The Research Proposal in Bioengineering Courses

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Abstract

Students in four bioengineering courses for upper-level juniors, seniors, and graduate students were required to write a research proposal. For these courses, the proposals ranged from a series of writing assignments to one writing assignment for the entire proposal. We observed that writing a research proposal was a challenge for the students. Breaking the requirements down into segments (such as a summary with specific aims, rough draft, and final draft) due on different dates helped make the assignment more manageable for the students. By the final draft, a great majority of the students were able to produce a proposal without major problems. On the order of one-fifth of the students wrote proposals that presented new and unusual ideas that were well explained and which could serve as the basis of a proposal to a federal granting agency. We conclude that requiring a research proposal is an excellent learning experience.

Introduction

The advancement of the economy in the United States is critically dependent on continuing new developments in science and engineering technology. Undergraduate students in engineering typically receive good training in how to solve well defined problems. However, they usually receive very little training in the creative activity that is involved in the development of new technology; often, students read only their textbooks in engineering courses.

One way to get students to think creatively about developing new technology is to incorporate a requirement for a research proposal into the course. However, a survey of the literature in education has revealed that little has been reported about using research proposals in courses taken by undergraduates. In fact, only two such instances have been found. In an undergraduate course for chemistry majors entitled “Introduction to Research” at Brooklyn College, students were required to select a research project provided by a chemistry professor (1). Then, students wrote a rough draft of the proposal; and then, after receiving feedback from the professor, they wrote a final draft. In another course entitled “Chemistry Research” for undergraduates at Youngstown State University, the students were required to select a research proposal topic, write a rough draft of the proposal, and then write a final draft after receiving feedback from the professor (2). For both of these proposals, the time allotted for writing both drafts of the proposal seems unrealistically short for undergraduates (5 weeks at Brooklyn College and 2 weeks at Youngstown State).

In this paper, our experiences in incorporating a research proposal in four courses in bioengineering for upper-level undergraduates and graduate students are presented. Bioengineering is a very broad field undergoing rapid development and has many opportunities for students to write research proposals on the advancement of science and engineering. The ability of students to propose new research will help prepare students to engage in life-long learning once they graduate.

Research Proposal

A research proposal was required in each of the following courses: Biochemical Engineering, Biosensors, Cellular Aspects in Tissue Regeneration, and Tissue Engineering. Each of these courses is an upper-level engineering course for juniors, seniors, and graduate students. Detailed information about the research proposal for each of these courses in given in the Appendix. This information includes the topic area, guidelines, grading, and due dates. A review of the information about the proposals for the four courses shows that there was a wide variety of requirements. The proposals ranged from a series of writing assignments (objectives, rough or first draft, and final draft in Biochemical Engineering and in Tissue Engineering; objectives and final draft in Biosensors) to one writing assignment for the entire proposal (Cellular Aspects in Tissue Regeneration). For one of the proposals, the students were required to give a presentation (Cellular Aspects in Tissue Regeneration).

Observations and Outcomes

Our main observations are the following:

1. Writing a research proposal was a challenge for the students in these four courses. It was the first time that any of them had been required to write a proposal, with the exception of a few students who had written a proposal in one of the four courses in a prior semester. For many of them, it was the first time that they had been required to do reading outside of the assigned textbooks in a course. In addition, we observed that students tended to underestimate the difficulty of writing a proposal, especially in coming up with new ideas to research.

2. Breaking the requirements down into segments (such as a summary with specific aims, rough draft, and final draft) due on different dates helped make the assignment more manageable for the students. Giving the students written or oral feedback about each of the segments helped the students do a better job on the next segment that was due.

By the final draft, a great majority of the students were able to produce a proposal without major problems. On the order of one-fifth of the students wrote proposals that presented new and unusual ideas that were well explained and which could serve as the basis of a proposal to a federal granting agency. Undergraduate students performed about the same as graduate students on the proposal.

Conclusions

We conclude that requiring a research proposal is an excellent learning experience for upper-level undergraduates, as well as graduate students, in bioengineering courses. Writing a research proposal requires a higher level of thinking than for a normal term paper, where the student is typically required to review the technical literature on a given topic. By proposing new research, the student is required to think more even critically about the previous research and to consider how to advance science and technology in the field. The requirement of a research proposal should be able to be applied in other upper-level engineering courses where technology is advancing rapidly.

Bibliography

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Appendix: Information about the Research Proposals, Listed by Course

I. Biochemical Engineering (CHE 5243)

Each student is required to write a research proposal on a topic associated with the production and processing of bioproducts. Specific topics include, but are not limited to, fundamental studies of:

Molecular and Cellular Engineering. This expanding area of engineering research encompasses pure and mixed culture processes, modeling, optimization, and control of cell and metabolite production, development of new biochemical reactors, biocatalysis, and conversion of synthetic gas and other chemical feedstocks to value added products via biological means. New techniques in the monitoring and control of molecular and cellular engineering are also of interest.

Downstream Processing. The capability to purify bioproducts in a cost-effective manner on a commercial scale is an important technical goal in the bioprocessing of substances of biological origin. New processes and a major enhancement of existing processes are needed to accomplish needed purification.

Guidelines

1. Objectives and significance: Write 1-2 pages giving the objectives of your proposal and the expected significance. Innovative or original aspects of the objectives should be discussed. Also, on a separate page give the complete citations, including the titles, of 5-6 literature references that relate to your proposal.

