UNDERGRADUATE SCIENCE

EDUCATION PROGRAM

by

EDWIN J. SCHEIBNER

Project B-233

Engineering Experiment Station
Georgia Institute of Technology
Atlanta, 1962-63

CONTENTS

GEORGIA INSTITUTE OF TECHNOLOGY
ENGINEERING EXPERIMENT STATION
ATLANTA 13, GEORGIA

6 August 1963

Program Director for Undergraduate Science Education
Special Projects in Science Education Section
Division of Scientific Personnel and Education
National Science Foundation
Washington 25, D. C.

Dear Sir:

The following is the final report of the Undergraduate Science Education Program performed at the Georgia Institute of Technology under Grant NSF-G-21317. A total of seven student participants were involved in this program, six during the summer of 1962 and one during the 1962-1963 academic year. Since the nature of the program instituted here and the work of the six summer participants were adequately covered in our interim report dated September 17, 1962, the following will be concerned only with the academic year.

The academic year participant was Mr. L. K. Jordan, a junior physics major. He chose to look at the bulk properties of magnetic materials with a Foner type Vibrating Sample Magnetometer. He designed and built an instrument which enabled him to make measurements on ferromagnetic samples at atmospheric pressure as a function of applied field and orientation.

The Georgia Tech chapter of Sigma Xi honored Mr. Tharp by awarding him a first prize for undergraduate research. He had submitted a report of his work under this program in the competition.

Mr. D. G. Bodnar received the B.S. degree in Electrical Engineering and is pursuing graduate studies at the Massachusetts Institute of Technology.

Sincerely yours,

E. J. Scheibner
Program Director

EJS: cjh

B 233

NSF-G-21317

DIRECTOR'S REPORT

UNDERGRADUATE SCIENCE EDUCATION

Interim, for the period June 18 to August 31, 1962.

Georgia Institute of Technology
Institution

September 17, 1962
Date

Director's Signature

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Introduction

The Undergraduate Science Education Program under Grant NSF-G-21317 is one of the activities of the Solid State Group at the Georgia Institute of Technology. The Solid State Group is an interdisciplinary research group in the Physical Sciences Division of the Engineering Experiment Station under the direction of Dr. E. J. Scheibner, Research Professor of Physics.

For several years, it has been the practice of the Solid State Group to provide opportunities for promising students to participate in its research activities. The scope of this effort has included recent high school graduates, college undergraduate students, and graduate students. They have been used in support of the primary research programs of the group. A brief description of the Solid State Group and its experiences in student participation was included in our proposal of September 8, 1961.

The support from NSF has made possible considerable progress in implementing the Plan for Education described in our proposal. During the summer of 1962, six students participated in the Undergraduate Research Participation Program, four of whom received stipends from the National Science Foundation. The manner in which this program was carried out, and the degree to which it contributed to the development of the students is the subject of this report.

Selection of Participants

The procedure followed in selecting students to participate in the NSF program is essentially that which we have used in the past when employing student assistants to work with the group. Three factors we have found most important, and which governed the choice of participants in the NSF program this summer, are:

1. The student's ability, as indicated by academic achievement and recommendations from faculty members.

2. His interests.

3. The degree to which it was felt that participation in this program could aid his professional development.

One of the NSF participants had worked with us the previous summer, following his graduation from high school. He is a winner of a Westinghouse Science Award, and was originally recommended to us by the Atlanta Public Schools Science Coordinator for that reason.

Each of the six students had displayed considerable promise toward pursuing graduate study. For these outstanding boys, it was felt that work in an active and well-equipped laboratory would benefit their future scientific careers far more than would available alternatives for summer employment in this area.

The summer program was formally organized around the following activities: orientation, participation in the group's research and/or special problems, participation in seminars, tours, and writing a report covering their activities. (Each of these is briefly described below.) The program was, however, kept on as informal a basis as practicable, since it was felt that the students would mature most rapidly if accepted as integral members of a working research team.

