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Reported is progress on an experimental curriculum development program by four liberal arts colleges (Clark, Morehouse, Morris Brown and Spelman) directed at the development of a one-year course in general science for non-science majors. The current version of the course and laboratory materials has been tried out with 2,000 students on a controlled experimental basis over the past two years. Information provided for the total program includes a rationale; discussions of materials, instruction, and problems encountered; student evaluation; and program evaluation. The physical science and biological science components and their respective laboratories are also discussed independently. Projections for the future are indicated. (RS)

PROGRESS REPORT 1966-68

COOPERATIVE GENERAL SCIENCE PROJECT

Clark College, Atlanta, Georgia 30314

Clark
Morehouse
Morris Brown
and Spelman
Colleges

Progress Report 1966 - 68

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ACKNOWLEDGMENTS

This Progress Report could not be completed without help from many individuals. To these persons, too numerous to mention, who have contributed to the preparation of this report, we are grateful.

We wish to thank the many teachers and students whose written comments have been most helpful throughout the last two years.

We should like to express special thanks to the U. S. Office of Education for the financial support of this Project. It has contributed greatly to the improvement of our academic program, and it is hoped that our efforts in producing these materials will be of interest and benefit to other educational institutions.

We are grateful, also, to the administrations of the four participating colleges, to Presidents Vivian Henderson, Hugh Gloster, John Middleton, and Albert Manley for their foresight in establishing this program.

We owe special thanks to the various chairmen of the departments who encouraged this program and to the Deans of the various colleges for their cooperation.

We cannot conclude this report without expressing our great appreciation for the time, thought, and judgment given over two years by President V. W. Henderson of Clark College.

Finally, we must express the hope that this report will prove helpful in the colleges and universities, and that it will advance, in some measure, the cause of good science teaching to liberal arts majors.

Atlanta, Georgia / O. P. Puri, Director

U. S. A. / W. P. Thompson, Associate Director

July 30, 1968

COOPERATIVE GENERAL SCIENCE PROJECT

A Report on Its Aims and Progress

Introduction

This is a progress report on an experimental program in curriculum development which has involved, so far, about thirty-five scientists. Four undergraduate colleges (Clark, Morehouse, Morris Brown, and Spelman Colleges) are cooperating to develop a one-year course in general science for use in liberal arts colleges. In 1965 we began a study with the belief that a new curriculum using an integrated introduction to science would be beneficial. The funds were granted by the U. S. Office of Education and work started in July, 1966. To date we have received approximately $500,000 to do this experiment in curriculum development.

The current version of course and laboratory materials has been tried out with 2000 students on a controlled experimental basis over the past two years. During 1968-1969 we anticipate using this approach for 1500 additional students. All these students are liberal arts majors who plan to be lawyers, economists, artists, historians, sociologists, theologians, teachers, or work in other non-science related fields. In this program, we have been relatively successful in developing and presenting the materials of science to undergraduate students who are strictly liberal arts majors. That is, we have taken a mixed group of majors, as stated above, and we have devised a curriculum and a set of activities which all add up to a one-year course in general science. Briefly speaking, the approach is conceptual and developmental in character. We attempt to teach students to understand something of the origins of science, the uniqueness of the scientific inquiry, the development of the scientific ideas, what was actually taught by the leaders and innovators of science, what developments have taken place, something of the content of technology, how problems are solved, the strengths and weaknesses of scientific thought, philosophical considerations of science, historical impacts, and the hierarchy and relative value in science of concepts such as verification, experiment, theory, hypothesis, probability, certainty, validity, and other related considerations of a logical nature.

Why do we need such a general science program?

Although the four undergraduate colleges of the Atlanta University Center (Clark, Morehouse, Morris Brown, and Spelman Colleges) have cooperated in some areas of curriculum offerings for several years, each of the colleges had a different offering in science for the non-science student until the formation of the Cooperative General Science Project. The Project has helped to bring about a uniformity in science requirements for non-science students by all of the colleges and has helped develop more cooperative efforts in all areas of academic concerns.

Through the efforts of the Cooperative General Science Project a one-year course, offering six semester hours credit, has been developed and is continuously being revised as the need for changes becomes apparent in the teaching of the course. The schedule of instruction provides for three one-hour lectures each week and a two-hour laboratory session. The course material has been divided into eight (8) basic units, each of which is meant to occupy four (4) to five (5) weeks of instruction time. This is a multi-disciplinary integrated approach and the units include: physics, chemistry, astronomy, geology, life and evolution, heredity and genetics, ecology and population, and economy of life and resources. The first four portions are taught in one semester by physical scientists and the last four portions are taught in another semester by biologists.

The course has been designed in such a manner that it is not necessary for students to take the course in a sequence. Some students may desire to take the second portion of the course before taking the first portion. We feel this gives more flexibility to individual student's choice and to scheduling problems. The course may be taken by the undergraduate during any year although the majority of the students taking the course are freshmen.

The program is intended to give students majoring in the humanities and the social sciences a firm background in physical and biological science. It emphasizes the most important changes in science that have taken place over the last several hundred years to help the non-science major relate these changes to the effects they have had and are continuing to have on our society.

Rather than making this course a "watered-down" version of a conventional course designed for science majors, we have attempted to emphasize those principles of science which can be of practical benefit to liberal arts majors. In the areas related to physical science, we have concentrated on establishing an understanding of the concepts involved with less emphasis upon the utilization of the principles involved through mathematics. In the areas related to biological science, we have concentrated on the concepts which can give the individual a clearer understanding of the human biological processes.

