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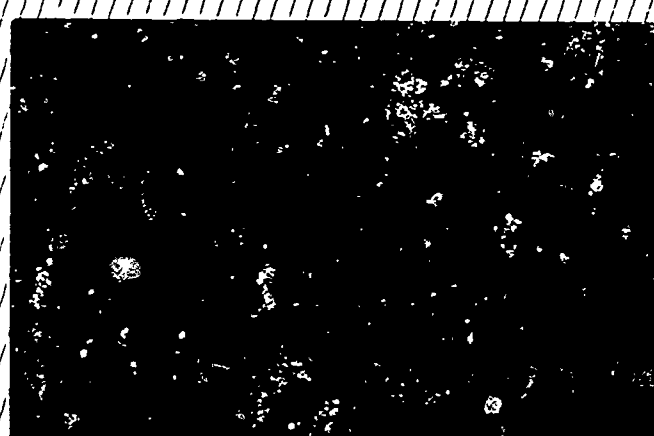
ABSTRACT

This science program, offered to all undergraduate students at the University of Iowa as an alternative to the traditional science core courses, is a three-course sequence designed primarily for elementary and special education majors. The program utilizes a student-structured laboratory setting with its main goal the development of a science awareness within the individual student. There are no formal lectures or required textbooks. The courses focus entirely on the student activities which the students, themselves, identify. Goals of the program are identified, the instructor's role is described, as are the grading procedures. An evaluation of the program has been undertaken and results presented here. References, films, suggested activities, and sample transcripts of student seminars are found in the appendices of the publication. (EB)

Technical Report



SCIENCE EDUCATION CENTER

The University of Iowa

December 1974

technical report 4

SCIENCE FOUNDATIONS: A Science Program for the Non-Science Student

by

James A. Shymansky

The Technical Report Series

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SCIENCE FOUNDATIONS:

A Science Program for the Non-Science Student

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SYNOPSIS

Science Foundations is a general science program offered by the University of Iowa to all undergraduate students as an alternative to the traditional "science core" courses such as physics, chemistry, botany, biology, etc. The three-course sequence comprising the Foundations program was designed primarily for elementary and special education majors, but the response of students other than education majors to the program in its brief period of operation has established the Foundations program as a viable undergraduate science offering for all students.

Utilizing a student-structured laboratory setting, the main goal of the Foundations program is the development of a science awareness within the individual student, i.e., an awareness in which the student sees himself as an active contributor in structuring an understanding of science and its processes rather than a passive recipient of some body of knowledge. Implicit in the Foundations approach is a definition which holds that science is the process by which man attempts to explain or make sense of his world and that science theories represent man's best explanations at any point in time. The emphasis in Foundations is on man's active role in imposing his thoughts on the world around him. The Foundations student is given the opportunity to <u>do science</u> -- to work with systems and make sense of those systems.

With the emphasis on individual student activity, Science Foundations involves no formal lectures or required textbooks. Each student is given the responsibility of identifying problems or questions which will require the use of manipulative materials and creative techniques in the pursuit of possible solutions or explanations. These problems or questions are selected by the student and depend only upon the interests, attitudes, and capabilities of the individual student.

INTRODUCTION

What kind of general science background should be provided for the non-science student and, in particular, the prospective elementary school teacher? Educators have pondered this question for some time now and, although there is no hard evidence on the subject, it appears that the typical watered-down course in such areas as physics, chemistry, or biology may not be the answer. This remark is based on an informal survey of many elementary school programs over the past ten years. If one considers that the vast majority of all the elementary school teachers presently working in the schools were probably exposed to one or more of the watered-down courses mentioned above and that nine out of ten children in any typical elementary school are not participating in any regularly scheduled science program (only an estimate, but surely a conservative one at that), there can be no doubt about the failure of the programs for prospective elementary school teachers.

It is no secret that most prospective elementary school teachers steer clear of any course dealing with science. If it weren't for the requirement in most certification programs making a course in "science methods" mandatory, few if any preservice teachers would enroll. This is true regardless of the fact that nearly all teacher candidates know or assume that they will be responsible for all parts of the curriculum in their future teaching positions, including science. The sad part is that the distaste for science among prospective teachers carries over into their classrooms. As good as some methods courses in science are, few teacher candidates are "turned on" enough for that enthusiasm to continue into their own classrooms. The upshod of the whole situation is that science is rarely, if ever, included in the elementary school child's program on a regular basis. And, if it is, science is the first activity to be "bumped" if time gets tight in the progression of the daily events.

THE PROBLEM

Looking at the problem from a prospective teacher's point of view, science is a poor investment in relation to all the other areas of the curriculum in which they might get involved. They feel that one or two courses in science will generally not provide a sufficient background for any practical application in the elementary school classroom. However, this is not the case in areas like reading, social studies, language arts, or even mathematics. The practicality and applicability of these areas is apparent. Hence, the prospective teacher devotes time and effort in those areas where there appears to be a high yield and eliminates science.

The above argument is very logical from the prospective elementary teacher's point of view except for one internal flaw; a flaw which the teacher candidate is in no position to detect. <u>Science as they perceive it</u> is actually a distorted image of what science ought to be based on experiences derived from their own formal instruction in science. Therein lies the teacher candidate's problem and therein lies the plight of the masses of young children with whom these same teachers will be in contact.

Science to the average elementary school teacher is a complex set of laws and theories which represent the results of years of thinking by men and women far more intelligent than they. This view is distorted further by the idea that the average person can do nothing on his own without full knowledge of "the scientific method." In short, the prospective elementary school teacher is awed and feels totally incapable of ever understanding or dealing with science in a meaningful way. The little science in which these people do get involved makes no sense beyond the confines and requirements of the course itself.

Recent curriculum efforts in the area of elementary school science have attempted to upgrade programs and to re-orient the teacher's thinking toward a "process" view of science as opposed to the traditional "content" view. But, by and large, the success of programs such as the <u>Elementary Science Study</u> (ESS), <u>Science Curriculum Improvement Study</u> (SCIS), and <u>Science - A Process Approach</u> (S-APA) has been impeded by the classroom teacher's personal bias and background in science. It has become abundantly clear that curriculum materials are not teacher-proof. By the time materials and activities filter down into the child's hands, a great deal of the potential learning may have been eliminated through the teacher's use or misuse of the activities. Unless the classroom teacher understands the nature of science as it is protrayed in the activities of the newer programs, it is highly unlikely that the children will perceive the nature of science any differently than the teacher. The result is the children get much "old science" disguised in the new, fancy wrappers of curriculum reform.

A RATIONALE

What type of science background does a prospective elementary school teacher need to meet the needs of tomorrow's citizen? As Toffler (1970) points out in "Future Shock", the very survival of future generations will depend upon their ability to deal effectively with the rapid changes brought on by an ever-expanding knowledge base and the booming world of technology. There is an imminent danger, according to Toffler, that man will be subsumed by his own progress unless he is able to place that progress in the proper perspective. "Staying on top" of the problem, however, does not necessarily mean increasing the bounds of "basic education" in our schools. In fact, Toffler denounces the efforts of education to deal with the basics implying that it is unrealistic to even attempt to teach the basics of an area like science given the diversity and complexity of the present day technology. The best thing education can do for the child is bring him to a point where he can understand the complexity of the technology explosion so that he is not overwhelmed and eventually subsumed by it.