Program Outline

A. Orientation. During the first week, orientation sessions were held each morning in the form of lectures and movies. The afternoons were spent in various laboratories becoming more familiar with the members of the group and with the equipment and work techniques. The

lectures were given by members of the group and dealt with the group's current activities. Certain fundamental physical theories and techniques were reviewed, in an attempt to bridge the gap between the students' academic training and the specialized activities of the research group. Since the participants were from several different disciplines and colleges, these sessions were useful in building a much needed common level of mutual understanding with which to begin the summer.

The six films shown during the orientation period were constructive in introducing material and techniques. One prepared by the American Vacuum Society on vacuum technology was helpful, since all participants were involved in vacuum operations at one time or another during the course of the summer. Reprints of an excellent review article on high vacuum from The Scientific American were given the students. The other films were prepared by the Bell Telephone Laboratories. They were concerned with crystals, memory devices, semiconductors, magnetic domains and magnetic hysteresis. These were good films and were felt to be quite helpful in introducing the students to topics related to the group's activities.

B. Participation in Group Research and Special Problems. Each participant was assigned to a particular laboratory and became associated with some phase of its research. In addition, four participants were given individual research problems within the laboratory's general area of interest but completely apart from the main research program. To begin with, each of these participants was provided basic references pertaining to his problem, as well as any necessary equipment and materials. He was then allowed to approach his problem according to his own ideas, and

to design and build (or have built) any special items needed. The other two participants worked with graduate students as two-man research teams on the group's primary activities. In the following paragraphs the research activities of each student are described briefly.

Don Bodnar, a senior electrical engineering student, was assigned to the Meissner High Vacuum Laboratory. His first individual problem was to study the temperature variation of the resistivity of thin nickel films. He prepared his film and made measurements under a continuous vacuum. He built an oven that enabled a nickel film to be heated above 500°C inside an evacuated bell jar in which the film was deposited. During this study he was able to observe the effect of annealing a film and the resistivity anomaly at the Curie point.

During the summer Mr. Bodnar developed an interest in the evaporation process that led to his formulating a mathematical model of thermal etching. He has written a program for Georgia Tech's Burroughs 220 Computer with which calculations can be made from his model. At the close of the summer period, he was in the process of checking his program. We plan to let him continue this work during the academic year as a participant. The present form of his model should make it possible to obtain a time sequence simulating thermal etching. Moreover, the model appears capable of modification so as to include variations in temperature, molecular bonding, and crystal structure.

David Brown, a senior physics major from Carleton College, was assigned to the Magnetics Laboratory in which the magnetic properties of thin films are being studied. As a special problem, Mr. Brown investigated the Hall effect in bismuth ribbon and films that were available commerically.

The procedures he worked out in this study would make an instructive experiment for the undergraduate laboratory. Most of Mr. Brown's work was done with a large electromagnet that had not been used for some time. He helped restore this instrument to operation initially, and then measured its characteristics and drew up field plots.

Jerry Goodrich is a senior in Georgia Tech's School of Mechanical Engineering interested in metallurgy. This summer he worked closely with a chemical engineering graduate student under the guidance of Dr. Robert Hochman in research on the initial attack of carbon monoxide upon magnetic materials. As his special problem, Mr. Goodrich undertook a study of the CO attack on stainless-steel wires by observing the variation of resistance with time in a high-temperature reaction chamber.

James Maddox is a sophomore at Princeton University who plans to study geophysics. He had worked with us the previous summer as an assistant in the Meissner High Vacuum Laboratory. This summer he was assigned to the Solid State Electronics Laboratory, where he worked with a physics graduate student developing experimental techniques for studying photoelectric emission at a metal-dielectric interface. In the process, he gained a working knowledge of several items of precision optical equipment and apparatus for measuring extremely small currents. One of his assignments was to calibrate the source and a phototube at various wavelengths. Considering the present level of his training, he learned a considerable amount about the theoretical developments in this field.

Besides the four students discussed above, who were supported by NSF stipends, two other undergraduates also participated in the summer program under support from other sources. During the past two and a half years, Neal Tharp, a senior physics major, has progressed through the first two

phases and into the third phase of the Solid State Group's undergraduate development program. While continuing his contribution to the primary activity of the Magnetics Laboratory, he was allowed to begin work on an independent problem about five months ago. Since then, he has built his equipment and developed the necessary techniques for observing domain walls in ferromagnetic films. Recently he was able to observe the formation of cross-tie walls in permalloy films. In August, Mr. Tharp visited the Bell Telephone Laboratories and talked with several men who are experienced in the use of this technique as a research tool.