As is true in even the most ideal situation, we have students whom we cannot motivate, but we are encouraged by the favorable response the program is receiving on the whole. There seems to be an indication that we are "breaking through" and are reaching the students in a manner to cause them to delve more deeply into related source books for information. We have actually received letters of appreciation from students who took the course and did the work. At the end of each course, an evaluation sheet containing several questions was distributed to each student. No names were placed on this sheet and the evaluation represented a true evaluation of the students feelings. The consensus of opinion is very favorable.

Lecture materials

To satisfy all non-science majors the course cannot be simply a traditional physics, chemistry, astronomy, geology, biology or social science course. A good integration of topics was developed from the sciences listed above to arrive at a curriculum which relates to the experiences and interests of liberal arts majors. This we have stated in the introduction of this paper. We feel this course should be taught during the freshman year in order to promote a basic understanding of certain aspects of science and its impact on society. The technical details are completely omitted as these do not serve any purpose for the group of students we are teaching.

Lecture topics (experimental version)

Physical Science

Development and definition of basic mathematical concepts, laws of motion--Aristotle, Galileo, Newton; gravitation, the solar system and space, energy and heat phenomenon, electrical and magnetic principles, matter; atomic theory, history of the earth in time; geological materials, historical and philosophical considerations.

Biological Science

Life, origin and evolution; energy for life; reproduction and growth; heredity and genetics as related to man; ecology and evolution; economy of life and conservation of resources; the future of man.

Laboratory exercises, sessions, and experiments are conducted to study special topics.

Teaching aids

Transparencies of illustrations using overhead projector are found to be very helpful for the detailed understanding. There are several good films available for the teaching of this course. Excellent short sound-films on scientific topics within the framework of our curricula, made by other projects or commercial companies, are available for use in conjunction with the topics. Films dealing with historical and philosophical aspects of science are rare.

Progress in Classroom Teaching--1966-67

General Science

Procedures of the Project

The procedures of the Project were those which naturally flowed from the academic responsibilities which the Project assumed when it began the task of communicating and teaching the materials of the sciences to liberal arts majors on a college level. Moreover, the procedures of the Project were all clustered around one major activity--the academic process of teaching. Teaching itself is an art; and the teaching of science to liberal arts majors in college is and must remain the work of a chosen few among those already endowed with the teaching art.

Essentially traditional efforts characterized our teaching activities. In our efforts to teach science to college liberal arts majors, we employed lectures on various topics in science. These topics in science had to be geared to the educational background of liberal arts students, nearly always characterized by a very weak attainment in mathematical ability and a disinclination toward analytical thinking. Also these topics had to be tailored and cut to fit the limited amount of time available for such instruction.

Facing a group of liberal arts majors in a science classroom brings out very clearly and very quickly the difference between manipulation and understanding. No longer can any degree of inadequate understanding be hidden under a manipulative cloak. The typical liberal arts science classroom group has little or no manipulative ability and no understanding in science. In such a situation as this, the liberal arts student often assumes an attitude of withdrawal, characterized by fear or hostility understanding neither the logical structure of science nor anything of its technical aspects, feeling swamped by the mushrooming activities of a growing technology all around him, reading or hearing everyday of scientific developments and achievements often reported in superlative and exaggerated form, such an individual puts the brunt of his intellectual effort into some completely different concern. These and other facets necessitate a change in tone of whatever is done in a science classroom to bring the materials of science to such students in any meaningful manner.

The classroom procedure was therefore slanted heavily on the side of conceptualization of scientific materials and ideas in such a way so as to aid understanding and generate interest among liberal arts students.

In addition to classroom work (lectures to students), the laboratory activities assumed the next rank of importance. Again experiments had to be designed to augment the understanding of the student enable, the student to grasp fundamental scientific concepts, and provide for the student an educational experience in science of some interest and enjoyment.

Recitation groups were arranged in order that there would be time and opportunity for the student to freely express himself concerning any questions or details that arose during lecture periods, laboratory sessions, or assigned readings.

The lecture periods, the laboratory groups, and the recitation periods, taken together, made up the structure of the teaching effort provided by the faculty for the liberal arts majors who enrolled in the science courses of our Project.

More will be said later in the report about the relative merits of these activities and what we feel was accomplished by each kind of activity discussed above. Of course the lectures and laboratory sessions were carried out under the direct supervision of instructors in laboratory sessions and a lecturer in the classroom or recitation session.

Equipment of the Project

Project equipment, both laboratory equipment and auxiliary classroom equipment, including certain audio and optical equipment, was available for the reasonable demands of a teaching program such as we undertook in our Project. The various items of equipment required for laboratory sessions were of good quality, standard make, in good repair, and adequate for the purpose. Much of it was new, well designed, and arranged to make for a minimum amount of lost motion in all matters pertaining to scheduling its use by various groups at different laboratory periods. In some cases, individual students had their own equipment. Where it was otherwise workable, two or more students shared a set of apparatus for a laboratory project. On rare occasions, demonstrations were arranged for a group and the equipment was handled and operated by an instructor in charge of the sessions. The auxiliary equipment consisted of certain items kept in a central location and requisitioned from time to time by those people in the Project who had specific use for such pieces of equipment. In general, there were no inadequacies or shortages as far as equipment was concerned. It was well cared for and remains with us for use this coming academic year of 1967-68.