When an elementary school teacher designs a science program for his students, he must be aware of the fact that in all probability 90% of what is thought to be fact now will be discarded or changed in favor of new explanations by the time his students graduate from high school.

At this point, logic might suggest simply explaining to the teacher candidate the nature of the expanding field of science and the implications of a future shock. Many science methods courses have tried this approach in the past 15 years with little or no success. The "future shock" theme leaves no impression on the future teacher because none of his own courses reflect that theme. The empty words of a "do as I say, not as I do" science instructor carry no weight whatsoever.

If the elementary school teacher is expected to conduct a science program emphasizing the dynamic nature of the field and the tenuous relationship between present day explanations and future knowledge, then it is time that our college and university science courses begin to reflect those same beliefs. This means shifting the emphasis from the hard core basics which are cemented in "laws" and "principles" of science to a first-hand experience with science in a real world setting that has meaning and understanding for the teacher and that has implications and practical application for the generations of children with whom this teacher will be in contact for the next 40 years.

THE PROGRAM

To meet the needs of the non-science major, especially the prospective elementary school teacher, a science program in which the student is allowed to structure his own knowledge and understanding of science through a hands-on approa is proposed as an alternative to the traditional basic courses in science. The "Science Foundations" program at the University of Iowa provides that experience.

The "Foundations" program consists of a sequence of three courses designed to give students first-hand experience in doing science. Unlike conventional courses in basic science, there are no formal lectures or required textbooks and no standardized or group administered tests. The courses focus entirely on the student activities which take place in the scheduled class time.

Each student in Foundations is expected to identify problems or questions which require the use of manipulative materials in seeking possible solutions or explanations. These problems or questions are selected by each student and depend only upon the interests, attitudes, and capabilities of the individual. In essence the student has almost complete charge of his own learning in Foundations.

This shift in student role also requires a shift in the instructor's role. The instructor's main job is to facilitate student investigations. In this role the instructor assists students in gathering material and equipment for use in their investigations and stimulates further experimentation through questions and comments concerning ongoing student activities. In general, the instructor is there to orchestrate student activity rather than to control it.

Goals of the Program*

Science Foundations is designed to present science as a human activity in which each person can assume an active role and to communicate how

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* Adapted from "Sample Goals for Science Education for Children" by Charles C. Matthews, The Florida State University, 1971.

creative and systematic thinking relates to solving self-perceived problems. The following goals are associated with the Foundations program:

(a) It enhances the thinking ability of the student. It provides opportunities for students to do activities which are compatible with their thinking abilities and personal interests.

(b) It enhances the student's belief that he can interpret and manipulate his own environment -- that he is a part of this environment and dependent upon it.

(c) It facilitates for each student the development of a positive self-concept with regard to independent learning and manipulation of his environment.

(d) It facilitates individual development of interests, attitudes, personality, and creativity which enhance the continued development of individuality in the student.

(e) It facilitates the student's tendency to accept the existence of individuals who have ideas and values which are different from his own.

There are specific program objectives associated with the five broad goals listed above. The student who completes the Science Foundations program should be able to design activities (without suggestions) and do activities (without instructions) in which he:

(a) identifies relationships among the properties of static objects or among the factors which affect the behavior of dynamic systems, and

(b) manipulates objects to test the usefulness of the relationships which he has identified.

The Foundations program is designed to enhance the student's self-concept with regard to science and independent learning. The student who completes the program should be able to

(a) identify himself as a person who can be successful in science and chooses to do science,

(b) describe science in terms of activities which make sense to him,

(c) state his own explanation for natural phenomena and should modify these only when they cease to be compatible with his own interpretation of his environment, and

(d) identify tentativeness as an important characteristic of scientific knowledge.

Student Activities

Every facet of the Foundations program is designed to allow the students maximum opportunity to structure their own learning in science. The activities in which the students become involved provide the framework on which this structuring can occur. It is recognized, however, that the average student, having been exposed to a very structured learning environment for the greater part, if not all, of his school life, will probably be unable to plunge right into an independent science investigation when the opportunity arises. This situation has been considered in the overall design of the three courses characterizing the Foundations program. In the first course of the sequence students are provided a set of "suggested activities" and given the option of working on one or more of these for the semester or of identifying a problem of their own on which to work. During the second semester of Foundations, the students may continue to work on activities from the suggested activities set with the stipulation that each student must identify a problem of his own and design an investigation around it. By the time the student enters the third course of the Foundations program, it is expected that he will spend the entire semester working on a self-designed investigation.

The nature of the activities with which students become involved are of prime importance in the Foundations program. There are no "cookbook" laboratory exercises within the suggested set of activities and students are discouraged from seeking out investigations of this type from other sources (such as the library or an old high school chemistry lab manual). All the activities provided during the first two Foundations courses have one thing in common -- they are designed to allow maximum student input and flexibility in the identification of specific problems and the actual experimentation. A sample set of suggested activities used in the first two courses of the Foundations sequence is provided in Appendix I.

The one question most often raised about the activities in which Foundations students become involved deals with the "science content" of the courses. There is a question as to what specific science concepts or processes are being emphasized in the various Foundations courses. The answer to this question is always a shocking "No specific ones!" This is not to imply that students will not acquire certain skills in the laboratory such as learning how to stain a slide, how to use an equal arm balance, how to use a microscope, etc. Furthermore, this is not to imply that students will not learn some "basic" science concepts or that concepts are unimportant. All the activities involve many science skills and processes as well as a great deal of content. The important ingredient, however, is the fact the student has the major decision of deciding with which skills, processes, and content he will deal. This practice of making the student responsible for this decision is consistent with the rationale and goals of the program. Ultimately, the student is responsible for deciding what he will learn and when he will learn it. And Foundations recognizes this fact.

Each activity is written in such a way that a student may get involved at various levels of sophistication. The questions pertaining to any of the activities are designed to be open-ended rather than prescriptive. After a quick perusal of the various activity sheets, students quickly get the message that it is up to them to develop the specific activity beyond the questions posed on the individual sheets. At the time the sheets are given to the students, it is made clear that these questions are meant to stimulate further investigation and that they must assume total responsibility for the activities they select and how much they do with them.

The students themselves provide the greatest source of continuing activities which are then used to supplement the suggested activities set. Although students are discouraged from working on "group projects", the class is conducted in an informal manner in order to facilitate student to student interaction. This allows students to capitalize on each other's mistakes and successes.

Students are required to keep a daily log of their activities listing such items as the problem or question they are pursuing at a given point in time, how they are proceeding to investigate that problem or question, and anything they encounter in the pursuit. Just as the daily class routine is very informal, so are the student logs. In fact, it is stressed that the logs are meant to aid the student in organizing his activity and then to facilitate interactions between the instructor or another student and himself. It is emphasized that the daily logs will not be viewed as representing student efforts in the courses but rather as an extra link of communication. The de-emphasis of notebooks is intended to maximize student involvement in the hands-on portion of the activities.

