"101" Independent Projects for Applied Microbiology

by

RAIDEL PETTIBONE

B.S., Kansas State University, 1982

A MASTER'S REPORT

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

FOOD SCIENCE

Department of Animal Sciences and Industry

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1983

Approved by:

Daniel Y. C. Fung

Major Professor

TABLE OF CONTENTS

THIS BOOK CONTAINS NUMEROUS PAGES WITH DIAGRAMS THAT ARE CROOKED COMPARED TO THE REST OF THE INFORMATION ON THE PAGE.

THIS IS AS RECEIVED FROM CUSTOMER.

ACKNOWLEDGMENTS

The author wishes to express her sincere appreciation and utmost gratitude to all those who so generously provided their professional and personal assistance for the completion of this study.

Grateful appreciation is expressed to Dr. Daniel Y.C. Fung, the researcher's major professor, for his valuable guidance and confidence which he has placed in her during this study. Special appreciation is expressed to the members of the advisory committee, Dr. Frank Cunningham, and Dr. Curtis Kastner, for their assistance and guidance throughout her graduate program.

Appreciation is expressed to Dr. Don Hoyt for his help in the statistical evaluation and to Deborah Mangelsdorf for beginning the project.

The writer wishes to thank the National Science Foundation for their financial support throughout this project.

Appreciation is expressed to friends and fellow students who provided friendship, encouragement, and support during her graduate studies.

Last, but not least a very special thank you is given to the author's family who continually gave their encouragement, love, and patience during the past five and one half years of study.

LIST OF TABLES

LIST OF APPENDICES

I. Introduction

Education is a process or course of learning, instruction, or training which imparts knowledge, skill, and competence to an individual. If an educator has been successful, a student can skillfully and competently research an individual project. This success in independent study is the major goal of all education.

Education in applied microbiology involves teaching a student how to apply his instruction and training. Independent study in applied microbiology is generally highly regarded, but has received little enthusiasm and involvement in the past. Very few programs today utilize independent study in general applied microbiology even though this is a good way of achieving confidence in ones work.

A design of independent study in applied microbiology should include a topic not covered by an existing course, digging deeper into a topic which has been introduced, laboratory investigation, and field study. A design like this will give all students a challenge, independent of their educational background.

In the past independent study, in any area, has been reserved for only the gifted and exceptional students. Independent study should give a student self-direction, irregardless of their present educational level.

A. NSF LOCI Grant Funding

Dr. D.Y.C. Fung has seen a need for an organized project of independent study in applied microbiology in the past. A grant awarded to Kansas State University entitled "101" Independent Projects for Applied Microbiology, has been funded by the National Science

Foundation. The research team, Dr. D.Y.C. Fung and myself, have undertaken this LOCI course improvement grant from the National Science Foundation.

B. NEED

The Department of Animal Sciences and Industry and the Food Science Program offer instruction to a large, diverse student population, including Animal Science majors, Food Science majors, and other disciplines at Kansas State University. This project design is concerned with the teaching of applied microbiology to both those students for whom it is required as well as to students who take the courses as electives.

The two courses primarily involved are Dairy Bacteriology and Food Fermentation. Dairy Bacteriology is a four-credit course with two hours of lectures and four hours of laboratory work per week. It has been taught for many years in the Department of Animal Sciences and Industry. The course is an elementary course in bacteriology, emphasizing the applied aspects of bacteriology as they relate to food and dairy product processing (Appendix A). Food Fermentation is a more recently developed four-credit course with two hours of lecture and six hours of laboratory per week. It is an advanced, applied microbiology course, dealing with the fermentation of microorganisms for the benefit of mankind (Appendix B).

Students at the beginning and advanced levels of microbiology possess a great deal of creativity. They seem to be fascinated by the microbes and their environment. Because of this, students in Dairy Bacteriology and Food Fermentation are encouraged to do experiments beyond the required exercises given in the laboratory sessions. These experiments are called independent projects. In this exercise, the students have the freedom of choosing an area of interest to explore. This independent project provides the students with an opportunity for creative thinking and planning, the freedom to experiment in a relaxed atmosphere, and the responsibility of independent research activity. The independent project potentially provides a great source of educational benefit to the students who wish to complete projects relevant to their educational goals of understanding the role of microbes in their home and natural environments. This opportunity fulfills one key objective of the educational mission -- to put knowledge into practical application.

Students are encouraged and assisted so they can do a good project, but the present procedures in applied microbiology are not adequate to maximize this excellent learning opportunity without utilizing considerable extra instructor time and materials.

In Dairy Bacteriology and Food Fermentation there will be students with exceptional microbiology skills and some with minimal, if any, exposure. Therefore an improved set of approaches and facilities need to be developed to respond to the needs of both groups of students. These approaches and facilities need to challenge the advanced student but yet remain simple enough for the beginning student.

C. Objective

The objective of this project is for the students to obtain a better understanding and approach to the practical application of applied microbiological skills in conducting independent research projects, and to develop an improved set of approaches and facilities to respond to the needs of the student.

For a student to achieve a better understanding and approach to the practical application of applied microbiology we (the research team in the NSF project) hope to do three things. We hope to increase the student's ability to articulate a sound rationale for their problem. Students frequently engage in microbiological study without having thought through why the analyses should prove helpful or the problems they might solve. We also hope to increase the students ability to demonstrate mastery of basic techniques of analysis. Individual projects provide ample opportunity for students to demonstrate this mastery of the basic techniques of analysis. Finally, we hope to increase the students ability to clearly, completely, and accurately write a scientific report.

The development of an improved set of approaches and facilities is essential to respond to the needs of the student. There is a need for independent project ideas, materials for field work, adequate laboratory resources, printed instructions, and reference materials.

Since many students have had very little previous exposure to research and independent work they have no concrete ideas as to where to begin. The students need to see models or examples of feasible projects that they can reasonably expect to complete in the alloted time. A well-organized list of suggested projects to help the students develop and perform well need to be developed.

Many students find microbes in the natural environment fascinating, and want to perform their experiments at sites that are of specific interest to them, such as their family farm somewhere in Kansas, a sewage treatment plant, the store in the neighborhood, the food at home, the plant in the garden, etc., Since microorganisms may grow or die rapidly after leaving the natural environment, it is not always possible to transport samples to the laboratory on campus for analysis, especially since many of the students' family farms are as far as 100 miles away. This has been a serious problem in many projects. A functional "travel kit" for the independent projects needs to be developed.

In many independent projects, students need to use the microscope, incubator, water bath, staining reagents, chemicals, etc., during times when the regular teaching laboratory may not be available. Students who do field work need to process some tests in the laboratory. Students need a well furnished laboratory (Activity Center) to maximize their efforts on the project.