Personnel of Project

The Project personnel retained essentially the structure it assumed when the activities of the Project were originally planned. The major professors, the laboratory personnel, the instructors and their assistants worked together as a group in an attempt to implement the Project's purpose of teaching science to liberal arts college majors. The number of individuals in each category was adequate and the various duties and their distribution among the several categories of individuals seemed also to work out satisfactorily. No staff member was so overworked as to have no time to think and evaluate what was being done by others and by himself. If problems arose among staff members or between students and staff members, the established administrative machinery and established lines of communication were nearly always sufficient to exhibit the details of such problems and resolve most of them in a satisfactory manner. There was little or no interstaff friction and there was evidence of intergroup cooperation. Assistance and advice were freely given when so desired. No staff member suffered from lack of cooperation or constructive assistance from his colleagues in the Project.

Evaluation of Project

1. Weak features

The weak features of the Project arose primarily from the inevitable disappointments associated with what was expected and what was actually realized. Students learned too little or much less than it appeared they should have learned. Surrounded by all manner of promising possibilities for learning new scientific materials, too many students did not adequately lay hold of these opportunities and disappointed the staff in terms of how much they had learned or how thoroughly they had learned what they studied. Teachers and staff members are inevitably optimistic in evaluating the excellence of their own teaching efforts and nearly without fail impose on their own students the benefits of a glowing hindsight of knowledge and understanding they did not possess themselves as students. Thus any kind of teaching effort must not only be prepared to enjoy the rewards of teaching, but must also be braced for the disappointments of teaching. It would be a square-headed view indeed which maintained that in an effort of this kind certain matters did not appear which made it advisable to make internal changes, make adjustments in cases of misfits, redress grievances and correct oversights when these appeared. Such things as these are bound to appear within the structure of such a program as the Cooperative General Science Project in operation here. The big question is whether or not such matters are completely handled when they do appear and whether there is sufficient sensitiveness to such matters--recognition of their existence and resourceful and prompt action to make adjustments in the interest of the goals of the overall program. Thus there has to be a bit of "housecleaning" from time to time and since this report is no place to "air" dirty linen, no time or space need be devoted to such matters except to remind the reader the staff members are human and "finite," and our Project is an activity within the structure of an educational enterprise involving human beings. Further explanation and analysis of the weakness of the Program will appear in the last section of the report when the topics of new approaches and fresh ideas are discussed.

2. Problems encountered

Virtually all the problems encountered in the actual operation of the Project boil down to one thing. This one thing is the effectiveness and efficiency achieved in communicating the materials of science to students whose primary interest is outside the field of science. The wealth of fine material available is embarrassing--at least a dozen wonderful texts, films, recorded tape, models, displays and like kinds of help are available to anyone who has a knowledge of scientific source materials already in existence for teaching purposes. Neither is there much of a problem concerning the selection of topics to be taught. With only a little discretion one can make an excellent selection of related and relevant topics suitable for any classroom presentation of the materials of science. The problems arise in the process of effectively communicating with the liberal arts students so that when instruction has ceased, the student is in possession of a body of material that makes for understanding, clarity, meaningfulness, and orientation in science. In actual cases, it will be found that successive repetitions of the significance of a certain discussion has been grasped by five out of twenty students whereas the instructor supposed everyone appreciated this point and on the basis of this assumption went on to other topics which themselves make sense only after the previous material is fully understood. The student can take only a limited amount of this kind of experience before one detects the student is "lost" and confused. It only grows worse with further presentation of new material. Finally, something else must be done or one will further confuse and alienate the student; the situation can worsen rapidly, the student concluding he cannot learn science, gives up, and may abandon any serious attempt to learn anything further. Thus it is that among liberal arts students one finds all attitudes ranging from neutrality, ordinary ignorance and indifference, to bitterness, anxiety or even hostility with an accompanying inability to think or be analytical at all in intellectually structured material. This attitude extends to mathematics in particular. Victims of bad learning experiences, the students may appear, and are often designated, to be "stupid." Far too much time is spent by teachers gossiping about the latest evidences of "stupidity" among their students instead of probing new ways and novel methods of communicating with such students on a level they can understand and in a manner that makes it possible for students to integrate the knowledge they are trying to learn with what they know already. The problems all pivot around this main point. Of course, if there is any disposition on the part of the student to slacken the effort or if an irresponsible attitude appears, the situation is further confused and confounded and may become nearly hopeless. One tries to detect trouble early enough to avoid extreme situations.

3. Strong features

The strong features of the Project arise out of the determination to so conceptualize and present the materials of science in a manner that will be both useful and acceptable to students pursuing a liberal arts curriculum on a college level. The extent to which a faculty appreciates the peculiar needs of such a student group largely governs the success and effectiveness of the presentation in a classroom or laboratory session. We are just beginning to make what could be called anything like a comparative study of such programs and, therefore, can say very little about the merits of our own individual program when compared to other such programs. When an instructor interviews a student taking such a course, discusses a certain sequence of topics representing a fundamental difficulty to the student, so relates the materials and illustrates the subject matter that the student comes to clear consciousness of a new insight in science--an explication both imaginative and challenging to the student--it seems then to the instructor that finally here is the meaning, the purpose, the goal that ultimately justifies all teaching efforts on any level. Adequately formulating this conviction in any systematic manner or producing a verbal account of it is a difficult if not impossible task. We have in the Project the faculty, the equipment, the materials and resources to accomplish such goals; these are the necessary prerequisites for doing the job we have in mind. When and if the unmistakeable evidence of communication and insight appears in the student, it is difficult to put one's finger on just which one of a given number of elements actually accomplished the result. In fact, it may appear at the time that no one of the known ingredients of the entire Project was responsible for the final success; or, it may even appear that some trivial unrelated cause triggered the whole affair. This is an example of some of the odd and unpredictable features of the art of teaching and the process of communication among individuals.