In the normal progression of events during the semester, students spend the majority of class time working on their own investigations for about the first 8-12 weeks. At that point, one hour period per week is set aside for "student seminars" (the classes meet three times per week, two hours per meeting). Basically, the seminar is a "show and tell" session in which students are given the opportunity to explain what they are doing and what they are finding out. However, the activities related to these seminars go far beyond the show and tell stage. As each student presents his investigation, the audience is charged with the responsibility of critiquing the speaker's presentation (usually 10-24 fellow students comprise the audience). These critiques are intended to focus on the design and method of the investigation rather than the content of the activity. After the student presentation, the audience is allowed to ask any questions needed to shed light on the merits of the design and validity of the investigation which will aid them in writing their individual critiques.

The actual seminars are not intended to evaluate the speaker's presentation but rather to test the audience's ability to analyze the speaker's experimental design and procedure. The critiques written by the student audience are turned in to the instructor at the end of each seminar. With each student in the class making at least one seminar presentation, every student in the class will have had the opportunity to critique 19-24 other investigations. (Transcripts of actual seminar discussions are contained in Appendix II.)

After each student reports on his investigation, the critique papers written by the other class members are given to the seminar speaker. It is the responsibility of the student giving the seminar to review the critiques and modify his investigation in light of the comments made by his fellow students. This process is repeated for all students in the class.

In addition to the daily investigations and weekly seminar sessions, a series of film-discussion sessions are scheduled throughout the semester. The films are intended to be thought provoking and to facilitate discussion about man's role in science and the role of science in society. Consequently, films dealing with conventional science topics such as "Newton's Laws" or "The Kreb's Cycle" are not used in these sessions. Rather films such as "Future Shock" (1972), "Why Man Creates" (1968), and "Marshall McLuhan the Medium is the Message" (1967) are used. These three films in particular were selected for their insight into the inner workings of man and society which in turn have direct implications for science and its role in today's and tomorrow's world.

Instructor's Role

From what has been described thus far, it is obvious that the instructor in Science Foundations cannot assume the stereotyped role of "Mr. Wizard" in the classroom. If there is any chance of accomplishing the goals listed previously or facilitating the kind of student activities outlined above, the instructor must be a "facilitator" who encourages the students to conduct their own investigations. The Foundations instructor cannot be an expert in all the areas of science represented by the diversity of student interests and activities, nor should the instructor even attempt to communicate such an expertise even in the one or two areas where he or she may have had considerable training. This is not to say that the instructor should walk around the room and profess ignorance of all science. But initially most students will look to the instructor for the "answer" or the "right explanation" so it takes a conscious effort on the instructor's part not to communicate that he or she does have all the answers. The instructor must be continually aware of the long-range goals of the program, the first of which is that the Foundations Program should enhance the thinking ability of the student. Telling students answers or giving students the explanation just because they ask does not facilitate the accomplishment of any of the goals.

The art of "not telling" is a very difficult one to master, especially for most science instructors. The students don't make it any easier for the instructor in this regard. They will generally badger the instructor continually at the initial stages for him to tell them if they are right or wrong. Sometimes students become a little frustrated because ideas or solutions don't "jump right out" at them and the instructor feels compelled to take the student "off the hook" -- to help him out. The temptation to tell or lecture will be constantly there, but the instructor must maintain a low profile as much as possible and allow the students to work things out for themselves.

With the primary function being that of a sounding board or facilitator, the instructor must constantly work on his listening and questioning skills. Note the order of those two. Listening skills rank first simply because the instructor must exhibit an interest in the line of investigation taken by the student. Only after the instructor has ascertained what the student is doing and how he is proceeding should the instructor entertain the thought of asking any questions of a probing or suggestive nature. This is especially critical with beginning Foundations students. They will be very dependent on the instructor's questions at first to direct them in their own thoughts and ideas on the particular topic of investigation.

Another danger in premature questioning of a probing or suggestive type is that these sometimes tend to communicate disapproval of student activity if the student didn't happen to be following that specific line of thought. This surely depends on the individual student and how secure he is, but more than likely the newer student will pick up on the instructor's line of questioning and pursue it regardless of his level of understanding. This is highly undesirable in view of the goals of the Foundations Program because the activities soon degenerate into "cookbook" or prescriptive laboratory exercises, the only difference being that the student doesn't have the recipe -- he thinks it's in the instructor's head and that he just has to guess what it is.

Typically the instructor spends most of the class time helping students locate materials needed in their investigations, working with students in planning and designing new procedures (in this capacity the instructor must take the responsibility for determining the feasibility of student plans in terms of available space, time, and equipment), and interacting with students about their progress on an activity (listening to student ideas and questioning them about their experiment).

Grading Procedures

Grading in Science Foundations is at first a "hang-up" for both the students and the instructor. Without a mid-term, a final, outside papers, and pop-quizes to average and crank out grades "objectively," arriving at a grade for a student turns out to be an interesting experience for both students and instructors.

Since the majority of the student's time is spent on independent investigation of one or more of a variety of problem areas, it is only logical that his grade should reflect his performance on those investigations. The critique papers written after each seminar represent another source of feedback as do the daily logs. But their weight is minimal in comparison to the student's classroom performance. Therefore, students are informed at the very start of each semester that their grade will be based on their daily performance. It is spelled out for the students in more specific terms that the instructor will be looking at (1) how effectively each student utilizes the available class time, (2) how extensively and carefully each student develops the activity(s) he is working on, and (3) how creatively or ingeniously each student overcomes problems encountered during the investigations.

The first criterion, dealing with effective time use, is fairly straight forward. Attendance is one factor which enters here but there is another aspect which is not so obvious. The informality of the classroom and the non-directiveness of the instructor can be interpreted by students as a license to loaf. To many students the line between freedom and irresponsibility is not well-defined and some will take advantage of the situation. For example, a student working on "Boiling and Freezing" (Appendix I) may decide to investigate the effects of various additives on the boiling point of water. So for ten straight class periods the student boils one solution instead of boiling several, if not all simultaneously. The student in this situation is concerned primarily with stretching out the investigation as long as possible and nothing more. This would probably be construed as inefficient use of class time unless the instructor had other input that indicated a legitimate but shortsighted effort.

The second grading factor is more difficult to deal with on the surface. In order to monitor the student's progress on an activity, the instructor must keep a current record on the student's daily activity if possible. Consequently, each instructor maintains a "daily log" of student activity. The instructor makes log entries based on the observations and interactions of each class period. By the semester's end, the cumulative entries on each student provide a profile of individual student progress on any one activity as well as an indication of the student's overall performance.

The third item in the grading scheme, creativity, is the most difficult of the three to assess. There are no reliable non-intervention techniques to deal with creativity in the daily routine of the classroom. Hence, this factor is weighed only slightly in the grading of students. In those cases where students are working on similar activities, relative assessments can be made. But even this alleviates the problem only slightly. However, creativity is included as a grading criterion simply to communicate to students that their ideas are of prime importance.