2. Each proposal (initial draft and final draft) must include:
   A. Project Summary – limit 1 page
   B. Project Description – limit 10 pages
   C. References – no page limit

3. The project description should be a clear statement of the work to be undertaken and should include the following: objectives for the period of the proposed work and expected significance, and relation to the present state of knowledge in the field. The statement should outline the general plan of work, including the broad design of activities to be undertaken and an adequate description of experimental methods and procedures. Typical section headings of the project description are as follows: Objectives, Significance, and Impact; Background; General Plan of Work; and Experimental Methods and Procedures.

4. Specifications for margins, spacing and font size: 2.5 cm margins on top, bottom, and on each side; double spacing; and 12 point font size.

5. Web site references should be limited to business and government web sites only. All other reference citations should be to peer reviewed articles in published journals.

6. For the revised proposal, any changes made to the initial proposal should be underlined or highlighted.

Grading and due dates

The grade for the research proposal will be based on the following criteria:

1. Approach. Are the conceptual framework, design, methods, and analyses adequately developed, well-integrated, and appropriate to the objectives of the project?

2. Innovation. Does the project employ novel concepts, approaches, or methods? Are the objectives original and innovative? Does the project challenge existing paradigms or develop new methodologies or technologies?

3. Utility or relevance of the research. This criterion is used to assess the likelihood that the research can contribute to the achievement of a goal that is extrinsic or in addition to that of the research field itself, and thereby serve as the basis for new or improved technology or assist in the solution of societal problems.

Grade credit and due dates (the course started on Jan. 12):

Objectives and significance (Feb. 24)	5%
Initial draft (March 30)	20%
Revised draft (May 5)	15%
Total for the proposal	40%

II. Biosensors (CH E 5480)

Each student is required to write an NIH style research proposal on biosensors which will be due at the end of the semester. Possible specific proposal topics include, but are not limited to the following: electrochemical sensing, potentiometric and amperometric biosensors, fiberoptic biosensors, immobilization of biorecognition molecules (enzymes, antibodies, receptor proteins), semiconductor electrodes, and ion-selective electrodes.

Guidelines

1. After turning in a 1-page summary and specific aims of the research proposal, students will meet with the instructor to receive feedback and guidance about writing the full proposal.

2. The full proposal should be in the NIH format and be 10-15 pages in length, single-spaced.

Grading and due dates

The research proposal counts 20% of the course grade.

Due dates (the course started on Jan. 13):

Summary and specific aims	March 27
Full proposal	April 30

III. Cellular Aspects in Tissue Regeneration (CHE 5480)

An individual research proposal that will target the regeneration of tissues using novel approaches is required from each student at the end of the semester. Specific tissues that can be investigated include skin, bone, cartilage, ligaments, tendons, hepatic tissue, heart tissue, heart valves, and neuronal tissue. Issues that can be addressed in connection with tissue regeneration include gene therapy and biomaterials.

Guidelines

1. Half-way into the semester the students initiate individual meetings with the instructor to communicate their ideas for their research proposal. One month before the end of the semester, each student has a project identified.

2. The research proposal should follow the general guidelines of NIH proposals:
   Abstract and Specific Aims (1-2 pages)
   Background and Significance (2 pages)
   Previous Studies (1-2 pages)
   Proposed Experimental Design presented in the form of Specific Aims (5-6 pages)
   (The total number of pages should not exceed 10 single-spaced pages.)
   References should appear at the end of the proposal (no page limit)

Grading and due dates

The research proposal counts 50% of the course grade. Grading of the research proposal has two phases:

1. Research proposal power-point presentation.
During the last two weeks of classes the students present their proposal in class. The total time available for each student is 20-25 minutes, allowing 5-10 minutes for questions from the students and the instructor. The participation of the students in this phase is strongly encouraged and rewarded with extra credit. Weaknesses identified in the research plan, the goals of the proposal, or the methods used will allow the student to improve the final version of the proposal that is due the last day of the examination period.

2. Written Research Proposal
The grading of the final proposal is based on the innovative nature of the methodologies proposed, the originality of the proposed project, and the general advancement of the knowledge in the field of tissue regeneration.

IV. Tissue Engineering (CH E 5373)

Individuals will work over the course of the entire semester to come up with a research proposal on some topic in the broad area of tissue engineering.

Guidelines

1. Specific aims: In one to two pages, give a brief overview of the project and then list three to five specific aims that will be accomplished within the timeframe of this proposal. The aims should be stated in the form of a hypothesis that can be tested and then give the experiments that will either prove or disprove the hypothesis. After turning in the specific aims, students will meet with the instructor to go over specific aims and discuss the scope of the proposal.

2. The format for the proposal will follow the guidelines set forth by the National Institutes of health (NIH) for proposal submission. See their web site (www.nih.gov) for complete details.

3. First draft of full proposal, 10-15 pages double-spaced: The rough draft should start with a revised version of the specific aims followed by a section on the background, followed by a section that goes into detail about how each aim is to be accomplished.

4. Final draft of proposal: 20-25 pages, double-spaced.

Grading and due dates

The proposal counts for 50% of the course grade.

Due dates (the course started on Aug. 26):

Specific aims	September 30
First draft	October 30
Final draft	December 11