Student evaluation

1. Type of students taking course

The students who take the course in General Science astonish one with their varied backgrounds, their divergent interests, their intellectual attainments and their characteristic mode of expressing themselves. Students who are capable of writing poetry stand beside other students who are concerned with anthropology and sociology and all inquire alike into the details of Galileo's Law of Falling Bodies or the principles of genetics while they try to understand the consequences of this knowledge and how, in particular, this knowledge effects the individual. Some students will need help in mastering the meaning of proportionality; others will have no notion of what a variable is or how and when a functional relation exists between variables; while still others will have difficulty in gaining an understanding of randomness and the law of probability. Those who are afraid of mathematics have to be led by the hand; others, who have concepts about quantification that sound like old wives' tales, have to be instructed in more rigorous and profitable scientific concepts; still other individuals, giving evidence of mastery of the main ideas already, can then be encouraged to look into additional material or more advanced concepts. A common case is a student not overly motivated in science, a student doing only moderately well in his work and missing many of the main points of the discussion. This case involves a struggle with a comparison of values, a first-thing-first type of inquiry and an appeal in the direction of intellectual liberalization and a curious imagination. The instructor who teaches science to liberal arts majors is never bored by uniformity in his students, nor can he always expect to have the right answers, or any answer at all for some of the situations encountered. These situations are unpredictable and unclassifiable. They arise from lack of knowledge, honest misconception, weak intuitive powers and the like kind of difficulties. Yes, the instructor of science to liberal arts majors must be a select person among those endowed with the art of teaching.

2. Expectations and goals of students

The students take the course to "learn science," "understand the human body," "become better acquainted with the world," "understand the behavior of machines," "develop practical and mechanical ability," "work off science requirements," etc., if one listens to their representations in the matter. Very few students have a pure and unsullied intellectual inquiry into scientific matters which led them to register for the course. Most of them think of any activity in science as something of a formidable undertaking on their part. Many do not expect to learn too much in the course; some think of the course as a review of high school general science and pre-judge the course in terms of such a misconception. Some do not anticipate or even want to learn as much as seems to be expected of them; a few rebel at what appears to them to be an inquiry of any depth; and others would take every opportunity to turn the inquiry into something that resembled science fiction or bold speculation. The instructor turns all such expressions of interest into constructive channels, pushes for new avenues of exploration, and makes constructive suggestions within a context that can be understood and appreciated by the student. The existing goals and expectations of students must be respected as far as possible and modified and reoriented when necessary. The natural curiosity and intellectual interest of all students must be preserved and directed, not ignored or crushed.

3. Teaching to student differences

The task of bringing the materials of science to the attention of liberal arts majors gives ample opportunities to observe the need of teaching to individual student differences. Such opportunities also sharply point up the rewards of such teaching to individual student differences. Our students have backgrounds so varied, temperaments so different, motives so mixed and confused, abilities so different and goals so diverse that some serious effort must be made to accommodate the materials and the presentation of the materials to these students as we find them rather than wait or hope they will change in any significant way in the direction of a more uniform kind of student with a common group experience. Repeated experiences with such students soon indicate that what is effective for one student will not evoke a favorable response from a second student. The time required, the materials employed and the pedagogical approach must all be modified and altered as the individual students come and go, being replaced by others who differ significantly from those who just departed. The goals, however, are always the same--to present the materials of science on such a level and within such a context as to make it possible for interested students to relate with the material and in some manner make it his own, appropriating and meaningfully integrating these materials within the context of the concerns of a liberal arts education.

4. Examinations and grades

Some major examinations were given throughout the semester. At the end of what seemed a natural division of material a one-hour examination was given, graded and returned to the student. Three such examinations were conducted. At the end of the course a final examination was conducted over the entire course work of the semester. Other work required of the student included weekly written assignments due on a definite day every week. These written assignments gave the student an opportunity to keep in close touch with the work in terms of a required regular effort every week. This feature proved to be of no little pedagogic value because it injected a certain amount of discipline into the required work by virtue of encouraging the student to produce something written in acceptable form once each week due on a definite day of the week. These weekly requirements were kept in order in a standard binder and retained by the student at the end of the semester.

The grades indicated some students were doing excellent work, attaining what we had hoped such students might accomplish in the course. A large group did only reasonably well on examinations as indicated by their grades, while some students did poorly in terms of writing papers deserving much of a grade. We did feel that in the case of liberal arts majors--non-specialists in any of the disciplines of science--the ordinary letter grade affixed to some written requirement is not a very good index to what was accomplished by the student in the course. A part of the purpose of such a course for liberal arts students is a modification of attitudes and the instillation of certain insights difficult to explore in a written examination or even difficult to describe in words. Whatever we accomplish in this direction, therefore, fails to show up on a grade sheet, but such goals are no little part of what we seek to achieve with our students in a course.