Recognizing that certain areas of student performance are more susceptible to instructor bias in the evaluation process, the Foundations program utilizes "third party" input on a regularly scheduled basis. The third party is another Foundations instructor who operates on a consulting basis to both the students and the regular instructor throughout the semester. In this capacity, a second instructor attaches himself/herself to a Foundations class and spends approximately one hour per week interacting with the students as a replacement for the regular instructor (this amounts to all the Foundations instructors simply switching one hour of class time per week). Students who are having communication problems with the regular instructor are afforded another sounding board and vice versa; instructors having problems with individual students can get another opinion on the matter.

The third party input is welcomed by the students (this practice was suggested by students at a weekly inter-class student-instructor rap session) and provides an added source of feedback to the regular instructor. But beyond the immediate payoff, the second instructor helps redefine the instructor's role in the classroom as one of a facilitator or partner in learning rather than the traditional authority figure of the class. The overall effect of the third party input is that of reducing the pressure on students to "perform" for their regular instructor. In consulting with a second instructor, it helps students to view the regular instructor in a similar role. Once the pressure to perform is reduced, the student is free to pursue his own line of interest and thought and that's what the program in Foundations is all about.

PROGRAM EVALUATION

As is the case with any new program, the question of effectiveness must be addressed. Does Science Foundations accomplish its stated goals and is the program more effective than existing programs designed for the same target population? Thus far two formal evaluations of student performance in Science Foundations have been completed (Berkland, 1973 and Siemro, 1974). Berkland's study compared a sample of Foundations students to a sample of students enrolled in a basic science course entitled "Earth History and Resources". The study focused on student attitudes toward science using an instrument designed by the investigator and the students' understanding of science processes as measured by a shortened form of the American Association for the Advancement of Science --Process Measures for Teachers (Form A). Results of these tests indicated that neither program produced significant changes in attitudes toward science, but that Foundations students did possess a greater understanding of the processes of science than students exposed to the traditional course.

Siemro also investigated the relationship between student experience in science (Science Foundations vs traditional core science courses) and student attitudes toward science and their understanding of science. On each of these factors, no significant relationships were revealed by the instruments used.

The overall problem of program evaluation is reflected in the two studies mentioned. Even with refined instrumentation and tighter experimental controls, definitive results will continue to be elusive. The traditional measures of factual recall and content memorization do not lend themselves to a true comparison of effectiveness between the Foundations courses and the conventional science course. Yet the higher level learning in both the cognitive and affective domains continues to defy assessment experts.

Currently evaluation efforts in Science Foundations are being directed at student perceptions in science. Intervention and non-intervention techniques are being explored to determine the effect the Foundations program has on changing the way the student views science and his role in science. There is some evidence to support the view that a rigidly structured science program tends to develop a "split perception" of science among students, i.e., a different view of science depending upon whether the student relates to science as an active participant or a passive observer (Shymansky, et al., 1974). Student perceptions are viewed as an important part of the Foundations program and will continue to receive careful attention in future evaluation efforts.

CONCLUDING REMARKS

The Science Foundations idea is not really that new nor is it a panacea. The general tone of the program resembles the "progressive" movement of the 1930's. Perhaps the most innovative aspect of the entire program is the fact that the instructors involved in the program believe in its goals and their classroom behavior reflects that belief. A visit to any of the Foundations classrooms would reveal that the ideas expressed in this paper are in operation with students. Perhaps the biggest problem confronting the instructors of the Foundations courses is the fact that many students just can't believe that such a program exists. Along those same lines, the biggest problem facing many students in Foundations is that, for the first time in their total education, they are given the responsibility of structuring their own learning in a course -- a chance to say what is relevant and irrelevant, a choice of routes to follow. To many students this is frightening!

The frustration among students enrolled in Foundations for the first time is extremely high. Students admit that they have never been given such freedom and responsibility in a course in their lives and that they don't quite know how to cope with it. Some students can't. Some students rationalize their inability to accept the directorship of their own learning by blaming the course or the instructor; they say they're just not turned on, so they tune out. Usually less than five out of 125-150 drop Foundations once the semester has begun, but there are usually another 25 students or so who remain in the course but just mark time throughout the semester.

There are still others who can never really accept their investigations as "science". These students feel that anything short of a complex passage in a textbook followed by a tough workout on the slide rule is just not science. Some of these students become real dyed-in-the-wool traditionalists by the end of one semester in Foundations, claiming they were right all along. Others of the same disposition do a 180 degree change and really get turned on to the idea that they can manipulate various segments of their environment and that science is, among other things, a collection of man's best explanations at the time. It's the latter group of students that make an instructor feel a sense of pride and satisfaction. It's the former group that makes other instructors reach out for new ideas and techniques for teaching science.

REFERENCES

Berkland, T.R. An investigation of the understanding of science processes and attitudes toward science of prospective elementary teachers from an unstructured science foundations course and non-science students from a structured earth science course. Unpublished doctoral dissertation, University of Iowa, 1973.

Matthews, C.C. Sample goals for science education. Unpublished paper, The Florida State University, 1971.

Shymansky, J.A., C.C. Matthews, R.G. Good, J.E. Penick, P.R. Kolebas, and T. E. Allen. A study of self perceptions among elementary school students exposed to contrasting teaching strategies in science. Science Education, 58 (3), 1974, pp. 331-341.

Siemro, D.L. An investigation of two approaches for education in science of preservice elementary school teachers. Unpublished doctoral dissertation, University of Iowa, 1974.

Toffler, A. Future Shock. New York: Random House, 1970.

FILMS

Future Shock. McGraw-Hill Text Films, 1972.

Marshall McLuhan the Medium is the Message. McGraw-Hill Text Films, 1967.

Why Man Creates. Pyramid Film Productions, 1968.

APPENDIX I

A SAMPLE OF SUGGESTED ACTIVITIES FOR FIRST AND SECOND SEMESTER FOUNDATIONS STUDENTS

AERODYNAMICS

Activity

Investigate aerodynamics by creating and building a variety of paper airplanes.

Some Things to Consider:

1. Which type of paper airplane can fly the greatest distance?
2. Which can stay in the air for the longest time?
3. What material produces the best paper airplanes
4. What aerodynamic properties of the plane affect its flight?

Are there other factors which might affect the performance of a paper airplane?

5.
6.
7.

ANTISEPTICS

Activity

Determine the effects of antiseptics on different sources of bacteria.

Some Things to Consider:

1. Do different antiseptics (iodine, alcohol, bactine, mercuricrome, lysol, etc.) have different effects on the culture growth?

2. Does the amount of antiseptic make a difference?

3. Does the part of your body the bacteria comes from make a difference (hand, arm, face, foot)

Can you think of other factors which might influence the action of antiseptics on bacteria?

4.

5.

6.

BATTERIES & BULBS: Simple Electrical Systems*

Activity

Find out all you can about electrical systems using batteries, bulbs, wires, and whatever.

