that humanities are unstructured.	3.58*	3.85*	3.43*	3.86*
14.	The scientific method should be applied to problems in all areas of life.	Disagree	Failure to recognize limitations of scientific method.	3.05	3.24*	3.16	3.14
15.	Research into sensitive areas like human reproduction or genetic manipulation should be discontinued if the early results indicate the information could be used for political purposes.	Disagree	Failure to see that virtually any knowledge could be used for political purposes or belief that use for political purposes would inevitably be bad.	3.15	2.94	3.76*	3.32*
16.	Our values should be based only on scientific facts.	Disagree	Confusion between values and nature of scientific information.	3.95*	3.96*	3.70*	3.86*

5 = "Sophisticated," 1 = "Naive"

* Responses significantly different from a random response mean of 3.0.

\- Significant difference is in direction of "naive."

TABLE 1A

SUMMARY

	Cluster		Non-Cluster	
	Pre-test	Post-test	Pre-test	Post-test
Number responses significantly greater than 3.0	8	14	10	10
Number responses significantly less than 3.0	1	1	1	1
Number responses not significantly different from 3.0	7	1	5	5

TABLE II

STUDENT EVALUATION

The following items do not seek your reaction to any one particular course or instructor in the past quarter, but to the total experience. Please keep this in mind when you respond.

Please indicate the extent to which you agree or disagree with these items by using the following key:

1) Strongly agree
2) Agree
3) Disagree
4) Strongly disagree

Average Response N = 81	I feel that during the past quarter
+2.24	I gained a sense of identity with an academic community.
+2.16	I was treated as though I am of some importance as an individual.
+2.24	I have been in an intellectually stimulating environment.
=2.38	There has been ample time for personal growth.
+2.86	I was treated as though I were an IBM card.
=2.55	I was generally tense and anxious.
=2.54	The work I did in different courses often seemed unrelated.
=2.53	Faculty placed a great emphasis on creativity.
+2.17	I often talked with faculty outside of a classroom setting.
+2.18	What I learned in one class often helped me to understand what I was doing in another class.
=2.50	Faculty placed a great emphasis on developing students intellectually.
=2.31	I spent a lot of time in serious discussions with other students.
=2.65	Most of what I learned was gained by reading books.
-2.80	Faculty placed a great emphasis on developing imagination in students.
=2.38	I was provided with an opportunity for being part of a meaningful social group.
+2.25	Faculty were responsive to the needs of students.
+1.98	I found myself learning by actually "doing" things.
?2.10	Course content was the focus of faculty attention.
+2.20	I was satisfied with my total experience.

\+ Indicates those responses that are significantly different in a favorable direction from a random response average of 2.5.

= Indicates those responses that are not significantly different from 2.5.

\- Indicates those responses that are significantly different in an unfavorable direction from 2.5.

? Response was significantly different from 2.5 but assignment of favorable or unfavorable direction not appropriate.

Month	Time	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY
MARCH		26 Introduction L	27 A M-CS H* B Phys L	28 Sci Seminar L	29 Sci Seminar L	30 A Phys L B Chem H
		A Phys L B Chem H	A Chem L B M-CS H		A Chem L B M-CS H	A M-CS H B Phys L
		Testing, 220 MS				
	AM 9:30-12	2 Sci Seminar L	3 A M-CS H B Phys L	4	5 Sci Seminar L	6 A Phys L B Chem H
	PM 2-4:30	A Phys L B Chem H	A Chem L B M-CS H		A Chem L B M-CS H	A M-CS H B Phys L
	PM 7-9			Visiting Lecturer, Harold Mayfield,220MS "Science as Avocation"		Lecture at T.U. 8 p.m. Hubert Alyea "Lucky Accidents"
APRIL		9 Sci Seminar L	10 A M-CS H B Phys L	11 REVIEW	12 Sci Seminar L	13 A Biol L B Geol H
		A Phys L B Chem H	A Chem L B M-CS H	REVIEW	A Geol L B M-CS H	A M-CS H B Biol L
				TEST over Chem, Phys and M-CS, 220 MS	Visiting Lecturer, Garrett Hardin, "Stalking the Wild Taboo" Ballroom	
		16 Sci Seminar L	17 A M-CS H B Geol L	18	19 Sci Seminar L	20 A Geol H B Biol L
		A Geol H B Biol L	A Biol L B M-CS H		A Biol L B M-CS H	A M-CS H B Geol L