Faculty and Project evaluation by students

1. Evaluation sheets from students

Near the end of the semester, we designed and passed around a questionnaire to be filled out and returned without affixing a name. The questions gave an opportunity for students to advertise their opinions about certain features of the course, making comments if they desired to do so. In some cases extended remarks were volunteered about whatever was on the student's mind. Most of the remarks were anticipated and we really learned very little that was new or startling. There was a positive expression of satisfaction concerning laboratory work and the lectures were generally evaluated as "good" by a large group of students. So we reviewed the results and took the answers to heart, to remember when we begin the program next fall, the beginning of the 1967-68 academic year.

2. Results of interviews, conferences, reports

We are always on guard to determine and evaluate the opinions of students about the affairs of the Project because the opinions of students determine to a great extent how well the student learns new material. We are not only giving our students the materials he might want in the topics chosen for the lectures or the work in laboratories, but we are constantly evaluating the reactions of our students to determine if we can make the course more meaningful to them. Only then can we benefit from what we call "feedback" from students. On the basis of such information, we may make some modifications or effect changes that appear to serve the best interests of our Project. Thus we conduct personal interviews with students exploring whatever is on their minds. These conferences result in some material of profit to us and to the students.

Fresh ideas and new approaches

1. Confrontation between faculty and students in personal conferences

One important result of our work was the discovery of how much good can be accomplished by engaging the students in personal conferences to fully discuss the difficulties that have arisen in connection with the course work. They often have to have additional explanation over and above what is in a textbook and even over and above what has been presented in a lecture which is also in a text. There is no substitute for repetition when understanding fails otherwise. Our students also need help in formulating an attitude about science that does not commit them to an extended course of study in details but is still consistent with their interest in the materials of a liberal arts curriculum. From our own experience we think the personal conference features of our Project must be expanded to include more and more of the students taking the course, and we are considering measures to increase this kind of contact with our students.

2. Field work

It was soon recognized that any kind of activity or experience outside of the classroom relating to science was of immense value in stimulating the imagination of the student, motivating the student to new levels of effort and attainment. Thus we organized a little viewing group in astronomy and went out a few evenings and discussed and observed some of the gross aspects of the evening and night sky. Field trips have been organized to study the life forms and life cycles represented in some of the nearby ponds and fields. Individual students expressed great interest in this kind of thing and the next academic year will see some renewed effort of this kind to encourage the student to exert himself even more vigorously and actively within the structure of things of scientific importance.

3. Seminars

An effort was made to provide extended time for student participation and discussion of subject matter only touched on briefly in class or subject matter of an extra-scientific or speculative nature. There was, however, little response by the students to this kind of optional activity and it will not be repeated next academic year.

4. Laboratory display room

An opportunity presented itself of acquiring an excellent room in a new building on the campus for displaying materials and equipment of use and relevance to science. We took advantage of this opportunity and will give it more attention in the coming academic year. We have located and displayed material in this room which we feel can be of interest to the type of student taking this course, and which possesses some teaching potential in line with the goals of the Project.

5. Audiovisual aids

We are gradually gathering together some of the excellent prepared materials in existence on a very great variety of scientific subjects. These consist of sound movies in black and white and in color, film strips, recorded tapes, etc. We will arrange some of this material in an accessible form in order that students who so desire can avail themselves of still other opportunities of learning through the medium of new and interesting methods of communication.

Physical Science--1967-68

This program is now in the second year of operation and is concerned with communicating the materials of science to liberal arts majors. The Physical Science division of the program attempts to engage the liberal arts student with those topics of science roughly classified as physical science. This means that a curriculum must have been developed and put into practice and a format evolved which will guide the presentation of such materials to these students. Since no science majors are enrolled in this course, the traditional kind of presentation to science majors must be reviewed both as to content and purpose in presentation before this is passed on as suitable for teaching liberal arts students. It is always a shame when the best thing that can be done for such students (liberal arts students) is to present a "watered-down" version of what is given elsewhere to science majors. There is involved in such a presentation a kind of built-in cheapness--a sense of being sold short and degraded on the part of the students, while the teacher is always too conscious of the deficiencies (lack of mathematical sophistication, backwardness in appreciating certain specialized definitions and slowness in attaining an analytical type of thinking fairly well developed in science majors). Very early in our efforts with these students we attempted to develop a format for our science presentations to our classes that would not be condemned to failure beforehand by built-in conditions and limitations of the type described previously. That is, so far as possible, we wanted no students to feel in any sense that he or she was a second-class scholar in the area of science and in particular we did not want students to feel that in this class they would be asked for more than they could really do or have required of them a kind of attainment suitable and proper for a different kind of student and a different kind of purpose--a study and a student in a course of study essentially oriented in the direction of technology. The faculty who teach these students on the other hand should not feel they are reduced to the teaching of the multiplication tables of science to incompetent and weak students. Rather the faculty must see a genuine challenge when the students are in the classroom and he is facing them with something worth his time and their listening to him.

The foregoing philosophy of work and approach then leaves one with the whole problem of putting together a mode or manner of teaching to liberal arts students as well as what materials to teach once a format has been decided upon that could be followed in a practical situation. The setting being a liberal arts college, the students representing various disciplines--law, economics, history, government, English, theology, etc.--the tradition of classroom work with textbooks, library facilities, laboratory resources, all these facts pointed to a lecture room, laboratory exercise, self-study format in which the students should work and exert themselves to meet the requirements of their faculty in an academic setting. We, therefore, adopted a lecture method with reference to presentation of the materials, augmented by laboratory sessions, and regularly required written assignments. These three aspects of work and study make up the regularly scheduled academic functions participated in by the students. Certain other irregular functions augment this regular schedule and provide some new opportunities and insights as well as a certain amount of diversion well within the limits of academic usefulness and a learning situation for the student.

