

in the index. The program then generates a list of plants on the monitor screen which all have the traits that were requested by the student. The more traits a student inputs, the smaller the list of plants to be generated.

Glossary

Because some of the terminology employed in categorizing plant characteristics may not be recognized by the students using the software, they can leave the program at any point, punch in the code term for definition, read the term's definition and then reaccess the program at the point where they left off.

Although the computer module has only been used in three sections of the landscape design classes to date, students are showing greatly increased knowledge of design characteristics, they are employing broader ranges of plant materials, and they are exhibiting better retention of woody plant characteristics. This knowledge has been reflected positively in the quality of their landscape designs.

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"101" Independent Projects for Applied Microbiology

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Abstract

The project, "101" Independent Projects for Applied Microbiology, was designed to help students utilize applied microbiology skills by conducting individual research projects. The objectives of this project were to develop approaches and facilities to meet the needs of the student and to provide an educational benefit to students wishing to understand the role of microbes in 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 pertains to problems that have been observed in previous research work.

The effectiveness of this project was determined by qualified microbiologists' 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 project. The projects were judged on the basis of the student's ability to select a project rationally, the ability of the student to employ

applied microbiology skills, and the student's aptitude in writing a scientific report.

Student opinion evaluations suggested that members of the experimental group were more confident that they could write a satisfactory report after using the individual project. Other questions on the evaluation form showed some slight improvement in the experimental responses.

Results indicated no significant difference between the experimental and control groups in their abilities to select rationally a project (Attribute 1). There was a slight, but not statistically significant, difference in favor of the experimental group in their ability to employ applied microbiology analysis (Attribute 2). There was a significant ($\alpha = .05$) improvement in the experimental group's ability to write a scientific report (Attribute 3). This improvement signifies the success of this NSF research project, since the ability to present the findings of a study reflects the student's grasp of the concept and execution of the individual applied project.

Introduction

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

Education in applied microbiology involves teaching a student how to apply instruction and training. Independent study in applied microbiology is

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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 such study helps students achieve confidence in their work.

A design of independent study in applied microbiology should involve a topic not covered by an existing course or further explore a topic that has been introduced through laboratory investigation or field study. In the past, independent study has been reserved for only the gifted and exceptional students. A design like this would present a challenge to all students, regardless of their educational background and potential ability.

NSF LOCI Grant Funding

Following an application by Dr. D.Y.C. Fung for an organized project of independent study in applied microbiology, a grant was awarded to Kansas State University by the National Science Foundation, through the Local Course Improvement program (LOCI). The project was entitled "101" **Independent Projects for Applied Microbiology**.

The Department of Animal Sciences and Industry offers instruction to a large, diverse student population, including majors in Animal Science, Food Science, and other disciplines at Kansas State University. This project encompasses the teaching of applied microbiology to both those students for whom it is required, as well as to students who take the course as an elective.

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. It is an elementary course, emphasizing the applied aspects of bacteriology as they relate to food and dairy product processing. 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 generally with the fermentation of many microorganisms.

Some students at all 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 laboratory exercises. These experiments are called independent projects. In this exercise, students are free to choose an area of interest to explore. Independent projects provide 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 provides a potential source of educational benefit to the students who wish to complete projects which will enable them to under-

stand the role of microbes in their home and natural environments. This opportunity fulfills one key objective of the educational mission — to put knowledge into practice.

Students are encouraged to do projects, but the present procedures in applied microbiology are not adequate to maximize this excellent learning opportunity without utilizing considerable extra instructor time and materials.

Dairy Bacteriology and Food Fermentation enrolls students with exceptional microbiology skills and others who have had minimal exposure. Therefore, an improved set of approaches and facilities are required to meet the needs of both groups of students. These approaches and facilities must challenge the advanced student but yet remain simple enough for the beginning student.

Objective

The objective of this project was to enable the students to obtain a better understanding of applied microbiological skills in conducting independent research projects, and to develop an improved set of approaches and facilities to meet student needs.

For a student to achieve a better understanding and approach to the practical application of microbiology, the research team in the NSF project attempted to do three things. We hoped to improve the student's ability to articulate a sound rationale for their problem. Students frequently engage in microbiological study without having studied why the analyses should prove helpful or what problems they might solve. We also hoped to increase the student's ability to demonstrate mastery of basic analyses, which are amply provided in individual projects. Finally, we hoped to increase the student's ability to write a scientific report clearly, completely, and accurately.

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 about where to begin. The students need to see models or examples of established projects that they can reasonably expect to complete in the allotted time. We had to develop a well-organized list of suggested projects for the students.