Michael Wynn, also a senior physics major, began working in the Magnetics Laboratory last February, and was given time this summer to study a special problem independently. He has designed, and, with the aid of the school's glass blower, constructed an apparatus for measuring the magnetic susceptibilities of para- and dia-magnetic liquids by the Quincke method. This experiment is still in progress.

C. Seminars. A seminar was held each week during the second half of the program, each member of the group having two opportunities to speak on topics of his own choice. In this way, the participants were introduced to a variety of topics, and, moreover, had the experience of preparing and presenting technical talks. In the fourth week each participant prepared a talk describing his individual problem and what he hoped to accomplish.

D. Tours. Although the participants' work was confined to the laboratories of the Solid State Group, they had opportunity to visit other research laboratories of the Experiment Station and academic departments. Formal tours were conducted of several, including the x-ray, computer, and microscopy facilities, and the students were allowed and encouraged

to visit others on their own initiative. In the final week, the entire group toured the new research reactor, now nearing completion. As mentioned before, one of the participants visited Bell Labs.

E. Reports and Notebooks. Each participant was provided with a log book in which to keep daily notes, and a loose-leaf binder for collecting reprints, etc. At the end of the second and sixth weeks, each was required to produce a one-page report on work accomplished and work planned for the remaining time. In the tenth week the participants wrote complete reports on their individual problems.

The program has been directed and supervised by Dr. Scheibner, with the assistance of Mr. B. R. Livesay. Dr. Hochman, who guided the metallurgical studies, was away part of the summer; however, good advanced planning prevented any difficulties in that regard. Both Dr. Scheibner and Mr. Livesay maintained a close association with each of the participants while working in the laboratories and through many discussions and in seminars. Mr. Livesay arranged the details of the orientation and seminar programs.

On July 12, Dr. Guenter Schwarz, advisory consultant for the National Science Foundation, visited the group. A conference was arranged in which each participant described his work and answered questions from Dr. Schwarz. He also visited the Meissner High Vacuum Laboratory and the Magnetics Laboratory, where he talked with the students. The discussions with Dr. Schwarz by Dr. Scheibner and Mr. Livesay were very helpful to our program.

Evaluation - Future Plans

This summer's NSF undergraduate program has been a very fruitful and pleasant experience. We feel that the students thoroughly enjoyed their work and progressed significantly toward their chosen careers. In

our opinion, the freedom to pursue a problem without being restricted by an imposed research program was especially helpful, by enabling the students to develop their own creative abilities. The members of the staff also benefited in their association with these outstanding young men.

Reflection upon our experiences with this summer program leads us to believe that our Solid State Group can make a worthwhile contribution in science education through this type of student participation. Moreover, the group itself benefits from the more comprehensive activity made possible. We, therefore, plan to continue and expand our efforts in this direction.

Overall NSF Recommendation

We found the 10-week period to be short in relation to the length of summer vacation. Since the participants appeared to be making their greatest progress during the 9th and 10th weeks, it would, in several cases, have been valuable to have had 11 or 12 weeks. One of the participants stayed an additional week to complete his experiment. Several of the students had vacation plans for the remainder of the summer. In view of this, we would like to recommend that the participation be extended to 12 weeks for certain cases.

LIST OF PARTICIPANTS

Name	Discipline	Class	Problem Title
D. G. Bodnar	E.E.	Sr.	Measurements of the Resistivity Anomaly in Nickel Films
			A Mathematical Model to Simulate Thermal Etching
D. W. Brown	Physics	Sr.	The Hall Effect in Bismuth
J. D. Goodrich	M.E.	Sr.	Carbon Monoxide Attack on Stainless Steel
J. H. Maddox	Physics	Soph.	Investigation of Photoelectric Emission at a Metal-Dielectric Interface
L. N. Tharp *	Physics	Sr.	Domain Wall Observation Using the Bitter Technique
W. M. Wynn *	Physics	Sr.	Liquid Susceptibility Measurements Using the Quincke Method

* Not NSF supported