As the students progress in their projects, they require more and more contact time with the instructor for materials, procedures, consultations, and report writing. Many students at this level do not know how to properly write scientific papers, and need individualized help. Individual contact is very valuable but it is also very time consuming. Many of the questions are repetitive. Therefore printed instructions on how to do the projects needs to be made.

Many students cannot easily find needed answers on certain topics on their projects. There is a need to develop a set of research materials relevant to these projects, and place these material in the Activity Center for the students.

In the past the students have been asked to think about their independent projects after one-third of the course is completed. The students then decide on their topics and write their outlines of what they wish to do and what materials they will need. The instructor evaluates the proposals and discusses with the students the feasibility of the projects in the context of time and materials involved. After one or two conversations regarding the proposed projects, the students finalize their proposals and submit final project outlines and lists of needed materials. At the appropriate time, the students take the materials and perform the experiments. About 30% of the students will come back again for a third round of discussions. These students are typically very good students, and are very eager to complete excellent projects. Some of the projects have developed into publishable work in scientific journals, and in a couple of cases actually developed into M.S. research topics.

The development of all the above items will hopefully minimize the instructors time required and maximize the students understanding and approach to applied microbiology independent projects.

II. REVIEW OF THE LITERATURE

The Oersted medalist, Robert Karplus said, "I believe that people become vitally interested in their studies and learn best when direction and guidance from a source of authority are combined with ample opportunities for the students to direct and control their own learning. The former may be called instructional input, the latter student autonomy." (Karplus, 1981). Learning is an individual process and requires student autonomy. However, a good input from the instructor is also essential to maximize learning. Couch (1973), assumed that students would learn just as much and score just as well on examinations under a nonlecture-plus-lab system as they had done under the traditional lecture-plus-lab system. This assumption proved incorrect.

Several efforts have been made to increase the performance of students in chemistry and physics in self-learning situation (Karplus, 1981; Ryan, et. al., 1980). However, very little work has been done to improve the teaching effectiveness in applied microbiology involving independent study.

A program in applied microbiology designed by Weiner and Howell (1975), allows the microbiology student to acquire isolates from an environment which interests him. The samples are used for a variety of tests in the laboratory. This project design is good because the student is discovering microbes in his environment which interest him. However, the same microbe is used for all of the experiments, and some tests may not be applicable.

The terms discovery and inquiry have been used to describe a variety of teaching and learning strategies over the last 20 years. Today if an insructor is not using the "discovery method," he is termed old-fashioned (Shymansky and Yore, 1980).

There are several books and laboratory manuals available which cover interesting aspects in microbiology, but none of them give the student a chance to select a project which interests him. These laboratory manuals provide specific directions for specific projects during course work.

Even though there are many programs available for laboratory work in science courses, very few use the philosophy of independent study in applied microbiology.

After reviewing the literature we have found a strong need for an individual project program in applied microbiology.

III. METHODOLOGY

A. Component Development

In the project, "101" Independent Projects for Applied Microbiology, 5 specific components have been developed. They are "101" independent project ideas, a travel kit for field work, an Activity Center, report writing material, and reference materials. Each component is responsive to problems which have been observed in previous individual research work.

Phase I of the project occurred between September 1981 and May 1982. During that time period the "101" project ideas were identified, the ten travel kits were developed, the Activity Center started to undergo development, and a set of reference materials was started.

During phase II of the project, June 1982, until May 1983, the project was initiated for student use. Also during this time period 5 different categories were developed for each of the "101" independent project ideas.

Phase III of the project involved completion and evaluation of the effectiveness of the project. The final report for the granting agency was also prepared at this time.

A list of "101" individual project ideas has been developed to guide the student in project selection. The student can see models or examples of feasible projects they can reasonably expect to complete in the allotted time. These project ideas cover many facets of applied microbiology which are often encountered. The project ideas are in 5 major categories which most students find interesting. These categories are:

1) The role of microbes in the natural environment.
2) The role of microbes in raw and processed foods and feeds.
3) The role of microbes in food fermentation.
4) The role of microbes in human and animal health.

5) Effects of chemical and physical agents on microbes.

Twenty sub-topics have been developed for each category, except for the fifth category which has 21 sub-topics (Appendix C).

Each project idea is typed on a card and then laminated in clear plastic so it will be accessible to the student. Each project idea card includes:

1) Title
2) Background
3) Materials and methods needed
4) Expected data
5) Expected conclusions
6) Further experiments
7) Questions
8) References

The student can choose a project which interests him and then reference a laminated card for the necessary information. He may take the card with him for his independent study and field work since it has been laminated.

A travel kit for field work has been designed which contains the necessary equipment for viable cell counts, a slide for sample collection, a sample collection bottle, and auxillary materials such as a needle, a loop, an alcohol lamp, a box of matches, a magnifying lens, forceps, paper towels, disinfectants, petri dishes, tapes, and wax pencils. Any additional equipment the researcher feels he or she will need is available upon request. The travel kit itself, is a medium size cooler, which can be easily handled by the student. Any samples which need to be kept cool during field work can be when the kit (cooler) is used.

In response to the need for special facilities to support these independent research projects, a small room near the teaching laboratory, has been set aside as an Activity Center (Appendix D). Through the LOCI grant, the following materials are provided in this center:

1) One household size refrigerator -- for cold storage of samples and perishables, and for freezing samples.
2) One water bath -- for constant temperature water to be used in microbiological procedures.
3) One incubator -- for cultivation of microbes.
4) One bacterial colony counter -- this is essential for counting bacterial colonies obtained in the viable cell count kits in the travel kit.

The Department of Animal Sciences has furnished the following materials:

1) Laboratory tables
2) Student microscopes -- for observation of samples under 100X, 400X, and 1000X.
3) Autoclave for sterilization -- this will teach students to make their own sterile material for experimentation.
4) Staining area -- an area with appropriate staining reagents and a sink.
5) A small supply of commonly used bacteriological agar and chemicals, and disposables and incidental supplies necessary in a small laboratory.
6) Instruction books for using the equipment, a set of the "101" project idea cards, a set of instructions on writing

scientific reports, and a set of relevant reference materials.

The Activity Center provides a space just for individual projects so the students can maximize their efforts.

A set of materials for reference has been purchased so the student can more effectively perform their projects and complete them in a timely manner. This collection includes materials which are relevant to applied microbiology and scientific report writing.