Some Things to Consider:

1. How many different ways can you light one bulb using
   (a) one battery, one wire
   (b) two batteries, one wire
   (c) one battery, two wires
   (d) two batteries, two wires
   (e) two batteries, ? ? ? etc.

2. How can you light two or more bulbs with one battery? Are the lights as bright as one bulb lit with a single battery?

3. Can you light more than two bulbs with one battery in such a way that when one bulb goes out, the others stay on? Are these bulbs as bright, less bright, or brighter than the bulbs from the #2 set-up?

4. What other kinds of arrangements can you make using switches, bells, batteries, and bulbs.

What are some other questions and problems you can think of?

5.

6.

7.

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* Some materials in cabinet ________.

BEHAVIOR OF MEALWORMS*

Activity

Investigate the relationship of mealworms to different factors within the environment.

Some Things to Consider:

1. How do mealworms react to heat? light? water? alcohol? sugar? salt? oil? etc.?
2. Do mealworms have personalities? Explore?
3. How do mealworms eat? Do mealworms sleep?
4. Can mealworms "walk" backwards? sideways?
5. How do mealworms react to different surfaces? Different colors? Different inclines or slopes? etc.

What other things can you find out about mealworms?

6.

7.

8.

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* See instructor for mealworms.

BOILING AND FREEZING*

Activity

Find out all you can about the properties of different liquids as they boil and freeze.

Some Things to Consider:

1. How do you know when a liquid has reached its boiling point?

2. Can the boiling or freezing point of a liquid be changed by adding materials?

3. How do the surroundings affect the boiling or freezing of a liquid? For instance, does a given liquid boil at the same temperature in a hot room as in a cold room?

What other factors can you identify that might affect boiling and freezing points.

4.

5.

6.

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* You decide what liquids and materials you would like to use.

BUILDING BRIDGES

Activity

Explore bridge designs by using various angles of structure and different building materials.

Some Things to Consider:

1. How many different angles can you design for constructing bridges?

2. What material might be used from the classroom to construct miniature models?

3. What are the advantages of one design over another design?

4. Find out if the strength of a bridge is due to its design, its building material, or/and the way the building material is held together.

5. Do bridges of different designs have different weights?

6. Is there a relationship between the angle/weight of the bridge and the amount of force it will support?

What other properties of bridges can you investigate?

7.

8.

9.

CHARACTERISTICS OF BLOOD

Activity

Find out all you can about the nature of blood.

Some Things to Consider:

1. Is all blood identical? What things can you identify that differentiate blood samples?

2. What techniques can you devise to differentiate between blood samples?

3. In what ways can you modify blood samples to take on certain desired characteristics?

What other techniques can you devise for differentiating various blood samples?

4.

5.

6.

EROSION*

Activity

Find out all you can about the relationship between water flow and soil erosion.

Some Things to Consider:

1. How can erosion be measured?

2. What are the important factors which govern erosion?

3. What affect does soil type, amount of water, and vegetation, have on erosion?

What other factors can you identify which might affect erosion?

4.

5.

6.

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* Some materials in ____________________.

FLATWORMS

Activity

Investigate the relationship of flatworms to different factors within their environment, and the various properties of flatworms.

Some Things to Consider:

1. How do flatworms react to light? heat? touch? etc.?
2. Can flatworms be trained?
3. What will happen if a flatworm is cut in half?

What other things can you find out about flatworms?

4.

5.

6.

FLOATING AND SINKING

Activity

Find out all you can about different substances that sink or float and different liquids in which substances sink or float.

Some Things to Consider:

1. Can a given substance which normally sinks be transformed to float? Vice versa?

2. Can a given liquid in which a substance normally sinks be transformed in such a way that the same substance will float? Vice versa?

3. What affect does temperature have on the sinking and floating abilities of substances or on the supporting abilities of various liquids?

What other factors can you identify that might affect the floating and sinking of an object?

4.

5.

6.

THE GENERATION GAP

Activity

Find out all you can about a population of fruit flies.

Some Things to Consider:

1. Can family traits passed on by the fruit flies be altered?
2. What factors seem to affect the traits of successive generations of fruit flies?
3. By manipulating the fruit flies environment, can you predict what characteristics succeeding generations of fruit flies will possess?

What other techniques can you investigate in "fruit fly engineering"?

4.

5.

6.

HAIR

Activity

What are some differences in hair?

Some Things to Consider:

1. Do both ends of a hair strand look alike?
2. Do different shampoos affect the appearance of the hair?
3. Do bleaches change the appearance of the hair?
4. Do dyes affect the hair's appearance -- other than changing the color?
5. Does naturally different colored hair look different?
6. How will you measure this difference?

What are some other characteristics of hair which can be investigated?

7.

8.

9.

MAGNETS*

Activity

Investigate as many properties of magnets as you can identify.

Some Things to Consider:

1. What is meant by the strength of a magnet? How can magnetic strength be measured?

2. What materials seem to be affected by magnets?

3. Can the strength of a magnet be changed? How?

4. Are all parts of a magnet equally strong in attracting other materials? Which parts are strongest?

5. Can materials which are not naturally magnetic be made magnetic? How?

6. Is there any relationship between magnetism and batteries, bulbs, and wires? What?

What other properties of magnets can you investigate?

7.

8.

9.

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* Some materials in cabinet ________.

MOUTH WASHES

Activity

What things affect the growth of bacteria in your mouth?

Some Things to Consider:

1. Do mouth washes have an effect on the bacteria? Is there a difference in them?

2. Do all mouth cultures look alike (from different individuals)?

3. Does diet affect the culture of your mouth?

What other effects of mouthwashes can you investigate?

4.

5.

6.

PENDULUMS*

Activity

Try to determine which factors affect the motion of a swinging object.

Some Things to Consider:

1. How can the motion of a swinging object be described? Measured?
2. What effect does the weight, shape, color, density, etc. of an object have on its swinging motion?
3. What effect does the type of string or cord or length of string have on the motion of a swinging object?

   What other kind of swinging systems can you devise? How does their motion compare with other systems you've investigated?

4.

5.

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* Some materials in cabinet ________.

QUALITATIVE ANALYSIS*

Activity

Given some "known" powders and liquids, make some positive identifications of some unknown powder samples.

Some Things to Consider:

1. What does it mean to make a positive identification of a substance?

   Can you "prove" your findings?

2.

3.

4.

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* Some materials in cabinet ________.

ROLLING OBJECTS*

Activity

Find out all you can about the way in which objects roll.

Some Things to Consider:

1. How can the "roll-ability" of an object be measured?
2. According to your system of measurement, which objects appear to roll the best? The worst?
3. What characteristics of an object seem to affect its "roll-ability"?
4. What effect does the surface on which the objects roll have on the "roll-ability"?
5. Can the "roll-ability" of an object be changed by adding a substance on the rolling surface? How does it change?

What other factors can you investigate?

6.

7.

8.

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* Some materials in cabinet __________.

THE SUN

Activity

Examine the sun indirectly through a telescope.
NOTE: NEVER LOOK DIRECTLY THROUGH A TELESCOPE AT THE SUN. USE A PROJECTION METHOD.