Many students find microbes in the natural environment fascinating and want to perform their experiments at sites of specific interest to them, such as their family farm, a sewage treatment plant, the neighborhood store, at home, or in the garden. Since microorganisms may grow or die rapidly after leaving the natural environment, it is not always possible to transport samples to the campus laboratory for

analysis, especially since many of the family farms are miles from the laboratory. This has been a serious problem in many projects. We needed to develop a functional "travel kit" for the independent projects.

For many independent projects, students need a 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 conduct some tests in the laboratory. Students need a well-furnished laboratory (activity center) to implement 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 write scientific papers and need individual help. Individual contact is very valuable, but it is also very time consuming. Many of the questions are repetitive. Therefore, we need to provide printed instructions on how to do the projects.

Many students cannot easily find needed information about certain topics in their projects, so we had to develop a set of research materials relevant to these projects.

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 are needed. 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 complete their proposals and submit final project outlines and lists of needed materials. At the appropriate time, the students perform the experiments. About 30% of the students come back again for the 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, and in a few instances, actually developed into M.S. research topics.

The development of all the above items should minimize the instructor's time required and maximize the student's understanding and approach to applied microbiology independent projects.

Procedures

Component Development

In the project, "101" Independent Projects for Applied Microbiology, five specific components have been developed. They are "101" independent project ideas, a travel kit for field work, an Activity Center, report writing materials, and reference materials.

Phase I of the project occurred between September 1981 and May 1982. During that time the "101" project ideas were identified, the 10 travel kits were

developed, the activity center was initiated, 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, five different categories (listed below) were developed for each of the "101" independent project ideas.

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

A list of "101" individual project ideas was 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 five major categories that 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 were developed for the first four categories and 21 sub-topics for the fifth category.

Each project idea was typed on a card and then laminated in clear plastic so it was 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 that interests him and then refer to a laminated card for the necessary information. He may take the card with him for his independent study and field work.

A travel kit was designed for field work containing the necessary equipment for viable cell counts, a slide for sample collection, a sample collection bottle, and auxiliary 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 needs is available upon request. The travel kit is a medium size cooler, which can be easily handled by the student. It can also be used to keep samples cool during field work.

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. This activity center reserves space for individual projects, so students can maximize their efforts. 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 — essential for counting bacterial colonies obtained from the viable cells collected in the field.

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 — for students to learn to make their own sterile material for experimentation.
- 4) Staining area — an area with appropriate staining reagents and a sink.
- 5) An adequate supply of commonly used bacteriological agar, chemicals, disposables and incidental supplies.
- 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.

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

Judges' Evaluations

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. The control group was students in Dairy Bacteriology (fall 1981). The experiment group included students in Dairy Bacteriology (fall 1982) and Food Fermentation (spring 1983). The experimental design was approved by an authority in education evaluation, Dr. Don Hoyt of Kansas State University.

Microbiologists from a variety of disciplines assisted with the evaluation of the individual 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 three 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 rationally to select a project (Attribute 1), the ability of the student to employ applied microbiological analysis (Attribute 2), and the student's aptitude in writing a scientific report (Attribute 3).

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

- 1 = Unsatisfactory
- 2 = Weak
- 3 = Acceptable
- 4 = Strong

Students conducting these projects also are 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 again was used by following an established set of guidelines.

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

Each judge was given a numbered folder. The contents of the folder included nine individual projects, a set of guidelines to follow while evaluating, a brief description of the project, and a score sheet.

Each team judged 21 projects. Each team member judged nine projects, six different from other team members and three the same. This enabled us to determine individual judge's differences on the three common projects. The other six project scores were adjusted accordingly.

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

Individual judge differences also were obtained for the three 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 three categories was found for both the experimental and the control groups. Standard deviations also were calculated. A t-test was conducted to determine if there was a significant difference between the experimental and control groups.

Student Evaluation

Student's attitudes toward the individual projects, before having the benefit of the NSF project and while using the project, also were 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 the students to rate their attitudes toward their independent project work. Several questions were asked concerning their confidence in writing a report, interest in the subject matter, enjoyment of the teaching approach used, and confidence in applying microbiological techniques to practical problems.

The evaluation form was distributed to the control group after completion of the course. The experimental group received their evaluation forms by mail along with a self-addressed and stamped envelope.