B. Judge's Evaluation

To determine the effectiveness of the project "101" Independent Projects for Applied Microbiology, an evaluation was obtained from qualified microbiologists. Student's independent projects before the implementation of the NSF project were used as a control group while the experimental group contained individual projects during the application of the NSF project. All projects were photocopied with names and identities deleted. The control group consisted of those students in Dairy Bacteriology (fall 1981). The experimental group included students in Dairy Bacteriology (fall 1982) and and those students in Food Fermentation (spring 1983). There was a total of 18 control subjects and 24 experimental subjects. The experimental design was approved by an expert, Dr. Don Hoyt, in education evaluation at Kansas State University.

Microbiologists, from a variety of disciplines, assisted with the evaluation of the individaul projects. The microbiologists involved were either graduate students or professors in areas such as food microbiology, ruminant microbiology, soil microbiology, genetic microbiology, veterinary microbiology, and medical microbiology.

Six teams were used in the evaluation with 3 team members per team, giving a total of 18 judges. The teams were labeled A, B, C, D, E, and F with judges numbered 1, 2, and 3 on each team. Eighteen control and 24 experimental individual projects were evaluated. The projects were randomly numbered and student names and dates of submission were omitted to prevent any personal bias by the judges.

The projects were judged on the basis of the student's ability to rationally select a project(Attribute 1), the ability of the student to employ applied microbiologocal analysis(Attribute 2), and the students aptitude in writing a scientific report(Attribute 3)

Students conducting individual projects are expected to develop and articulate a sound rationale for their investigation (Rationale). The judges on teams A and D were asked to rate the degree to which the student acheived this objective in his report. The following scale was used by following an established set of guidelines (Appendix E):

1 = Unsatisfactory

2 = Weak

3 = Acceptable

4 = Strong

Students conducting these projects are also expected to demonstrate their ability to employ basic techniques of microbiological analysis. The judges on team B and E were asked to rate the degree to which the student displayed mastery of basic techniques of analysis through this project (Analysis). The previous scale was again used by following an established set of guidelines (Appendix F).

Finally, the judges on teams C and F were asked to evaluate the students on their ability to succinctly and accurately describe the problem, procedures, results and conclusions (Report Writing). The same scale was again used by following an established set of guidelines (Appendix G).

Each judge was given a folder with a number. The contents of the folder included 9 individual projects, a set of guidelines to follow while evaluating, a brief description of the project (Appendix H), and a score sheet (Appendix I).

Each team was required to judge 21 projects. Each team member judged 9 projects, 6 being different from his other team members and 3 being the same. This enabled us to determine individual judge differences on the 3 common projects. The other 6 project scores were adjusted accordingly.

The scores on the 3 common projects were averaged for each individual judge. The average scores for the 3 judges on a team were also averaged. The adjusted scores were then obtained by adding or subtracting the adjustment factor to all of the other scores for the individual projects.

Individual judge differences were also obtained for the 3 common projects. If the judges had a perfect match it was recorded as well as differences of 1, 2, or 3.

Using the adjusted scores, an average for each of the 3 categories was found. This was done for both the experimental and the control groups. Standard deviations were also calculated. A t-test was conducted to determine if there was a significant difference between the experimental and control groups.

C. Student Evaluation

Students attitudes toward the individual projects, before having the benefit of the NSF project and while using the project, were also evaluated. An evaluation form was given to both the control and experimental groups. This form briefly explained the purpose of the NSF project and then asked them to rate their attitudes toward their independent project work. Several questions were asked concerning their confidence in writing a better report, interest in the subject matter, enjoyment of the teaching approach used, and confidence in applying microbiological techniques to practical problems(Appendix J).

The evaluation form was distributed to the control group right after completion of the course. The experimental group received their evaluation forms through the mail. The envelope contained an addressed and stamped envelope for the student to return the form.

A chi-square test was run to determine variance of the control and experimental groups.

IV. RESULTS AND DISCUSSION

A. Project Component Development

On completion of this LOCI grant project, Kansas State University has developed a set of "101" project idea cards, created travel kits, developed an Activity Center, and has developed a set of relevant reference materials. These materials will hopefully enhance the learning opportunities for independent study in applied microbiology in the future.

B. Judges Evaluation

To determine the effectiveness of "101" Independent Projects for Applied Microbiology, adjusted scores were calculated for each project in each category. The scores were adjusted by calculating an adjustment factor. This was accomplished by averaging the 3 common scores for each judge on a team and then averaging these averages. The adjustment factor is the difference between the total average for a team and the individual judge average (Tables 1 and 2). The adjusted scores were recorded along with the raw scores for both the experimental and control groups (Tables 3,4,5,6,7, and 8). A t-test was used on the basis of the adjusted scores given by the qualified microbiology judges. The adjusted scores were averaged and the standard deviation was calculated. At an α-level of .05, a value of 1.68 was needed to show a significant improvement of the experimental group over the control group. The category of report writing showed a significant improvement of the experimental group over the control group with a t-value of 1.86. If the average scores are examined, the skills category shows a slight improvement. However, the evaluation of the rationale category showed no improvement in the experimental group over the control group. The total score showed an improvement if the α-level was lowered to .25 (Table 9).

Table #1

Determination of adjustment factors for the team members individual project scores.

Judge	Project Number 03	11	18	Average[A]	Total Average[B]	Adjustment Factor[C]
A1	2	3	4	3	2.56	-.44
A2	1	3	2	2	2.56	+.56
A3	2	2	4	2.67	2.56	-.11
B1	3	2	4	3	2.67	-.33
B2	2	3	2	2.33	2.67	+.34
B3	2	3	3	2.67	2.67	.00
C1	3	2	2	2.33	2.33	.00
C2	3	2	3	2.67	2.33	-.34
C3	2	2	2	2.00	2.33	+.33

[A] The average of the individual judge's project scores

[B] The average of all the individual judges average on a team

[C] The difference between Total Average[B] and Average[A]

Table #2

Determination of adjustment factors for the team members individual project scores.

Judge	Project Number 23	31	38	Average[A]	Total Average[B]	Adjustment Factor[C]
D1	3	4	4	3.67	3.00	-.67
D2	1	3	4	2.67	3.00	+.33
D3	2	3	3	2.67	3.00	+.33
E1	2	2	3	2.33	2.67	+.34
E2	3	2	4	3	2.67	-.33
E3	1	3	4	2.67	2.67	.00
F1	1	3	4	2.67	2.89	+.22
F2	2	4	4	3.33	2.89	-.44
F3	2	2	4	2.67	2.89	+.22

[A]The average of the individual judge's project scores

[B]The average of all the individual judges average on a team

[C]The difference between Total Average[B] and Average[A]

Table #3

Individual project raw scores and adjusted scores on the basis of rationale for the control group. (Attribute #1)

Judge	Project Number	Raw Score	Adjusted Score
A1	03*	2	1.56
	07	2	1.56
	11*	3	2.56
A2	03*	1	1.56
	08	3	3.56
	10	4	4.56
	11*	3	3.56
	13	4	4.56
A3	03*	2	1.89
	11*	2	1.89
D1	22	2	1.33
	23*	3	2.33
	24	3	2.33
	25	4	3.33
	26	2	1.33
	31*	4	3.33
D2	23*	1	1.33
	30	3	3.33
	31*	3	3.33
	32	1	1.33
	33	2	2.33
	35	1	1.33
D3	23*	2	2.33
	31*	3	3.33
	36	1	1.33
	37	2	2.33

* Common projects used for determination of judge difference.
The average of the common projects was used for calculating the mean.