Month	Time	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY
APRIL		23 Sci Seminar L	24 A M-CS H B Geol L	25	26 Sci Seminar L	27 A Geol H B Biol L
		A Geol H B Biol L	A Biol L B M-CS H		A Biol L B M-CS H	A M-CS H B Geol L
					Visiting Lecturer, Frank Rhoades "Science and Society"	
	AM 9:30-12	30 REVIEW	1 Chicago FIELD TRIPS (ALL DAY)	2	3 Sci Seminar L	4
	PM 2-4:30	TEST over Biol, Geol and M-CS.		Lab Orientation	Lab Orientation	
	PM 7-9			Lab Orientation		
MAY		7 Sci Seminar L	8	9	10 Sci Seminar L	11
				Visiting Lecturer, Wasley Krogdahl,220MS "Creation of the Universe"		
		14 Sci Seminar L	15	16	17 Sci Seminar L	18

QUESTIONS ABOUT SCIENCE AND SCIENTISTS

1. An American biologist reports having found microscopic life in the very hot water of one of the Yellowstone geysers. French scientists will accept this report if

   a. French scientists are allowed to visit the geysers and make their own studies.
   b. other independent observations confirm it.
   c. the U. S. government certifies the report.
   d. no one contradicts the report within one year.

2. The principle aim of science is to

   a. raise the living standard of persons all over the world.
   b. make orderly observations about all of nature.
   c. explain natural phenomena in terms of principles and theories.
   d. seek for truth.

3. If we ask a botanist why some plants turn toward the sun, he will most likely give his explanation in terms of

   a. the results of investigations into the mechanisms by which plants turn toward the sun.
   b. the benefits derived by the plant.
   c. the need of plants for sunlight.
   d. an accumulation of data showing the different kinds of plants that turn toward the sun.

4. Scientists sometimes describe the atom as "a minute solar system composed of electrons orbiting around a nucleus." This description can best be characterized as a <u>scientific model</u> because

   a. it describes how an atom looks under a powerful electron microscope.
   b. scientists have found it to be one useful way of thinking about atoms.
   c. it describes atoms adequately and to the satisfaction of scientists of all disciplines.
   d. it is used only in teaching.

5. Which of the following is the most accurate statement about scientific laws?

   a. Scientific laws are merely hypotheses upon which most scientists agree.
   b. Scientific laws are tentative hypotheses which have been called laws because of their importance.
   c. Scientific laws are statements of relationships among natural phenomena.
   d. Scientific laws are principles "enforced" by nature and cannot be violated.

6. If new findings are published which are not explained by an existing theory, scientists

   a. recognize that the theory is no longer useful.
   b. disregard the new findings.
   c. lose confidence in the scientists who published the new findings.
   d. attempt to modify the theory to explain the new data.

7. If a botanist wishes to determine what factors are necessary for the germination of a certain kind of seed, which of the following things will he be least likely to do?

   a. follow in order a series of steps called the "scientific method."
   b. design a series of experiments.
   c. read about seed germination in the library.
   d. formulate a hypothesis based on what he thinks the factors might be.

8. If a prominent American research chemist were to visit a chemistry research laboratory in Russia, he would probably find all of the following to be true except

   a. Russian chemists use the same chemical symbols and numerical constants as do American chemists.
   b. Russian chemistry students are taught similar material to American chemistry students.
   c. the Russian chemists are familiar with his work.
   d. the experiments being performed are rather elementary.

9. A student is told in an introductory biology course that saliva breaks starch down into sugar. He plans an experiment to test this idea. He puts 5 ml of starch solution into a test tube, adds 5 ml of saliva, waits 10 minutes and tests the solution for starch and for sugar. Which of the following would be the best "control" for the experiment?

   a. 5 ml starch, 10 minute wait, test for sugar.
   b. 5 ml starch, 5 ml water, 10 minute wait, test for starch and sugar.
   c. 10 ml starch, 10 minute wait, test for starch and sugar.
   d. 10 ml saliva, 10 minute wait, test for sugar.

10. When a scientist speaks of an accepted "theory" in his field he implies that

   a. the theory will soon become a law or will be discarded.
   b. most scientists in his field like the theory.
   c. the theory has been found to be true.
   d. the theory is an explanation of phenomena consistent with present evidence.