Some Things to Consider:

1. Is the sun a "perfect, unblemished body"?

2. Do sunspots change with time?

3. Do colored filters allow you to see greater detail on the sun?

4. How do atmospheric conditions and/or time of day affect the image of the sun?

5. Does the sun rotate? How do you know?

6. Can you determine any characteristics of the sun's rotation?

What other properties of the sun can you investigate?

7.

8.

9.

APPENDIX II*

SAMPLE TRANSCRIPTS OF STUDENT SEMINARS

* Author's note: The enclosed transcripts were made from audio tapes of the student seminar sessions. These transcripts represent the actual discussions with no editions or changes.

TRANSCRIPT #1

Seminar Speaker's Topic: The Behavior of Mealworms

Background of the Speaker: The speaker in this selection is a first-semester Foundations student with no previous science course work beyond the high school level.

<u>Speaker</u>: I'm just doing certain things with them now. When I first started out I first observed it under the microscope and did a lot of stuff that I found out that certain parts of the body that I can't see with just the eye alone. I found out that they have a small hair fiber on their lower sides and underneath their body and each worm has six legs, three on each side, up toward the head part. It can crawl forward or backward. As far as sideways, I haven't determined that yet. You can tell the difference between the head and the tail. The tail has a little -- I haven't determined what yet -- but just from observing a little black thing out at the very end of it. You can see possibly where two eyes could be in the head. That's just from observing it that I found that out. Next I wanted to start finding out about how mealworms react and I first started with heat and I started by immersing the mealworms in heated water at different temperatures and this is the way I would determine if the mealworm was dead or alive when I did other experiments. At 60 degrees I stuck the mealworm in for 7 seconds and the worm moved around very fast like it was resisting and then it stopped and then there was no response anymore from the mealworm -- it was cooked. At 58 degrees it did the same thing so finally I got it down to 50 degree and there was no movement left at all but at 35 degrees I immersed the mealworm in for 7 seconds. The mealworm squirmed around for the full seven seconds and when I took it out it was still moving.

<u>Discussant</u>: Did you totally submerce the worm?

<u>Speaker</u>: Yes, I did. You see I know that it wasn't drowning because I did all of them for 7 seconds yet the one that I put in the 45 degree water lived so I didn't drown it because I didn't do it for any longer than 7 seconds.

<u>Discussant</u>: Do you think the mealworms differ in their lung capacity or in their ability to make it through?

Speaker: Well, so far I've put 5 mealworms in for 30 seconds. I just did this kind of as a quick experiment because I thought about that. They were all in there for 30 seconds in 45 degree water or just a little below that and they were still living at the end of 30 seconds so I'll eventually further my experiment and see how . . . perhaps a mealworm . . . I can't determine yet because I put one in for two minutes once and when I took it out it was still living but it eventually died. So I don't know -- it didn't die from seven seconds.

Discussant: What was your purpose in doing this?

Speaker: This is how I would determine whether mealworms were alive or dead. If I picked up a mealworm, say I've had it in alcohol. Sometimes it won't move. But when I dip it in the 45 degree water it always brought a response because it was such a quick change of temperature. Like a quick movement and if there was no movement whatsoever then the mealworm wasn't living. Then I started with alcohol and my first experiment was dipping them in alcohol for like 3 seconds and then taking it out to absorb the excess alcohol so it wouldn't drown, so it wouldn't breath it in. And I really thought that they'd die from being in alcohol but it was still living so I decided that even after putting it in for 3 seconds it still lived. So what I'm doing now is seeing if it has an effect on . . . it will eventually have an effect on it. So what I can do is I have ten mealworms in one little glass thing and 10 in another and the one case with just ten in are living in normal conditions and the other that I have ten in I dip in alcohol for seven seconds every time I come to class. So far five of the worms in alcohol have died and still five living but it is starting to effect them because they are moving very slow and they are very sluggish and they don't have as quick a response as the ones that haven't been dipped in alcohol. That should have some effect on whether they live or die.

Discussant: Why did you decide on seven seconds for everything? Do you time it with a stop watch or do you just look at the clock?

Speaker: I look at the clock. I time it that way.

Discussant: Why did you decide on seven seconds?

Speaker: Well, three seconds wasn't much and seven seconds seemed to be enough. I just decided on that.

Discussant: Have you tried it on anything else? Like, what if you did it at ten, would they die?

Speaker: I haven't tried that yet, I've been just doing it for seven seconds now and see what eventually what the turnout will be.

Discussant: Did you ever think that their age might be a factor?

Speaker: Yes, I have. What I've decided is I've taken the mealworms that have been approximately the same size. I haven't determined how old the worms are because I've just gotten them out of the carton.

Discussant: What do you think is being effected on the mealworms when you put them in alcohol? Why do you think he's more sluggish? Do you think it's from inhaling the alcohol?

Speaker: I can't be for sure about what it is. I can make a hypothesis that it would be the fumes of it, the content of the alcohol, but I'd have to go into some kind of study of the alcohol to find out what is in it that affects something like that. What I'm saying now is if alcohol does have an effect on them. Then I'm going to see if maybe sugar does, and light, and on down the line. At first I thought the alcohol would kill it right away but it didn't so I had to go on with a more prolonged experiment to see what would happen.

Discussant: I just want to know, on the second experiment of this long-term experiment where everyday you are coming in and dipping them in the alcohol you said five of them have died already out of ten. Why would the long-term effect be any different than the first time that you dipped them in and they all lived. Were the conditions the same as the first time you did it and the following times?

Speaker: Yes, I mean, everything is the same.

Discussant: You mean you do it for seven seconds or for however long you did it and then you just take them out and let them dry off?

Speaker: Yes, I do the same thing every day.

Discussant: How long is it that you've been doing that?

Speaker: I'd say I've been doing that for about two weeks now so I've, well, not quite, maybe a week and a half, so I've dipped them in say five times all together.

Discussant: Do you think that possibly the long range time has affected it more than just doing it once? You think that continuously doing this is what is affecting the mealworms?

Speaker: Yes, I think the continuous . . . . The ones that I did for three seconds, that I thought would all die but didn't, I still have in the same container and all of those are still living. And I think two of them have turned into what is called the beetle stage. They've transformed into right before what they turn into before they turn into a beetle. What I'm seeing now is the ones that have been dipped, I'm seeing if that has an effect on how long it takes them to actually turn into a beetle. I'm just seeing if alcohol will prolong the time it takes for it to turn into the beetle stage.

Discussant: Did those five die on the same day or at different times?

Speaker: Last Monday two of them died and today three of them have died. So they are all within just this week and I haven't determined yet why.

Discussant: Do you leave the mealworms exposed to your stimuluses, like alcohol and whatever else you are using over a certain period of time?

Speaker: You mean, do I have alcohol in the container?

Discussant: Do you leave them in the alcohol?

Speaker: No. I don't even store the alcohol, I go to the cupboard to get the alcohol and I throw away the dish that I use. Once I dip them in and set them on the paper towel to get the excess off, the paper towel absorbs the excess, I put them in a container but they aren't around the alcohol.

