

number of land-grant universities but the lowest representation of women agricultural scientists.

Precautions to Interpreting Findings

The focus of the study is directed toward women scientists in colleges of agriculture at U.S. land-grant universities; non-land-grant universities have not been studied. The research is not a comprehensive study of all women agricultural scientists with academic rank.

Because of the diverse nature of academic departments at land-grant universities, all women scientists in agricultural disciplines may not be located in colleges of agriculture. For example, an entomologist may be housed in the college of life sciences at one university and in the college of agriculture at another university.

Implications

This study provides needed answers to questions about the employment of women in the agricultural sciences. The initial findings indicate a need for the recruitment of qualified women scientists in agricultural colleges. The findings provide benchmark data that can be used for the on-going study of women agricultural scientists. The data can be helpful to agricultural college administrators for comparative analysis of universities and academic disciplines.

The study raises additional questions: How do the women perceive their positions as agricultural scientists in academia? Why did they enter an agricultural field? Do they have successful publishing and grant records? What is their level of involvement in professional organizations? Answers to these important questions will provide valuable information to university and college administrators for the recruitment of women into academic careers in the agricultural sciences. In addition, answers to these questions will provide a description of the role models now available to young women entering undergraduate and graduate programs in the agricultural sciences.

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Form and Content: Theses and Dissertations

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Abstract

Modifications of thesis requirements by graduate programs have led us to examine the purpose of a thesis and to propose changes for the agricultural sciences. Our objectives are to (1) make the thesis serve the student by developing skills in scientific communication and (2) aid the advisory committee in evaluating the student's performance. To accomplish these objectives in the agricultural sciences, a thesis should demonstrate the thinking and writing ability of the student as well as his/her research competence. The writing exercises should be similar to those the student will encounter professionally. Our thesis format would first present a thorough literature review based upon a given hypothesis. The second part would be a proposal outlining an original research problem. Following the research, the student would write one or more manuscripts styled as publishable articles. Reports on experiments or data not publishable, discussion of ideas, and commentary on scientific theories can also be included. The proposed format will give the advisory committee a realistic basis for evaluation and will allow the student to acquire practical training in scientific communication concurrent with the research.

Introduction

As a part of the requirements for a graduate degree, the thesis has remained essentially unchanged during a time when science has undergone dramatic changes (Porter et al., 1982). (The term thesis in this paper will refer to both master's theses and doctoral dissertations.) In a survey of ten graduate schools in the United States, Heiss (1970) reported that 88% of faculty members questioned approved the thesis as it was then required, 9% thought it should be modified, and less than 1% thought it should be dropped. The survey included faculty from disciplines in humanities and social sciences as well as natural sciences. However, several educators have questioned the validity of the requirement of a thesis for a graduate degree (Gilman, 1974; Tronsgard, 1963; Williams, 1971). Reid (1978) stated that the traditional thesis does not make a substantial contribution to graduate education because it fails to develop skills in scientific

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communication which are needed to produce journal publications. Reid (1978) and Brandner and Teare (1974) contend that the thesis requirement should be maintained, but the form and content of the thesis should be modified from the traditional style.

Although arguments for omitting the thesis from some programs may have merit (Wolff, 1969), we believe that the idea that research is not completed until it is communicated is more convincing, especially for agricultural disciplines. However, the traditional thesis form can be modified to better serve both the student and the advisors. The most practical suggestion for modifying the thesis in agricultural sciences is to have the degree candidate produce publishable journal articles from the research project (Brandner and Teare, 1974). Certainly the experience of writing and revising a paper and following the publication process should be a valuable part of the education of a student researcher.

The publication of a journal article provides for training in precise communication but may not require extensive literature searches beyond the immediate research problem, and therefore, alone it is not an adequate substitute for a thesis. In addition, a single effort with a publishable research report may not give the degree of training in writing skills which additional writing would provide. Reid (1978) advocates the practice of substituting journal-style articles for the dissertation but contends that some compromises should be made which preserve the values of traditional form and content. Most important, according to Reid, is to include an in-depth literature review. He also suggests the possibility of including a research proposal.

The fundamental purpose for any academic requirement should be to improve the student's education and training for a career. In a recent employer assessment of agricultural graduates, Broder and Houston (1986) reported that employers placed the most importance on communication skills. To improve communication skills, the graduate student of agricultural science needs to know how to synthesize ideas from literature, from scientific principles learned in the classroom or laboratory, and from original research into written reports and speeches. The practical objectives for a thesis should be to produce written communication that will serve the student in developing skills in scientific writing and serve the advisory committee in evaluating a student.

We propose that a thesis can help to develop a student's writing skills better if the student produces more than one kind of scientific communication concurrent with the research program. The thesis can include various forms of writing often expected from agricultural researchers: (i) the literature review, (ii) the research proposal, (iii) journal-style articles, (iv) reports on experiments, and (v) commentary on research and scientific theory. During a degree program, the advisory committee can use these thesis

components as a basis from which to advise and evaluate the student.

Thesis Format

The thesis format we propose would first present a thorough review of literature based upon a given hypothesis. Second, the student would present a written proposal outlining an original research problem. Following the research, the student would write one or more manuscripts styled as publishable articles. Reports on experiments or data not publishable and discussion of ideas would be contained in additional sections.