11. Today a freshman or sophomore who is interested in doing scientific research would probably be advised most often

   a. that few important discoveries have been made by those who consider science to be an avocation.
   b. to plan to work on one or more advanced degrees after college.
   c. to look for a job in industry since it is the main support of scientific research in this country.
   d. to confine his studies to the specific field of his interest since science today is so specialized.

12. When we hear of an important scientific advance, we may safely assume all of the following except that

   a. new or "creative" ideas were involved.
   b. experiments were performed.
   c. it will quickly lead to technological advances.
   d. the advance would not have been possible without the work of many persons.

13. Which one of the following statements best describes the relationship between science and technology today?

   a. Technology involves application of scientific knowledge.
   b. The amazing advances in technology in the past century are largely responsible for scientific progress.
   c. Present "scientific" research is really "technological" research since most of the discoveries that could be classified as true science have already been made.
   d. Technology is the part of science that deals with mechanical problems.

14. An article reporting new findings in geology is most likely to be well received by other geologists if the methods used to make the discovery are

   a. a co-operative development of several scientists.
   b. described clearly so that other scientists are able to repeat them.
   c. new and mentioned at the beginning of the article.
   d. easy and inexpensive.

15. In discussing our country's disarmament policy, a famous scientist declared that we must continue experimenting with nuclear bombs. How should we regard this scientist's statement?

a. His conclusion is probably right since he approaches the problem with a scientific attitude.
b. His conclusion and reasons should be given extra consideration, because scientific knowledge is used in bomb making.
c. His conclusion should be disregarded because scientists do not show proper concern for the consequences of scientific advances.
d. His conclusion and reasons should be given the same consideration as those of other informed citizens.

16. Which of the following is not true of scientific societies?

a. They promote the exchange of ideas and help to maintain professional standards.
b. They negotiate contracts with companies and institutions employing scientists.
c. They help scientists find jobs.
d. Their membership may include scientists from many nations.

17. Published reports of scientific research are often assumed to be very accurate, honest and reliable. This assumption is made

a. because a scientist realizes that other scientists must be able to confirm his results.
b. because research is reported only after the correct answer is found.
c. because only accurate, honest and reliable people are likely to have their work accepted for publication.
d. only by persons who know little about the actual workings of scientists.

18. In the 17th century, Newton formulated his laws of motion and the theory of universal gravitation, which were eventually accepted by all physicists. In the 20th century, Einstein proposed the theory of relativity, which physicists have generally accepted. Physicists today consider Newton's ideas as

a. adequate for the world Newton lived in, but not for the modern world.
b. the basis for Einstein's more comprehensive theory.
c. superior to Einstein's, because they are easier to understand.
d. more useful than Einstein's, because they can be proven.

19. Which of the following is the best statement about scientific knowledge?

    a. "Scientific knowledge is the information gained by the rigorous application of the scientific method."
    b. "Scientific knowledge is an accumulation of facts--an encyclopedia of careful observation."
    c. "Scientific knowledge presents the world as it is--stripped of emotional and cultural bias."
    d. "Scientific knowledge is a catalog of man's observations and understandings of how the universe is and works--revised by each new generation of scientists."

20. A geologist who was attempting to establish a theory about the origin of the present continents would probably do all of the following except

    a. throw out the information on which the old theory was based.
    b. attempt to explain how his theory was an improvement over existing theories.
    c. use much of the same evidence upon which old theories were built.
    d. get criticism from his co-workers.

21. Biology, chemistry and physics are interrelated because

    a. they are different approaches to the same subject matter.
    b. they all depend heavily on mathematics.
    c. there are certain unifying principles which are applicable to all three.
    d. advances in one will always stimulate progress in the others.

22. When the telescope became available for use, astronomers

    a. discovered new problems for investigation.
    b. recognized that it was the perfect instrument for their science.
    c. discovered the truth about the universe.
    d. recognized they could use it to prove their previous theories about the universe.

23. The reasoning from the specific to the general, from the facts to a generalization, from events to a theory, is the process called

    a. reduction.
    b. deduction.
    c. hypothesis.
    d. induction.

24. In science, predictability is usually stated as

    a. an educated guess.
    b. a certainty.
    c. a probability.
    d. a scientific law.

25. To be useful a scientific hypothesis <u>must</u> be

    a. ingenious.
    b. true.
    c. simple.
    d. testable.