Discussant: Do you submerg the worms in the alcohol completely for 7 seconds?

Speaker: Yes.

Discussant: Didn't you find that this killed most of them?

Speaker: No, it didn't. See, it hasn't. That is what I thought it would do but it hasn't. I dip them all the way in for seven seconds and it has just been since Monday that -- Monday two of them died and today three of them died.

Discussant: Do you think it could be attributed to what was brought up earlier, that all mealworms are not alike? You know, there might be stronger ones and weaker ones?

Speaker: Yes. That is something that I can just go by looks. I can pair up a mealworm -- I mean you can't study it so that this one's healthier, this one's not so I take the ones that are the same size and that I got the same response to like a touch. Like, if I touch one and it hardly moves it would seem that wouldn't be in as good of condition as if I touched one and it was really lively. I tried to take the ones that had the same response and the same size.

Discussant: After you blot your mealworms off to remove the excess alcohol, do you wash them off with water?

Speaker: No, I don't. I let them lay there until . . . . What it seems like is after I dip them in alcohol they kind of go into an unconscious stage. I wouldn't know how to determine if they are unconscious or not, but they walk like say two inches and stop and kind of curl up. That's why I thought they were dead when I first did it for three seconds. But after I let them lay there, and I'd go home and the next time I'd come back, almost all of them were all moving again so it's kind of like they go into an unconscious stage for a little bit but I haven't determined exactly what it is.

Discussant: Of the five that have died, did they die after you dipped them in the alcohol that day or did you just find them dead in the container?

Speaker: I found them dead in the container because I can't really tell if they are dead or not until after I let them set for a while because like I said they go into this stage that they . . . .

Discussant: So it wasn't like after quite a while?

Speaker: No. It was after I'd let them lay there.

Discussant: How do you know if you've left them there for a couple of days that they didn't die from something else?

Speaker: I don't know, but they are under the same conditions as the ten that I haven't dipped in alcohol and those are still living.

Discussant: Don't you think if you tried doing it with a larger number, like maybe say dipping 20 and leaving 20 and maybe that would eliminate the fact that different mealworms have different . . . I mean if you use the larger number you can eliminate the possibility that different mealworms are stronger or that they died from something else if you had a large result one way or the other?

Speaker: Yes, I would try that. But I thought ten was a sufficient amount. I could do five and say I should do more and do ten. I could do 100 but I thought ten was a sufficient amount. I probably could go on to do that too.

Discussant: I'm not quite understanding your purpose here. Is it that you're just observing the reactions that you're getting from the mealworms after dipping them in your various solutions?

Speaker: I'm just learning what effect alcohol has on them. I'm going to test what effect light has on them, what effect sugar has on them, I'm just seeing what effect alcohol has on them. And so far this is the effect that alcohol has on them. I'm in the middle of that right now.

Discussant: Are all ten of the control mealworms living?

Speaker: Yes, they are.

TRANSCRIPT #2

Seminar Speaker's Topic: Bacteria Growth in a Vacuum

Background of the Speaker: The speaker in this selection is a second-semester Foundations student with approximately 20 semester hours of basic science background.

Speaker: What I did here is I mixed up various nutrient agars and I exposed them to different types of bacteria. For example, skin bacteria and mouth bacteria. I think mainly that was the only two that I did use because when I ran my first test on my skin bacteria I got three different types. This had to be repeated two or three different times to get the bacteria down to one single strain. In doing this you use a device as you can see here and I'm not sure what it's called. You sterilize this by putting it in a bunsen burner until it turns red hot and then you lift up the top of your dish and you make an exposed line in a "Z" pattern all the way across the dish so at the first point of contact there is going to be more of a variety of growth of bacteria than it would be toward the end as you can see on this. This dish is one of about the third step down after I have separated them out quite a few times and starting up here at the top you can see how it is much thicker than when it gets down toward the bottom.

Discussant: I just want to make sure I understand what you're doing. You're transfering the bacteria from one of your petri dishes to another?

Speaker: Yes. First of all, I sterilize the needle then just expose it to my arm. Then I lift the dish up and just expose it to the media. I then left if set for I think it was about 7 days. I had a variety growth -- I think it was three different types -- you could tell there was three different varieties of bacteria without running tests just by observing it because one was a colony of fungus-type thing, another looked like a concentration of cream just dotted on just the top of like this dish here. One other one tended to be very hard as this one and then another was just yellow like mustard. I had to separate each of these out so I did this separately by touching each different bacteria and putting them in their own separate containers. Then I put them in the vacuum and I devised a set up that would sustain the vacuum over a period of time and after exposing these dishes to these various bacteria I put them in the vacuum, I let them set. Each dish had its brother or sister -- what ever you want to call it -- one just that was exposed just like it and it acted as its control. This was placed in a container right next to the bell jar vacuum and it was exposed to normal atmospheric pressure whereas the one in the vacuum was completely vacated. After taking these out I couldn't really see a lot of difference except for in one mouth bacteria it didn't grow in either one. I felt that I brushed my teeth that morning -- it must have killed them off. My skin bacteria grew wild and I couldn't really see a lot of difference between the control and those in the vacuum because they both had about the same amount of growth. Skin bacteria #1 (I numbered them all off in three different groups) and the first one was a fungus and fungus grows -- if you look at it under a disecting microscope, it has all kinds of fine hairs and at the tip of these hairs they have little pollen balls, I don't know what it is called. But there was a different story in the color. The one that was in the vacuum was really a light shade of gray across the top whereas the control was very dark. It wasn't because the pollen was a different color, it was because it was just the number. In the vacuum there was a lot less of these little balls than there was towards the control. I'm about to a point now where Bacteria #2 and #3 were pretty close together. I couldn't see any difference really between the two except for the control did have a little more concentration of bacteria growth than both 2 and 3 in the vacuum so I'm running these tests again and that is what I'm in the process of doing right now.

Discussant: What's that yellow stuff in the bottom of the dish?

Speaker: That is the nutrient agar. It's one of the chemical appliances over there. You mix it 23 grams per liter. After mixing this up and heating it together you sterlize it in the autoclave so that there will be no germs in there. With my first culture that I had I had three different types of bacteria. This could have been three different variations out of my skin or it could have been just bad procedure on my part. Because as soon as you open up the dish you are exposing the medium to bacteria that is floating around in the air or if you happen to touch a portion of your needle on the side of the dish you can't really tell for sure. That's why you got to do it two or three times and get the bacteria down to just one single strain before you can work with it.

Discussant: How long do you keep them in the vacuum?

Speaker: Last time I had them in there I kept it over the weekend. I think it was three to four days.

Discussant: What does the vacuum do? Like there's no bacteria, there's nothing in a vacuum?

Speaker: Well, I can't say that because definitely there is. It's not sterilized. It's not clean because all a vacuum does is withdraw all air pressure and possibly oxygen and what ever should be in the jar at the time.

Discussant: What conclusions do you gather then from your difference between why would one look different from another one in a vacuum? What would be the reason?