Table #4

Individual project raw scores and adjusted scores on the basis of rationale for the experimental group. (Attribute #1)

Judge	Project Number	Raw Score	Adjusted Score
A1	01	1	0.56
	02	3	2.56
	04	2	1.56
	05	3	2.56
	06	3	2.56
	18*	4	3.56
A2	09	1	1.56
	12	3	3.56
	14	2	2.56
	18*	2	2.56
A3	15	3	2.89
	16	2	1.89
	17	3	2.89
	18*	4	3.89
	19	4	3.89
	20	3	2.89
	21	2	1.89
D1	27	2	1.33
	28	2	1.33
	38*	4	3.33
D2	29	1	1.33
	34	2	2.33
	38*	4	4.33
D3	38*	3	3.33
	39	1	1.33
	40	2	2.33
	41	2	2.33
	42	3	3.33

* Common projects used for determination of judge difference.
The average of the common projects was used for calculating the mean.

Table #5

Individual project raw scores and adjusted scores on the basis of analysis for the control group. (Attribute #2)

Judge	Project Number	Raw Score	Adjusted Score
B1	03*	3	2.67
	07	2	1.67
	11*	2	1.67
B2	03*	2	2.34
	08	3	3.34
	10	3	3.34
	11*	3	3.34
	13	3	3.34
B3	03*	2	2.00
	11*	3	3.00
E1	22	3	3.34
	23*	2	2.34
	24	4	4.34
	25	3	3.34
	26	4	4.34
	31*	2	2.34
E2	23*	3	2.67
	30	3	2.67
	31*	2	1.67
	32	3	2.67
	33	2	1.67
	35	4	3.67
E3	23*	1	1.00
	31*	3	3.00
	36	4	4.00
	37	2	2.00

*Common projects used for determination of judge difference.
The average of the common projects was used for calculating the mean.

Table #6

Individual project raw scores and adjusted scores on the basis of analysis for the experimental group. (Attribute #2)

Judge	Project Number	Raw Score	Adjusted Score
B1	01	2	1.67
	02	4	3.67
	04	3	2.67
	05	4	3.67
	06	3	2.67
	18*	4	3.67
B2	09	1	1.34
	12	3.5	3.84
	14	1.3	1.64
	18*	2	2.34
B3	15	4	4.00
	16	4	4.00
	17	4	4.00
	18*	3	3.00
	19	4	4.00
	20	4	4.00
	21	3	3.00
E1	27	3	3.34
	28	4	4.34
	38*	3	3.34
E2	29	2	1.67
	34	3	2.67
	38*	4	3.67
E3	38*	4	4.00
	39	1	1.00
	40	3	3.00
	41	3	3.00
	42	3	3.00

* Common projects used for determination of judge difference.
The average of the common projects was used for calculating the mean.

Table #7

Individual project raw scores and adjusted scores on the basis of report writing for the control group. (Attribute #3)

Judge	Project Number	Raw Score	Adjusted Score
C1	03*	3	3.00
	07	1	1.00
	11*	2	2.00
C2	03*	3	2.66
	08	3	2.66
	10	3	2.66
	11*	2	1.66
	13	2	1.66
C3	03*	2	2.33
	11*	2	2.33
F1	22	2	2.22
	23*	1	1.22
	24	3	3.22
	25	3	3.22
	26	3	3.22
	31*	3	3.22
F2	23*	2	1.56
	30	3	2.56
	31*	4	3.56
	32	2	1.56
	33	3	2.56
	35	3	2.56
F3	23*	2	2.22
	31*	2	2.22
	36	1	1.22
	37	2	2.22

* Common projects used for determination of judge difference.
The average of the common projects was used for calculating the mean.

Table #8

Individual project raw scores and adjusted scores on the basis of report writing for the experimental group. (Attribute #3)

Judge	Project Number	Raw Score	Adjusted Score
C1	01	2	2.00
	02	1	1.00
	04	3	3.00
	05	4	4.00
	06	1	1.00
	18*	2	2.00
C2	09	4	3.66
	12	4	3.66
	14	2	1.66
	18*	3	2.66
C3	15	3	3.33
	16	4	4.33
	17	4	4.33
	18*	2	2.33
	19	3	3.33
	20	3	3.33
	21	2	2.33
F1	27	3	3.22
	28	3	3.22
	38*	4	4.22
F2	29	3	2.56
	34	3	2.56
	38*	4	3.56
F3	38*	4	4.22
	39	1	1.22
	40	1	1.22
	41	3	3.22
	42	4	4.22

* Common projects used for determination of judge difference.
The average of the common projects was used for calculating the mean.

Table #9

The average scores and statistical data obtained from judge evaluation of experimental and control individual projects.

Category		Mean	Standard Deviation	N	t-value
Attribute #1 Rationale	Exp	2.36	.87	24	-.341
	Con	2.46	1.10	18	
Attribute #2 Analysis	Exp	3.04	.96	24	.240**
	Con	2.97	.84	18	
Attribute #3 Report	Exp	2.86	1.07	24	1.860*
	Con	2.33	.68	18	
Total	Exp	8.25	2.30	24	.770**
	Con	7.75	1.80	18	

*Significant at $\alpha = .05$

**Significant at $\alpha = .25$

An improvement in the area of report writing implies the subjects in the experimental group can more clearly, completely, and accurately describe the problem, procedures, results, and conclusions then the control subjects. If a student can conduct individual research projects which include all of these attributes better now then before the use of the NSF project, the project has been successful.

The individual judge variation was determined to see how closely the agreement on scores was among various judges. Thirty three percent of the common projects had perfect matches and 56% were different by one point. Only 11% deviated by 2 (Table 10). This indicates the judges were reasonably consistent when giving the project a score.

Judge variation is often a problem in a survey such as this. However, with the guidelines given to each judge before his evaluation, this factor was kept at a minimum.

C. Students Evaluation

Students attitudes toward the independent projects were evaluated using a questionnaire. When a chi-square test was used to determine the variance between the experimental and control groups. The experimental group gave a significantly higher positive response then the control group when rating their confidence in writing a better report. There was no significant difference in the two groups for other questions on the evaluation form which were directed toward "interest in the subject matter", "enjoyment of teaching approach used", and "confidence in applying microbiological techniques to practical problems". There was some improvement in the experimental responses but not a significant amount.