Within this format we face the next important matter of what materials from science should be presented, what approach should be adopted, and what could be done to insure that the majority of the students in the course would derive benefit from his work that represents genuine gains to the student in his own area of major interest. A presentation that is called science which leaves the student puzzled and uncertain about how or to what extent he has been benefited in his own area of interest in college work naturally would be a failure. Even the magic and built-in optimism associated with the study of science and the aura surrounding science cannot bridge the awful feeling of uselessness that might arise in a history student taking our course and feeling when he finished there was no relevance between what had been presented and his own area of interest and study.

Any attempt to translate these ideas into a concrete program that will really accomplish what can be so easily stated actually represents an innovation and educational practice both in the area of method and the material presented.

Our efforts to meet the requirements flowing out of the situation and conditions as they have been described represent a thrust in the direction of what has been discussed from time to time by eminent physicists and science educators. These people have developed the situation in which a specialized approach to science and its teaching has led to graduating students with degrees in science who lack much of a notion of the important aspects of science outside the accumulation of such materials as are involved in problem solving and the mastering of a technology. If within the area of study and concern of science majors, the situation was worsening and displaying ugly proportions then what will we be inclined to think about the case of the intelligent undergraduate, a liberal arts major and future citizen, who is supposed to know something about the structure and meaningful aspects of a society annually becoming more and more involved and committed within a context including the knowledge, claims, and the benefits of science. The traditional classroom presentation of science devoted to the purposes of research and technology really did no justice to the needs of the liberal arts major. From his point of view such a presentation represented a distortion of a legitimate branch of knowledge, discovery, and adventure. For causes which include some rebellion to this state of affairs, there grew up new disciplines which are science centered but which avoid the distortions growing out of the drive to advance research, create new specialists in science and advance the enterprise of technology. The history of science and the philosophy of science are now well-established courses of study in the universities. These disciplines concern themselves with a presentation of topics that emphasize a scientific subject matter long neglected in the traditional presentation. In the meantime, several different programs have been developed. These new courses cover a select group of topics from the materials of science, including a group of experiments in science with the idea in mind that the needs of high school groups in science could be best served with the development of these materials. The PSSC materials are available and the Harvard Project Physics people are now at work with some materials completed and tested. These efforts grow out of a need to present the materials and claims of science to a wider group of students than those who merely anticipate work in research and technology. This new thrust in scientific education is not at an end. It is probably just getting well underway at the present time.

The thinking which guided us reflected the considerations about science which are primarily conceptual, intuitive and qualitative in character--matters that have a bearing on the outlook and interests of a liberal arts student in college as well as matters which will concern such a student and his responsibilities as a citizen when he graduates from college. A course of study has been formulated and drawn up which brings the students into contact with instructors in lecture and laboratory sessions. The lectures are conceptually oriented and represent a genuine thrust of the intellect into the materials of science while they avoid a one-sided presentation which is in trouble even in the curriculum of majors in science. In these lectures, the instructor attempts to explicate the origins and roots of science. This cannot be done without some idea of what science is about and the stage is then set for a discussion of that rationalistic, speculative thrust of the imagination that occurred in Greece about 600 B.C., from which all science in the Western World flowed and whose character it reflects to this present day. The fact and reason for the antiquity of astronomy are discussed, the materials of the various early sciences are taught as far as they are known, Aristotle's formulation of the physical world is presented until the physics of Aristotle is seen to make sense and its strengths and weaknesses are explained. The theoretical, experimental and philosophical aspects of science as it existed in those days are discussed and the student feels that his feet are still on the ground. Every effort is made to impress on the student that science both in its original form and in its present-day practice is a concern of human kind devoid of all forms of magic, independent of the benefits of divine intervention and an enterprise that does not require special personal gifts to understand. The sad plight of science in the West during the Middle Ages is discussed and its reawakening in the twelfth and thirteenth centuries. The glorious discoveries and rapid development of a kind that is characterized as a revolution is presented as best we know how and as thoroughly as time allows. Careful attention is paid to what individual scientists taught, what ideas they advanced, how original they were, to what extent these ideas were related to predecessors and how influential they were in the science that followed them. Thus, Newton's statement that he "stood on the shoulders of giants" is explicated with the result that he looks less like a magician and a being of super-human endowment than he did before when he was studied out of context. The end result of this kind of academic presentation is what we would like to call an orientation in science. Outside lecturers, laboratory work, field trips, special sessions, and audiovisual materials give the student a wide range of experience in the instruments and techniques of science. Required outside readings and research in which the students actually read the materials of Newton, Huygens, Copernicus, Galileo, and Kepler provide a rare opportunity for enriching the mind and enhancing the scientific understanding of any student who will avail himself of the opportunity. Our problems, such as they are, seem to be only those that beset any other department and its presentations to students who may lack motivation, possess wrong motives, and the like. We are glad to note that few, if any, of our problems stem from the fact that these students are studying science. This seems to be an indication to us that we are "breaking through" and are reaching these students in a manner somewhat similar to what we anticipated and expected, or better yet, hoped, in the beginning. We have actually received letters of appreciation from students who took the course and did the work. The unofficial reports and rumors of a positive character that go around the student body confirm us in the view that we are getting somewhere in this approach to our students.

When students get inspired over a subject and the faculty is challenged in the presentation of the materials of the subject, we feel these signs alone are no little indication that the probing is in the right direction and that the situation justifies our planning and our efforts.

