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**Oregon State University's Undergraduate Minor in Bioenergy - Producing Graduates with the Skills to Advance the Bioeconomy**

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Abstract

A variety of skills from diverse fields will be needed to develop a sustainable bioeconomy, ranging from discovery science on feedstock and conversion to business and marketing. As part of the USDA-funded Advanced Hardwood Biofuels Project, we developed a Bioenergy Minor at Oregon State University (OSU). The minor is interdisciplinary, highly flexible, open to students in any major, and has a required research component. Previous studies have shown that participating in research results in many gains for students, including a variety of skills highly desirable to employers, such as experience with technology, communication, leadership, project management, and organization. Thus participation in research is an efficient way to gain integrated skills needed to develop a sustainable bioeconomy.

Bioenergy Minor requirements include three core courses: Introduction to Regional Bioenergy, Research in Bioenergy, and Bioenergy and Environmental Impact. The rest of the minor can be tailored to fit each student's interests. They choose electives from three different categories: Technical; Environmental; Social/Economic/Policy. With the help of the bioenergy Instructor/Advisor, they identify a faculty research mentor and complete a 10-credit research project in any field, culminating in a thesis and public seminar.

The OSU Bioenergy Minor was implemented in 2012 and has enrolled approximately 50 students; over 100 have been involved in the classes. Student research covers the entire bioenergy landscape, from discovery science to social and economic impacts and entrepreneurship.

Evaluation of the program assessed how well students were achieving four program learning outcomes. Pre-Post surveys were administered to students new to the program at the beginning of each term and again at the end of each school year. Students responded on a Likert-type scale to statements based on the learning outcomes, and answered open-ended questions. We analyzed results using ANOVA and two-tailed t-tests. All of the learning outcomes showed statistically significant increases from the pre- to post-surveys. For example, “Understanding of the core concepts of bioenergy” increased from 2.63 to 4.17 on a 5-point scale ( $p < 0.01$ ), with 4-5 representing “Excellent”. Understanding of qualitative and quantitative research methods both scored highest (4.22) of all outcome statements. Specific experiences reported as contributing to those increases were research experiences and courses. The aspects of the program students indicated were important for their persistence and engagement included making a difference in the world, sustainability, and networking. In open-ended responses students reported gaining skills, particularly in communication and experimental design, as well as soft skills in problem solving and self-management. Furthermore, they indicated that the program would benefit them in their future career and through the research experience.

Open-ended responses also revealed areas that needed improvements. These included offering course-specific comments, such as more hands-on activities and clearer timelines for research milestones. Other suggestions focused on organizational issues, such as the offering of more options and providing more marketing of the program. Program staff used these suggestions to modify and enhance the program to better meet the needs of the students.

Overall, the students were very satisfied with the program and the experiences, particularly their relationships with the bioenergy faculty and staff, the advising, and the overall quality of the undergraduate experience. They planned to use their knowledge and skills in their graduate school work and in their future careers in the field.