Speaker: Definitely with the skin bacteris #1 I had -- like I said, there was a light shade of gray in the vacuum whereas with the control it was a dark, really a dark strain growing across the top and I could tell right there that the one in the vacuum was lacking oxygen for its growth. It would have been just as abundant in -- I don't know what they're called -- these little tiny dark balls. There would have been just as many if not more of these as compared to the control.

Discussant: You didn't get the same results on a couple of the other ones?

Speaker: On 2 and 3 it's a different strain. Number 1 was a fungus and fungus grows hairs and everything. Numbers 2 and 3 were bacteria of some type because one, like I said, looked like a mustard, a cream. I tested these with pH paper and litmus paper and my tests came out that there was a difference in the pH between the control and the vacuum just be minute -- not very much at all. As for litmus paper, I couldn't see any difference there.

Discussant: So you think maybe it's the type of bacteria or the kind that is affected by the vacuum?

Speaker: It could be. Some bacteria doesn't need atmosphere to grow and that's maybe what I'm trying to find out.

Discussant: Do you let your bacteria get started before you put it in the vacuum after you've touched it and anything. Do you let it grow in regular conditions like the other one?

Speaker: The first time I let it set for 2 days and it had a fairly good start. You could only tell because on the line of exposure there was just a very slight, minute, you know, where it was starting to grow. Then I placed them in but the second time I did it I placed them in the vacuum immediately after I exposed it. I don't know if there was a difference there or not. I couldn't really tell because then again it's how long you want to let them grow.

Discussant: Where did you get your different bacterias from?

Speaker: Like I said, I got mine off my arm. You just expose your innoculating needle to your arm and then you expose your needle to your culture media. This supposedly is supposed to take whatever bacteria that was on my arm and place it on the media. Then you sterilize this again.

Discussant: Why did you say you made the "Z" shape?

Speaker: This is done in the first point of contact with you media you may have two or three different types of bacteria on your needle. In doing this they tend to fall off at a different rate. I threw away all of my other really good samples because I didn't think I needed them. On this you can tell how much more concentrated it is than it is down towards the bottom. The first time you do this you'll get maybe two or three different types of bacteria all grown together in one lump sum up here. Whereas when you get down here towards the bottom of it they'll be separated out so that you can sort of independently . . . .

Discussant: Do you understand what it is in the bottom of those culture dishes that make the bacteria grow?

Speaker: It's like a nutrient broth of some type, beef broth or . . . I don't know, it's just an agar that is put out by chemical supplies -- I can't tell you what it's made up of because I don't know. It doesn't smell very good.

Discussant: Are they all the same like maybe you could have gotten different bacteria or molds just from having different things in the bottom of the culture dish?

Speaker: There is a variety of different types of agars that they use in testing. Like when they come down to test for tetanus or some of the hard core diseases, they use these different varieties of media in order to see what kind of reaction they get from it. If they expose it and nothing grows it is a negative reaction so they go to another media. They do this until they get a reaction from it. There are I don't know how many hundreds of . . .

Discussant: Is that what you did?

Speaker: No. I'm only using one type of media here because I have no idea what type of bacteria it is. Now, if I wanted to go through the long lengthy process of figuring it out, I could probably figure it out, which would take a lot of background and it would take a lot of studying to find what bacteria media would react negative or positive to certain medias. You've just got to do it step by step.

Discussant: I'm not exactly clear what your purpose is. Is it to see if the bell jar would alter the growth of bacteria as compared to just having it set out?

Speaker: I was comparing it to a control, as I said. First, when I set out I wanted to see if there was a difference in growth rate of the bacteria.

Discussant: Was there a difference?

Speaker: As far as I can see there is a small portion but not a major disturbing difference because, like I said, they all tended to grow. They all had really good growth on the media but there was just that little difference between concentrations - the density of it. One seemed to be a little bit darker shade than the other telling you that the control (like the mustard type bacteria) was definitely a brighter yellow than the vacuum was.

Discussant: So the ones outside the vacuum do grow more?

Speaker: To a certain extent, yes.

Discussant: What led you to believe that there would be a difference in the growth rate?

Speaker: I don't know. -- Curiosity?

Discussant: So, you thought that the one in the vacuum would really be obvious and show no growth rate at all.

Speaker: That's what I thought.

Discussant: Is the vacuum really tight or what ever . . . ?

Speaker: I played around with it quite a bit before I actually found a way of keeping the vacuum. I don't know how much of the vacuum is in there. Maybe this is why they did grow at the same rate because I'm not completely vacating the jar. After playing around with it a bit -- I sealed it with wax at all the different places and I did get it to keep a vacuum over a period of time. Now as to how much of a vacuum, I don't know.

Discussant: Does the vacuum slowly go out after a certain period?

Speaker: Normally before what I was doing it was leaking through the valves and stuff that I had set up so that is why I had to seal them with wax. After I did this it tended to keep its vacuum up better.

Discussant: How did you know, like you said, that the cultures in the vacuum were a lighter shade and that led you to believe that there were less bacteria? How could you know there were less bacteria? Could you definitely see it under a microscope?

Speaker: Yes. Under a disecting microscope you can because you can see all the fine hairs and then right at the top of your culture are all these little balls. The difference in the color was only because of the number of these balls. With the one that was in the vacuum there was very few along the line of exposure causing it to be a shade of gray compared to the control there was gads of them which tended to give it a lot more darker shade.

Discussant: Now was this the one that you left out a while before you put it in the vacuum?

Speaker: Yes.

Discussant: What did the one look like that you put directly into the vacuum?

Speaker: There was a growth on it but it hadn't grown that . . . . Like I said, it takes a period of time before each culture can reach a certain stage and I didn't let the one right after exposure that I put in the vacuum I didn't leave it in there long enough to really let it reach a stage to where these balls were formed.

Discussant: So far you've been talking about culture you got from your skin. What happened to the culture yougot from your mouth?

Speaker: I ran that test again and I still came up negative. I couldn't get any bacteria to grow. My dentist must be pleased.

Discussant: On both the control and the experimental?

Speaker: Both

Discussant: Did you try it without brushing your teeth?

Speaker: No, I haven't.

Discussant: Do you keep trying it to see if you can get bacteria from your mouth to grow?

Speaker: Yes. From the last test I got somewhat a difference between one and two. Definitely one was the most, two I got somewhat of a difference. Three is still up in the air because I couldn't really estimate growth rates and it was pretty much constant between the control and the vacuum so today I'm running it again.

Discussant: So the reason or difference is just because you're getting a better vacuum?

Speaker: Possibly. That's what I think hopefully that it is - just a lack of procedure. Some fault in the line of doing all this that is screwed up so I've got to redo it again. Maybe it isn't, maybe it is.

Discussant: Why did you use the litmus papers to test?

Speaker: I used the pH paper because definitely when you have a growth of something you're going to have a heat change and I had somewhat, towards placing the pH paper on the exact top of the media that wasn't exposed to the bacteria and placing it in the bacteria, there is a definite difference in pH. That's all I could come up with. With the litmus paper though, it was just out of curriosity, I wanted to check and see if maybe the bacteria was producing any type of acid or something of this sort.