It may suprise some to hear that even with a full-time staff a certain period of orientation and adaptation is often required before such staff members come to the place where they understand the situation in which they work and appreciate how it differs from a more traditional program of science teaching. Most of the full-time staff members have to have some time and experience in the program before they can size up what kind of values are to be sponsored, what the techniques are which promote these values, and how they can best relate to this new teaching situation. In a very few cases, a full-time instructor just has not been able to adjust to the kind of program we have described, but this has not been too much of a problem. It is more a matter of interest than a problem.

One matter that has come fairly clear is the fact that the course as given is too short. That is, one semester is too little time for the covering of the subject matter and that a much more adequate presentation and coverage could be effected if the course were expanded to be taught over the period of time of one academic year. This change is seen by the faculty and staff members and it is often pointed out in the various surveys given to students from time to time. There are some remarks about there being so much material in too short a time and to some extent this is true. So this is a highly desirable change and as yet we have no plans for effecting this change because it is just becoming clear. Such a change would involve some complications and require adjustments and it will have to be done in the near future.

Physical Science Laboratory Program--1967-68

The laboratory experiments used during the past year in the physical science course were designed to help the students become further acquainted with the concepts and ideas presented in the lectures. As with the rest of the course, the stress was placed primarily on concepts rather than mathematical manipulations whenever possible. In some cases, however, this was not possible as the ideas involved required a certain amount of analysis in order for them to be brought out in the course of the experiment. In these cases, a program of graphical analysis was adopted as the simplest procedure that would obtain the desired result.

The result observed from the laboratory program has been that the students were able to come away from the laboratory sessions with at least a better understanding of the ideas involved in the content of the individual experiments even if they were not able to gain a complete understanding. The individual experiments were designed so that the instructor would give a brief lecture at the start of each session covering the ideas and concepts involved in the experiment, an exhibition of the equipment to be used and its operation, and some comments on the way in which the results were to be analyzed. The students were given an opportunity to ask questions as a group before they began their portion of the exercise.

During the students' work, as much opportunity as possible was given for the students to make their own discoveries concerning the principles involved with a minimum of interference or distraction from an instructor. With a student-teacher ratio of no more than 15 to 1 at most and 8 or 10 to 1 on the average, sufficient opportunity was available for answering any and all student questions to the student's satisfaction. It was felt that this would allow the maximum impact on the student for determining by himself the desired results of the experiment in such a way that would allay his initial fears concerning science in general and the laboratory in particular and that would be the most effective in removing science from the realm of "magic" and into the realm of understandable, logical processes.

Within the limitations imposed upon the laboratory program in the past year, the program has been a success. Student acceptance of and interest in the laboratory experiments has been observed to be continually improving with each semester. The problems encountered are being systematically removed with each repetition of the sequence of experiments.

In the Fall semester, the entire series of experiments was completely rewritten. This restructuring of the program was found to be more effective in creating student enthusiasm than the series used the previous spring. Of the fourteen experiments presented in the Fall semester, approximately six were found to be unsuitable for students involved in the Cooperative General Science program. These were either replaced completely for the Spring semester or were rewritten. In the spring, only thirteen experiments were eventually scheduled due to unexpected days without classes. Out of this sequence, approximately three of the experiments were found to be less than completely satisfactory in terms of effectiveness and illustration of the desired principle. These experiments are currently being revised for the Fall semester and an additional group of experiments are being prepared for incorporation into a laboratory manual which is scheduled to be ready for the 1968-69 academic year.

There are three further drawbacks that should be mentioned in connection with the laboratory program as it is currently being operated. First, we have been hampered and delayed in implementing our planned program by the length of time encountered between ordering and receiving supplies and materials for new laboratory experiments. This is a problem that should resolve itself eventually, but in the meantime, experiments that we would prefer to present have to be omitted and replaced by others that are not quite as satisfactory. Second, is the problem of scheduling experiments in such a manner that they would coincide with the lecture topics. This problem is most acute at the beginning of a semester when exercises have to be planned that will acquaint the students with the laboratory and the methods that will be employed for data analysis, etc. This has been and is being resolved to a great extent, but the basic problem will probably always be present to some degree. Third, with the vast amount of material that could be covered and that one feels obligated to cover in order to give the students the fullest possible background, there is a tendency to either skim too lightly over the material or to try to include more material in a particular experiment than the students can absorb. This is being counteracted with each review of the overall program of experiments and, hopefully, the final result will be a series of experiments that go into selected topics in depth with the painful exclusion of other topics. A problem of this sort is almost automatic in a program of this scope, but it is felt that the effects are gradually being reduced with each revision of the material.

While the laboratory program could be implemented elsewhere as it currently stands, further revisions are currently being carried out and it is felt a more viable and refined sequence would be more appropriate. This should become available for the Fall of 1969. The laboratory manual currently being assembled would by then have had sufficient review to allow its adoption elsewhere with success. With the manual, a complete sequence of conceptual, i.e., non-mathematical, experiments designed to illustrate the primary features of physical science will be available that could be used either with the lecture portion of the Cooperative General Science Physical Science program or in conjunction with any other course sequence in physical science of one or two semesters' duration.

Biological Science--1967-68

The Cooperative General Science Project that has been in operation for two years in the undergraduate institutions in the University Center has certainly played a paramount role in causing the non-science major to be aware and more appreciative of science and scientists in our society. Moreover, it has caused the student to become more involved in science. Prior to the introduction of the Project into the Center, most non-science majors showed little or no interest in science. Today, this negative attitude toward science has mostly disappeared.