Table #10

The number of deviations in judge agreement for the 3 common projects.

Judges	Number of Deviations		
	0	±1	±2
A1 vs. A2	1	1	1
A2 vs. A3		2	1
A1 vs. A3	2	1	
B1 vs. B2		2	1
B2 vs. B3	2	1	
B1 vs. B3		3	
C1 vs. C2	2	1	
C2 vs. C3	1	2	
C1 vs. C3	2	1	
D1 vs. D2	1	1	1
D2 vs. D3	1	2	
D1 vs. D3		3	
E1 vs. E2	1	2	
E2 vs. E3	1	1	1
E1 vs. E3		3	
F1 vs. F2	1	2	
F2 vs. F3	2		1
F1 vs. F3	1	2	
% deviation of 3 common projects	33%	56%	11%

D. Summary

Results show there is no significant difference between the experimental and control groups in their ability to rationally select a project. In addition, there was no significant difference between the experimental and control groups in their ability to employ applied microbiology skills. However, the experimental group received a higher average score from the judge evaluation. There was a significant improvement in the experimental groups ability to write a scientific report over the control group. The experimental group was also more confident in their report writing ability then the control group.

E. Recommendations

In the future, an evaluation needs to be done to determine the effectiveness of "101" Independent Projects for Applied Microbiology when using the laminated project cards. The authors think this will significantly increase the students ability to employ correctly the basic techniques of microbiological analysis. In addition, the authors would like to see the materials, developed in this project, made available to other faculty members at Kansas State University, as well as other institutions nationally and internationally. Continual improvement on this project is recommended so that all the initial goals can be acheived.

BIBLIOGRAPHY

Couch, R. Is Lecturing Really Necessary? American Biology Teacher, 1973, 35, 391-395.

Karplus, R. Response by the Oersted Medalist: Autonomy and Input. American Journal of Physics, 1981, 49, 811-814.

Ryan, M.A., Robinson, D., & Carmichael, Jr., J.W. A Piagetian-Based General Chemistry Laboratory Program for Science Majors. Journal of Chemical Education, 1980, 57, 642-645.

Shymansky, J.A. & Yore, L.D. A Study of Teaching Strategies, Student Cognitive Development, and Cognitive Style As They Relate to Student Acheivement in Science. Journal of Research in Science Teaching, 1980, 17, 369-382.

Weiner, R.M. & Howell, G.F. The Microbial Isolate: Relating the Acquisition of Fundamental Technique to Scientific Inquiry. Journal of College Science Teaching, 1975, 5, 96-98.

APPENDIX A

Dairy Bacteriology 020 550 Fall term 1980 Professor Daniel Y.C. Fung
Kansas State University, Manhattan, KS 66506

COURSE OUTLINE

Lecture	Date	Topic
1	8/26	Introduction to Dairy Microbiology
2	8/28	Principles and Practices in Applied Microbiology
3	9/2	Principles and Practices in Applied Microbiology
4	9/4	Intrinsic and Extrinsic Parameters of Foods
5	9/9	Yeast and Mold
6	9/11	Yeast and Mold
7	9/16	Bacteria
8	9/18	Bacteria
9	9/23	Viruses and Other Microbes
10	9/25	FIRST LECTURE EXAMINATION
11	9/30	Effects of Physical Agents on Microorganisms
12	10/2	Effects of Physical Agents on Microorganisms
13	10/7	Effects of Chemical Agents on Microorganisms
14	10/9	Microbiology of Milk and Dairy Farm Environments
15	10/14	Mastitis, Standards and Regulations
16	10/16	Growth of Microorganisms in Milk and Psychrotrophs
17	10/21	Food-borne Infections and Intoxications
18	10/23	Food-borne Infections and Intoxications
19	10/28	Epidemiology and Public Health
20	10/30	SECOND LECTURE EXAMINMATION
21	11/4	Microbiology of Raw Milk and Market Milk
22	11/6	Microbiology of Starter Culture and Lactic Cultures
23	11/11	Microbiology of Fermented Milk Products
24	11/13	Microbiology and Chemistry of Cheese Making
25	11/18	Microbiology of Various Types of Cheeses
26	11/20	Microbiology of Cheese and Spoilage Control
27	11/25	Microbiology of Cream, Butter, and Dry Milk Products
28	12/2	Microbiology of Ice Cream and Related Products
29	12/4	Dairy Plant Sanitation
30	12/9	Waste Disposal and Whey Utilization
31	12/11	Automation and Rapid Methods in Microbiology
		FINAL COMPREHENSIVE EXAMINATION

APPENDIX B

Food Fermentation 020-711 Spring term 1981 Professor Daniel Y.C. Fung
Kansas State University, Manhattan, KS. 66506

COURSE OUTLINE

Lecture	Date	Course Outline
1	1/15	Introduction
2	1/20	Important microorganisms in food fermentation
3	1/22	Important microorganisms in food fermentation
4	1/27	Important microorganisms in food fermentation
5	1/29	Biochemistry of food fermentation
6	2/3	Theory and practices of food fermentation
7	2/5	Selection and handling of microorganisms for fermenting
8	2/10	Fermentation of dairy products
9	2/12	Fermentation of dairy products
10	2/17	FIRST MID-TERM EXAMINATION
11	2/19	Beer and related beverages
12	2/24	Beer and related beverages
13	2/26	Distilled liquors
14	3/3	Distilled liquors
15	3/5	Wine
16	3/10	Wine
17	3/12	Vinegar
18	3/24	Oriental fermented foods
19	3/26	Oriental fermented foods
20	3/31	SECOND MID-TERM EXAMINATION
21	4/2	Bread fermentation
22	4/7	Plant foods
23	4/9	Plant foods
24	4/14	Pickling
25	4/16	Pickling
26	4/21	Fermented meat products
27	4/23	Fermented meat products
28	4/28	Single cell protein
29	4/30	Waste treatment
30	5/5	Potential microbial pathogens in fermented foods
31	5/7	Automation and rapid methods in food microbiology
		FINAL COMPREHENSIVE EXAMINATION

APPENDIX C

PROJECT TOPICS

I. Environment

A. Water

1) Enumerate the bacteria in samples of water from varying sources.
2) Identify organisms found in samples of water.
3) Compare the effects of temperature on the bacterial count of samples of water.
4) Compare the bacterial count/survival in sewage at various stages of treatment.

B. Air

1) Sample and enumerate the airborne organisms from a from a variety of environments.
2) Identify airborne organisms.
3) Count the bacteria and molds caught on air filters.
4) How many bacteria are in a sneeze? A cough? A spoken word?