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

Results and Discussion

Project Component Development

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

Judges' Evaluations

The statistical analysis of adjusted scores is shown in Table 1. At a level of .05, a value of 1.68 was needed to show a significant improvement of the experimental

Table 1. The average scores and statistical data obtained from judge evaluation of experimental and control individual projects.

Category		Mean	Standard Deviation	N	t-value
Rationale	Exp	2.36	.87	24	-.341
	Con	2.46	1.10	18	
Skills	Exp	3.04	.96	24	.240**
	Con	2.97	.84	18	
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 $\alpha = .25$

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 level was lowered to .25.

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

The variation among judges was determined to see how closely they agreed. Thirty-three percent of the common projects had perfect matches and 56% were different by one point. Only 11% deviated by two. This indicates that the judges were reasonably consistent in their project scoring.

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

Student's Evaluation

A questionnaire was used to evaluate student's attitudes toward the independent projects. 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 than the control group when rating their confidence in writing a 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 significant.

Summary

Results show that there was no significant difference between the experimental and control groups in their ability to select a project rationally. 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. There was a significant improvement in the experimental group's ability to write a scientific report. The experimental group also was more confident in their report writing ability than the control group.

Recommendations

In the future, there is need for an evaluation to determine the effectiveness of using the laminated project cards for "101" Independent Projects for

Applied Microbiology. The authors think these cards will significantly increase the student's ability to correctly employ 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 to other institutions nationally and internationally. Continual improvement on this project is recommended so that all the initial goals can be achieved.

An Analysis

Faculty Movement and Composition Within a Land Grant Institution

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and

John D. Malloy

Abstract

Land grant institutions are faced with the difficult tasks of maintaining quality teaching, research, and extension programs under declining student enrollments and reduced financial support from federal and state governments. A major factor in the quality, reputation, and flexibility of different colleges within a land grant institution is the composition of the college's faculty. For this paper a Markov Chain Faculty Flow Model was developed to project future faculty composition for each college given a specific faculty hiring policy. When the Markov Chain Faculty Flow Model is combined with the university budget and curriculum direction of the university administration, administration and faculty of the College of Agriculture can estimate the potential effects as to teaching loads, course offerings, and research fund support within the college.

Introduction

Land grant institutions like many other university systems are faced with adjusting their priorities and hiring practices as they move from the enrollment expansions of the 1960's to lower enrollment numbers and retrenchment of the 80's. Student enrollment is projected to decline in the 80's because the college cohort age group has declined by 15 to 20 percent. In addition, enrollment patterns by students have changed in many universities. The traditional liberal arts education major has changed to a curricula orientation toward professional careers (such as agriculture, business, and engineering). This shift in curricula preferences has also changed hiring practices of universities. In some liberal arts areas the demand for new faculty is low, while in some professional curricula disciplines the supply of new faculty members does not meet the demand at current salaries. This has increased salary differences across disciplines and has

contributed to the phenomenon of salary compression¹ in many of the professional curricula areas.

Also, during this period, revenues from tuition, federal and state sources, and endowments have not kept pace with the increased costs of operating a land grant institution. Administrators and faculty members cognizant of these budgetary problems have enacted plans to reallocate resources. Central to resource allocation in a university system is the problem of faculty and its composition. Faculty related institutional costs represent at least 50 percent of an institution's expense (Wilson, 1979), and the tenure and rank composition of a university's faculty greatly effects the flexibility of a program, or lack of it, to respond to changes in demands and costs.

Many faculty models and studies have been done at non-land grant institutions which investigated the effects of changes in tenure-ratios, increases or decreases in retirement age for faculty members and other faculty management scenarios on the university's faculty composition, and ultimate financial status of the university (Eddy and Morrill, 1975; Franz et al., 1981; Hopkins, 1974; Pickett, 1971). However, these models have not investigated the separate colleges within a university system to detect faculty composition differences between colleges and potential effects of such faculty composition on the flexibility of the university to enact personnel changes.

Professors and instructors in the Agricultural College of a land grant institution need to be aware of the flow of faculty or changes in faculty composition, not only in their own college but other colleges within the land grant university. Because colleges within a university are interrelated primarily through the university budget, changes in faculty flow of a particular college such as the College of Engineering, will affect funding levels and faculty support in the College

¹Because of the limited number of new doctorates in many of the professional curricula areas, the salaries offered to the new doctorate usually exceed the salaries of assistant professors, who were hired two or three years prior by the university. Often the salaries offered to the new doctorate approach or exceed salaries of some of the associate professors in the discipline. Because the salary differences between ranks of faculty members in many of the professional curricula areas are quite small, this phenomenon is called salary compression.

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