There is little doubt that the biology taught in the Cooperative General Science Project has had a great impact on the students and teachers in this Center. The very nature of the cooperative aspect of the program almost immediately assured its success over the traditional and haphazard way of treating biology for the non-science major. Before the beginning of the Cooperative General Science Project, each school treated science differently. At two schools there were lectures and no laboratory experiences. The number of credit hours for the course varied at different institutions and only two schools offered any form of physical science and one year of biology for the science requirement. The direct thrust at improving and making experiences in the laboratory more meaningful has enhanced the outlook on science for the non-science major.

The lectures and the laboratory experiences in this program supplement each other. Every effort is made to assure the student of this. As a general rule, the student has attended special sessions and lectures pertaining to upcoming laboratory exercises before he is turned loose in the laboratory. Because of this briefing prior to the laboratory exercise, the student is better able to carry out his assignment.

Indirectly, this program has had a profound impact upon the teaching of science throughout the Center. It has placed considerable equipment on each campus, it has made it possible to release faculty members to concentrate more time on biology majors and research since the Project has its own staff, it has caused more real cooperation among the institutions of the Center, and it has brought the students closer so that a true exchange of ideas may take place. The Project is ideal for a cluster of institutions as found in this Center.

The program is a very successful one but, as in all innovations, problems do arise. However, the truly successful points far outweigh any shortcomings of the Project. An attempt is made to continually evaluate the program and modify it when the need becomes recognized. Weekly meetings are held to discuss the program and the upcoming assignments. An attempt is made to make sure that each staff member is fully aware of what is going on. The exercise for the week is discussed and analyzed for possible pitfalls. Any problems that may have arisen or anticipated are deliberated and some decision made relative to them.

Equipment has always been a major item in conducting a very interesting and efficient course in biology. In this Project, considerable equipment is available and funds are on hand for audiovisual aids, guest lecturers and field trips. These are truly important in the success of a program in any science course. Of course, the contributions of the staff members to the program is recognized to be of prime importance.

The counseling and very close contact with the students by the staff members have helped greatly. This kind of program could possibly be initiated at other campuses, but these institutions are ideally located for the implementation of a cooperative project for several hundreds of students.

Biological Science Laboratory Program--1967-68

The laboratory approach has afforded many students the opportunity of gaining greater knowledge, and therefore greater facility in grasping scientific principles. In the process of teaching these students, the scientific method is not overlooked in procedure, or in presentation. The combined effort of the lecture-laboratory method has proved to be beneficial to the students by presenting the same information to a large number of students in large lecture classes, and by giving each student personal attention in smaller laboratory groups.

The laboratory instructors have added to the effectiveness of the course by their recent knowledge of academic and technical advances due to their recent studies or technical employment. Their varied backgrounds have enhanced the development of the laboratory exercises performed during the year. This feature has made it possible for the students to become more cognizant of scientific methods resulting from historical and contemporary achievements. It should be noted that greater emphasis was given the modern biological concepts and procedures in the laboratory exercises. The object of these exercises, devised and written by all the faculty members affiliated with the course, was to present experiments that would complement the lectures while making reference to the anatomical, physiological, as well as morphalogical composition of the students.

Trying to induce non-science majors early in their collegiate experiences to seek careers in biology was the challenge for most of the laboratory instructors--who would have preferred to teach biology majors. This is especially true in the University Center where a lower percentage of the combined student bodies pursue majors in the life sciences than in any of the schools attended by the present members of the Cooperative General Science faculty. The students were introduced to general biology as well as to the wide array of specializations with the broad areas. Field trips and individual experimental exercises allowed for student mobilization and interpretation of biological materials.

Impact and Influences on Cooperating Colleges

The four undergraduate institutions in the Atlanta University Center have been cooperating for the past several years but this program, more than any other, has made each school aware of the tremendous advantages of pooling resources for greater strength and unity. There is freer movement of faculty and students from campus to campus at all levels of learning and in all areas of academic concerns. Each of the undergraduate colleges had a different offering for the non-science student: two colleges required only biological and physical science, but no laboratory or field work; one college permitted students to enroll in a general science program only at the sophomore level; while three colleges allowed freshmen to enroll in biological science or physical science. The Project has helped to bring about some kind of uniformity in the requirements for non-science majors.

Aside from the immediate impact on the non-science majors, the new faculty and staff involved in this program were of special benefit to the total science program in the Center. Several faculty members came with varied experience and talents and they brought with them new ideas and innovations in teaching methods. This program has provided us with data and pertinent information about the weaknesses of students who had no training or exposure to any of the sciences, but who found themselves confronted with the task of making an adjustment to the scientific enterprise in real life.

We feel that our Project is an organic part of long-range plans which evidence "drive and potential" to make substantial growth.

Future Activities

Somewhat longer-range plans call for the use of video tapes for use in closed circuit television. The enrollments of the colleges are increasing considerably and the key to the success of this kind of effort remains with our colleagues in sciences. However, the basic concern of this Project is to review and revise the materials already produced by us in their experimental versions. During 1969 these materials should be available to several other institutions that have sent such requests for their evaluation and use. Interest in the progress of the Cooperative General Science Project during the past year has given us the idea that there is a urgent need for the establishment of a Project Newsletter. This we hope to plan and implement during the coming year.

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