C. Soil

1) Enumerate microorganisms found in soil samples.
2) Isolate species of bacteria or molds from soil samples.
3) Identify organisms in decaying organic material.
4) Isolate organisms from plant roots.
5) Compare the numbers of organisms found in treated and untreated soils.

D. Surface

1) Enumerate the microorganisms on surfaces in a variety of environments.
2) Compare the enumeration methods of surface swabbing and the adhesive tape method.
3) Identify indicator organisms on surfaces.
4) Compare surface material or texture and bacterial/mold viable cell counts.

E. Equipment

1) Enumerate the mocroorganisms on various pieces of equipment or utensils.
2) Identify the species of bacteria and molds found on various equipment.
3) Follow samples of milk through the collecting and processing equipment and enumerate the bacteria at various steps.

II. Raw and Processed Foods and Feed

A. Dairy Products

1) Enumerate the microorganisms in samples of raw milk.
2) Identify organisms found in milk products.
3) Isolate molds from milk or milk products and identify the family of mold.
4) Identify the spoilage organism from a spoiled milk product.

B. Meats, Poultry and Eggs

1) Enumerate the microorganisms from samples of meat, poultry, or eggs.
2) Compare the processing and handling of meat, poultry or eggs and numbers of microorganisms.
3) Compare and identify the species of microorganisms found in meat, poultry or eggs.
4) Compare the chemical treatment of meat and meat products and bacterial count.

C. Vegetables and Fruits

1) Enumerate the microorganisms in various fruit and vegetable samples.
2) Compare various processing and preparation methods of fruits and vegetables and bacterial counts.
3) Isolate and identify bacteria from samples of fruit and vegetables.
4) Isolate and identify families of molds on fruits and vegetables.

D. Cereals

1) Enumerate the microorganisms from samples of milled cereals.
2) Enumerate the microorganisms from samples of processed cereal products.
3) Compare the numbers of microorganisms in processed cereal products treated with different chemicals.
4) Compare the numbers of microorganisms in baked goods and various chemical treatments.
5) Identify the families of molds found in various cereal products.

E. Feeds

1) Enumerate the microorganisms from various feeds.
2) Identify the families of molds found in feeds.
3) Compare the numbers of microorganisms found in feeds processed by different methods.

III. Food Fermentation

A. Brewed Beverages

1) Enumerate the microorganisms from samples of brewed beverges.
2) Isolate and characterize the fermentative organism(s) in samples of brewed beverage.
3) Isolate and characterize spoilage organism(s) in samples of brewed beverage.
4) Compare the chemical and physical aspects of brewed beverages and bacterial numbers.

B. Fermented Dairy Products

1) Enumerate the microorganisms from samples of fermented dairy products.
2) Identify the fermentative organism from samples of fermented dairy products.
3) Identify spoilage organisms from samples of fermented dairy products.
4) Prepare a fermented dairy product and investigate its microbial succession.

C. Fermented Cereals

1) Enumerate the microorganisms from samples of fermented cereals.
2) Identify the fermentative organisms from samples of fermented cereals.
3) Quantitate the end products of fermented cereal.
4) Laboratory Production of beer or other beverages and monitor microbial changes.

D. "Oriental" Fermented Foods

1) Enumerate the microorganisms from samples of "Oriental" fermented food.
2) Identify the fermentative organism from samples of "Oriental" fermented food.
3) Quantitate the end products of "Oriental" fermented foods.
4) Laboratory production of Tempeh or other foods and monitor microbial changes.

E. Pickling

1) Enumerate the microorganisms in samples of pickled foods.
2) Identify fermentative organism(s) in samples of pickled foods.
3) Identify spoilage organism(s) in samples of pickled foods.
4) Prepare a pickled food product and investigate the microbial succession.

IV. Human and Animal Health

A. Human Normal or Opportunistic Flora

1) Enumerate the microorganisms found on/in normal individuals.
2) Identify microorganisms of normal human flora common to several individuals.
3) Compare the numbers of microorganisms of an opportunistic nature in healthy vs. ill individuals.
4) Compare the numbers and species of microorganisms in healthy individuals vs. individuals on various medications.

B. Animal Normal or Opportunistic Flora

1) Enumerate the microorganisms found on/in normal animals.
2) Compare the microorganisms of normal flora between species of animals.
3) Compare the numbers of microorganisms of an opportunistic nature in healthy vs. ill individuals.
4) Compare the numbers and species of microorganisms in animals fed or managed differently.

C. Human-Borne Potential Pathogens

1) Isolate and identify enteropathogenic organisms from human fecal material.
2) Isolate and identify potential pathogens from the upper respiratory tract(s) of individuals.
3) Enumerate the organisms borne in a sneeze, and identify a potential pathogen.
4) Compare the numbers of potential pathogens in persons on antibiotic therapy with normal individuals.

D. Animal-Borne Potential Pathogens

1) Isolate and identify potential pathogens from animal feces.
2) Isolate and identify animal potential pathogens from milk.
3) Identify the causative agent of pneumonia in calves.
4) Identify potential mastitis-producing organisms in healthy cows.

E. Food-Borne Potential Pathogens

1) Isolate and identify potential pathogens in "left-overs".
2) Enumerate the potential pathogens in foods after various storage procedures.
3) Isolate and identify enteropathogenic organisms in meats.
4) Compare the survival of potentially pathogenic organisms through various processing of foods.

V. The Effects of Chemical and Physical Agents on Microorganism

A. Chemical Agents
1) Investigate the effects of preservatives in foods on the growth of microorganisms.
2) Investigate the microbial inhibition properties of disinfectants.
3) Investigate the effects of antibiotics on microorganisms.
4) Identify organisms that are acidophilic and basophilic.
5) Identify halophilic organisms.