The Literature Review

The literature review would be written at the beginning of a graduate student's program. Before pursuing a research question or hypothesis for a specialized project, any student should thoroughly investigate the literature on that subject and be able to synthesize ideas into a written review. A thorough literature review requires the student to relate ideas, compare techniques and results, and put this information together in an organized form. This effort serves to train the student not only to write but also to think through and apply research ideas acquired from the literature. An update of subsequently published literature should be made at the end of the degree program, but the bulk of this section should be written before research is initiated.

The Proposal

The research proposal, also written at the beginning of a graduate student's program, would be a complete document in itself, but it would follow the literature review as the second section in a thesis. The literature review has traditionally been a part of the thesis, but the proposal has hardly been considered as a thesis section (Reid, 1978). Both are preliminary steps in any research program. Although the traditional thesis is begun with the proposal of a hypothesis and, in general, justifies the pursuit of the research, this hypothesis is often fragmentary without the support of the entire thesis. We suggest that the graduate student will benefit from writing a more formal and complete proposal. This training in graduate school should prepare the student to follow a concise format to produce well-justified and feasible proposals. In addition, the advisory committee's review of the proposal as well as the literature review will establish a basis for advising the student and evaluating his/her initial efforts.

Writing and revising the proposal for inclusion in the thesis will require that a student think through the logic, the feasibility, and the methods that are involved with the research. Subsequent proposals that students will write during their careers will often follow a format designed by the grantor. However, basic to any proposal are sections identifying the problem or hypothesis, the objectives, the procedures, and a statement of need or justification (e.g., Hall, 1977). The graduate student may be advised that many for-

mats also require a summary or abstract and details on facilities, personnel, and budgets, but his/her research proposal may omit some details. We recommend that a definite, concise format should be established which contains an abstract, a statement of purpose or hypothesis, background and justification, objectives, materials and methods, and conclusions. The writing of a proposal should be a valuable experience for the student since researchers will be expected to continue to produce research proposals throughout their careers.

Journal Articles

Traditionally, research findings from an M.S. or Ph.D. program are written as one large thesis. Along with Brandner and Teare (1974), we see the task of making decisions and judgments about publishable data as positive training which the journal article affords but the thesis traditionally may not have required. When research is completed and data are analyzed, the student should write at least one manuscript in a style suitable for publication. Each manuscript will follow the style for a scientific journal and teach the student a great deal about writing and about the review and publication process. The task would demand that the student condense data into publishable tables and figures as well as write and revise work to the concise form required by journal editors and reviewers. The development of these skills in communication and publication can promote the student's career, and by the time the student graduates, a manuscript can be into journal review, accepted, or even published.

Complementary Chapters

Beyond the literature review, the proposal, and the journal article, additional material included in the thesis will differ for individual programs. Written reports on data not publishable and discussion of scientific ideas can improve the student's thinking and writing skills and can be incorporated as valuable contributions to the complete thesis. Depending upon the extent of these reports and discussions, they may be included in the thesis as one or more complementary sections.

Materials which might be included in these complementary chapters include information from preliminary experiments to evaluate the methods or the analyses to be used. Often, data are acquired and analyzed which are too extensive or peripheral to be included in the journal article. By writing reports on these data for the thesis, a student will think through ideas on experiments that were aborted, failed, or lacked repetition or replication to make them qualify for publication. These data may not be of immediate, publishable value but may serve future researchers in the area and should not be discarded. The thesis offers a repository for such materials and will continue to be available to the scientific community. The writing of this section is additional career training for the student who will routinely write progress reports not publishable in standard journals.

Discussion of ideas and theories which lie outside the format for proposals or journal articles can also be presented in these complementary sections. Although style sheets for journal publications may encourage some speculation (Anonymous, 1984), both space and subject matter for such discussion must be limited by the journal format. Discussion beyond that acceptable for publication will encourage the student to think and to communicate thinking rather than simply to tabulate data. For many theses, it could be beneficial to require that a conclusions section be given to discussion of scientific theory, application of the research the student has done, and suggested research for future studies. One of the greatest benefits in writing is that it requires thinking by the writer and transmits that thinking to another scientist.

Conclusions

The most important goals of a graduate degree program are to give the student the best training possible and at the same time put research results into the best form possible. Also, the student's thesis needs to be presented in a form which can serve the advisory committee in directing and evaluating the student. The thesis format outlined here differs from that of the traditional thesis. The proposal and the journal article can be excerpted to serve their individual functions, but the proposed thesis need not be less comprehensive than that of the traditional thesis.

The student should produce the thesis as the degree program progresses. The proposed format will move the student forward in a research project more efficiently than the traditional thesis can. After its initial preparation prior to conducting the research, the literature review will require only an update at the end of the student's program. The proposal can be used by the student's graduate committee as a basis for advising the student. Reports on each experiment or on collection and analysis of data can be compiled as acquired to incorporate into the journal article or complementary sections on the thesis. Toward the end of the degree program, there remain only the revisions of the journal article and the discussions in complementary sections or conclusions. This kind of thesis format offers broader training than the traditional form by requiring the writing of research proposals and journal articles, both essential for communication and professional advancement.

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