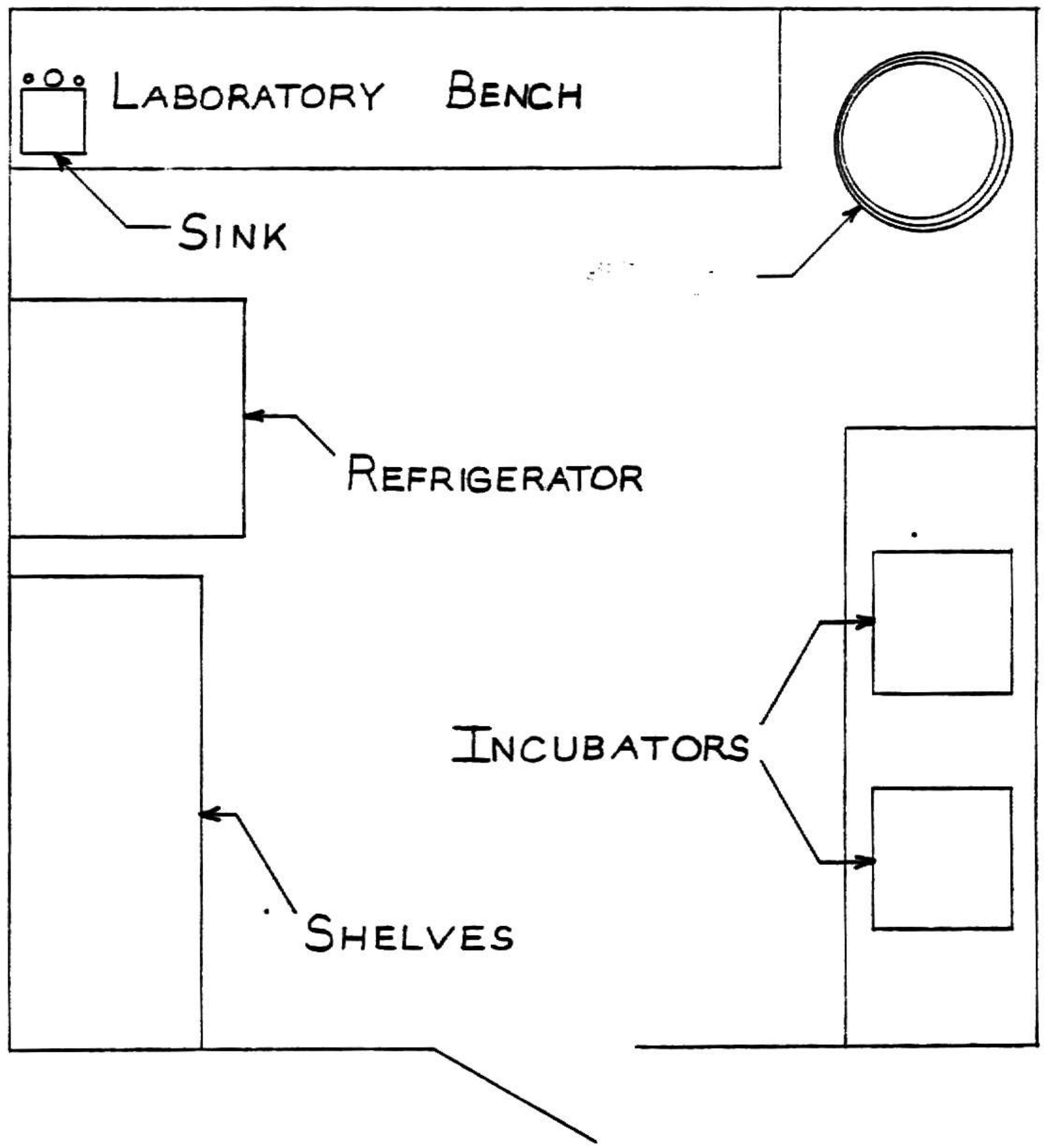
B. Irradiation
1) Compare the % kill of microorganisms with varying dosages of radiation.
2) Compare the survival rate of microorganisms exposed to varying kinds of radiation.
3) Investigate the % mutation rate of microorganisms exposed to different kinds of radiation.
4) Effect of microwave cooking on microbial survival in liquid and solid foods.

C. Temperature
1) Identify the preferred temperature ranges for growth of various species of microorganisms.
2) Compare the growth and survival of microorganisms at various temperatures.
3) Identify the thermal death curve for different species of microorganisms.
4) Compare the growth curves for a microorganism at 2 or more different temperatures.

D. Gas Environment
1) Identify and isolate an anaerobic organism.
2) Compare the growth of a microaerophilic organisms on the surface or under the surface of agar media.
3) Compare the growth of various microorganisms in different anaerobic conditions.
4) Investigate the survival of various organisms after treatment with gasses.

E. Water Activity (Aw)
1) Enumerate microorganisms in samples of freeze-dried foods.
2) Enumerate microorganisms from foods with different Aw.
3) Investigate microbial growth potential in intermediate moisture foods.
4) Construct a series of liquids with different Aw and investigate microbial survival.

APPENDIX D


LABORATORY BENCH
SINK
REFRIGERATOR
INCUBATORS
SHELVES

APPENDIX E

Guidelines for Judge Evaluation on the Basis of Rationale

Students conducting individual projects are expected to develop and articulate a sound rationale for their investigation. Usually, this is found in the "Introduction" and "Methods" sections. Please rate the degree to which the student achieved this objective in the report. Use the following scale:

1 = Unsatisfactory

2 = Weak

3 = Acceptable

4 = Strong

Signs of an Unsatisfactory Rationale

1. No rationale cited
2. Rationale inconsistent with known facts
3. Rationale based on incompatible assumptions

Signs of a Weak Rationale

1. Only a few of relevant known facts are cited
2. Reasoning is shallow or superficial
3. Logic is imprecise or ambiguous
4. Problem is so trivial that the quality of its rationale is of little meaning

Signs of an Acceptable Rationale

1. Most of the important known facts are cited
2. Reasoning appears sound, but not creative
3. Logic is internally consistent but not complex

Signs of a Strong Rationale

1. All the important known facts are cited
2. Findings from different sources are considered simultaneously
3. Logic is internally consistent and complex
4. Reasoning appears creative (goes beyond the obvious)

APPENDIX F

Guidelines for Judges Evaluation on the Basis of Analysis

Students conducting projects are expected to demonstrate their ability to employ basic techniques of microbiological analysis. In each report (usually in the "Materials and Methods" Section) the student described the techniques applied to the problem being studied. On the basis of this description, please rate the degree to which he student displayed mastery of basic techniques of analysis through this project. Use the following scale:

1 = Unsatisfactory

2 = Weak

3 = Acceptable

4 = Strong

(Note: It is best to skim the entire report to determine which section(s) contain information about the analysis)

Signs of Unsatisfactory Mastery

1. Techniques were inapproporiate
2. Proposed application of technique would produce unreliable results
3. No microbiological analysis was done
4. The design of the study and analysis was flawed; results could lead to erroneous conclusions.

Signs of Weak Mastery

1. More preferred techniques were available
2. There were indications that insufficient care was given in preparing material for analysis.
3. The description of the analysis was incomplete or vague.
4. The design was not adequate to draw firm conclusion (too few samples, too little variation in experimental condition, too limited a time period, etc.).

Signs of Acceptable Mastery

1. Acceptable techniques were used, even if more useful ones were available
2. Material to be analyzed was properly prepared for analysis
3. Procedures were described with enough detail to permit independent replication

4. Design permitted reasonably conclusive answers

Signs of Strong Master

1. Techniques used were optimal for the question and conditions of the experiment

2. Care was taken to gather and prepare materials for analysis

3. Procedures were clearly described and appropriately sophisticated

4. Design of the study and analysis permitted firm conclusions

APPENDIX G

Guidelines for Judge Evaluation on the Basis of Report Writing

Students conducting projects are expected to write reports which succinctly and accurately describe the problem, procedures, results and conclusions. Please rate the degree to which each report displays these characteristics. Use the following scale:

1 = Unsatisfactory

2 = Weak

3 = Acceptable

4 = Strong

In making your rating, please use the following guidelines:

Signs of an Unsatisfactory Report

1. Disorganized (describes results before procedure, or procedure before "problem", etc.; divides description of a section - methods, rationale, results, etc. - in a confusing way).

2. Ambiguous. The writing was generally unclear; it was hard to tell what was meant.

3. Imprecise. The procedures or results were imprecisely described.

4. Literature was not cited, or was cited incorrectly, or was inappropriate (too limited, too general, too dated).

Signs of a Weak Report

1. Organization was marginal; difficult to see the relationships among the several sections of the report; or the report lacked enough separate sections.

2. Written expression lacked clarity part of the time.

3. The description of procedures or results were incomplete or insufficiently precise; on at least one point, it was hard to infer what was done or found.

4. Although relevant works from others were used, they were incorrectly cited or not cited at all.

Signs of an Acceptable Report

1. The report was organized logically; but either the content of some sections seemed misplaced or the relationship between sections was not clear.

2. The report was written clearly, but was unnecessarily wordy.

3. Procedures and results were described with accuracy but lacked the detail needed to conduct a replication.

4. Literature was used and cited appropriately.

Signs of a Strong Report

1. The material included in each section was most appropriate to that section.

2. The relationship between sections was clear and logical.

3. The writing was clear and crisp; words were not wasted.

4. Procedures and results were described with sufficient precision that an independent investigatory could replicate.

5. Appropriate literature was cited properly and integrated logically into the report.

APPENDIX H

The National Science Foundation awarded a grant to Kansas State University to improve teaching effectiveness in applied microbiology. This project is designed to help students utilize applied microbiology skills when conducting individual research projects.

The evaluation which you will be doing will determine the effectiveness of the project. Each individual project has been photocopied for evaluation purposes. There is a control set and an experimental set of projects which have been randomly dispersed. All names and dates have been removed to avoid possible bias. Each project will be evaluated on:

1) Ability of a student to provide a rationale for their project
2) Ability of a student to employ applied microbiology skills
3) Students aptitude in writing a scientific report

Each judge will only evaluate their projects on the basis of one of the criteria above. The criteria which you will be judging is on the outside of your file. A set of guidelines is included to aid you in the evaluation rpocess. Please follow them carefully. Ignore the title page and arrangement of the title because in many cases they have been removed. On your score sheet record the project number (upper right hand corner of project) and the corresponding score on a scale of 1 to 4.

Thank you very much for your cooperation,

Raidel Pettibone

Graduate Assistant

Major Advisor: Dr. D.Y.C. Fung

APPENDIX I

JUDGE # ________

SCORE SHEET

PROJECT NUMBER	SCORE
________	________
________	________
________	________
________	________
________	________
________	________
________	________
________	________
________	________

APPENDIX J

NSF LOCI GRANT

Individual Project Evaluation

The National Science Foundation has provided funds to help us improve your course. The basic goals of this project were to provide you with an opportunity for creative thinking and planning, the freedom to experiment in a relaxed atmosphere and at your own rate, the experience of being responsible for independent work, and a chance to put knowledge into practical application.

The following questions are to help the instructors and assistants evaluate the project design. Your cooperation is answering these and any additional comments are appreciated.

Check One:

1) Exposure to research and independent work prior to this course:

   ___very much ___some ___little ___none

2) Availability of materials for field and lab work:

   _poor _fair _adequate _good _excellent

3) Equipment and availability of lab:
   _poor _fair _adequate _good _excellent

4) Instructor/Assistants were available for help and consultation:

   __never __little __some __often __always

5) How would you rate your interest in your project?

   __zzzzz __low __medium __fair __high

6) Do you think you mastered the basic techniques of microbiology?

   __NO! __few __some __many __YES!

7) Can you write a better report than before?

   __not necessarily __maybe __somewhat __definitely

8) Do you feel that you could perform another individual project successfully, applying your knowledge of microbiological techniques to solve practical problems?

   __definitely not __not very well __maybe __fairly well

   __DEFINITELY

9) Your rating of the overall individual project exercise:

   __F no good __D didn't care for it __C could take it or leave

__B was O.K. __A enjoyed doing it

10) What were the biggest problems you had with the project and how might they have been solved? Any suggestions?

11) What did you like most about the project?

Additional comments:

"101" Independent Projects for Applied Microbiology

by

RAIDEL PETTIBOME

B.S., Kansas State University, 1982

AN ABSTRACT OF A MASTER'S REPORT

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Animal Sciences and Industry

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1983

ABSTRACT

The project, "101" Independent Projects for Applied Microbiology was designed to help students utilize applied microbiology skills when conducting individual research projects. The objectives of this project were to develop an improved set of approaches and facilities to respond to the needs of the student and to provide an educational benefit to students wishing to understand the role of microbes in their home and natural environments.

The components of this project include "101" independent project ideas, a travel kit for field work, an activities center, report writing material, and a set of materials for reference. Each component is responsive to problems which have been observed in previous individual research work.

The effectiveness of this project was determined by qualified microbiologist's evaluations of the individual projects and by student evaluations. The control group consisted of independent projects before the implementation of "101" Independent Projects for Applied Microbiology and the experimental projects were those used during the application of the project. The projects were judged on the basis of the students ability to rationally select a project, the ability of the student to employ applied microbiology skills, and the students aptitude in writing a scientific report.

On the student opinion evaluation forms, the experimental subjects were more confident they could write a better report after using the individual project then before using it. The control group did not give as strong of a positive response. Other questions on the evaluation form showed some improvement in the experimental responses but not a significant amount.

Results indicated there was no significant difference between the experimental and control groups in their ability to rationally select a project(Attribute 1). There was a slight but not statistically significant improvement betyween the two groups in their ability to employ applied microbiology analysis(Attirbute 2) with the experimental group receiving a higher average score from the judges. There was a significant (α = .05) improvement in the experimental group's ability to write a scientific report (Attribute 3) over the control group. This improvement significes the success of this NSF research project since the ability to present the findings of a study reflets the student's grasp of the concept and execution of the individual inepedent applied microbiological project.