AC 2010-1985: BIOSUCCEED: BIO-PRODUCTS SUSTAINABILITY, A UNIVERSITY COOPERATIVE CENTER FOR EXCELLENCE IN EDUCATION

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BioSUCCEED: Bio-products Sustainability, a University Cooperative Center for Excellence in Education

Abstract

Three land-grant universities have identified mutual and complementary interests for the pursuit of an academic program in biomaterials and bioenergy, Bio-products Sustainability, a University Cooperative Center for Excellence in Education (BioSUCCEED). BioSUCEED's innovation is based on the development of graduate-level programmatic modules that can be delivered by any of the three University partners. The initiative has been developing content for six biomass and bioenergy related classes: *Fundamentals of Biomaterials Science, Biomaterials Characterization, Thermal Conversion Processes, Biological Conversion Processes, Solid State Composites, and Environmental & Policy Studies of Biomass Use.* To maximize the dissemination and impact of the courses, all of these customizable classes are being offered at no cost (open access website) to the national biomass and bioenergy community. The partnering universities expect that BioSUCCEED will help to produce students who will contribute to the innovation in biomass and bioenergy that is needed to allow them to be utilized more widely and sustainably. Evaluation data on the current impact of BIOSUCCEED is provided.

Introduction

Biomass is a renewable and sustainable resource consisting of forest, agriculture, and organic-based materials (biomaterials=value-added biomass) that can be exploited to address current societal energy and materials needs in a manner similar to the current petroleum-based economic paradigm. A confluence of factors, including regional importance of biomass, current curricula, land grant and agricultural missions, regional energy policy issues, and existing collaborative arrangements have created a favorable environment for North Carolina State University (NCSU), North Carolina A&T State University (NCAT), and the University of Tennessee Agricultural Experiment Station (UT) to formally unite their efforts in the creation of an electronic, advanced degree program in biomass.

The College of Natural Resources (CNR) at NCSU has already identified products from biomass in several components of its long-range strategic plans. This strategic plan identifies its Forest Biomaterials and Biotechnology Initiative (FBBI) as a key growth area in terms of both research and instruction. NCSU has a number of Biomaterials courses that it regularly offers.[1]

NCAT has over the past few years begun to focus upon the development of interdisciplinary graduate programs and initiated this past fall within its interdisciplinary Energy and Environmental Systems graduate program a concentration in Sustainable Bio-products.[2] This concentration capitalizes on NCAT's agriculture and engineering research strengths. The BioSUCCEED initiative will help NCAT enhance its graduate course offerings in materials from biomass and better educate a growing crop of students interested in this area.

The final partner, UT has a long, rich history of research and development activities in biomass processing. Much of this effort has addressed development of agricultural practices for sustainable production of bioenergy crops such as switchgrass and poplar. Considerable

expertise has been established around public policy issues, as well as techno-economic considerations of biomass production. New research capabilities in molecular genetics, process engineering, and feedstock preprocessing have been added. The US Southeastern SUNGRANT Center headquartered at UT is one of the BioSUCCEED partners. The SunGrant Initiative is a concept to solve America's energy needs and revitalize rural communities with land-grant university research, education, and extension programs on renewable energy and biobased, non-food industries.[3] The Southeastern Sun Grant Center coordinates activity in Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, Tennessee and Virginia. The UT PI is the Center Director and has been actively involved in incorporating the mission of BioSUCCEED in a number of initiatives at the Center.

The BioSUCCEED team has reduced instructional duplication and costs by jointly developing and testing six graduate-level classes. All three of the partners have participated in the development of these classes, and all of the classes are available to the biomass community through a web-based distribution system.[1] These classes serve as a template for other universities interested in developing their own curricula and degree programs; to be used as is or modified for individual needs. This approach of jointly developing and testing the classes, and offering them without cost to the community-at-large reduces the costs of others interested in developing similar classes, workshops, continuing education or degree programs.

Importance of Sustainable Bio-products Education

It is clear that bio-products, in the form of fuels, energy, chemical, and materials, offer a significant opportunity for the U.S. to begin to develop domestic sources of non-petroleum feedstocks. Actions by Congress and the President have defined bioproducts as an area of national interest, e.g. Executive Order 13134 Developing and Promoting Biobased Products and Bioenergy[4], the Biomass Research and Development Act[5] set targets and defined policies meant to enhance research and development of biobased materials, etc. Both USDA and DOE have identified bio-products as an important area for research and development and have issued a series of joint RFPs in this area. But in addition to the research and development of bio-products, there is also a clear understanding that the large-scale production of biomass feedstocks will have an environmental and economic impact. The environmental impacts on soil, air and water can be minimized, or become more significant, depending on the specific application of the technology. Thus, in addition to detailed discussions on the composition and characterization of biomass and chemical and biological processes used to convert biomass to useful products, BioSUCCEED addresses both the strengths and weaknesses of large scale collection and harvesting efforts of biomass and residues.

Curriculum

The core courses that have been developed are:

1. *Fundamentals of Biomaterials Science*
2. *Biomaterials Characterization*
3. *Thermal Conversion Processes*
4. *Biological Conversion Processes*

5. *Solid State Composites*
6. *Environmental & Policy Studies of Biomass Use*

A number of modules or individual lectures have been developed in such a way that they are well suited for stand-alone use. This is because it is very difficult to add an entire class to the already very full schedules common to many engineering and science degrees. Individual lectures that use biomass to illustrate concepts in chemistry, biological, engineering, and materials science can be added to the classes that are currently taught. Descriptions of each course are provided in Table I.

Table I. BioSUCCEED Course Descriptions

Fundamentals of Biomaterials Science *(NCSU LEAD):* This course offers a fundamental definition of the concepts of "biomaterials" and "biomass" and their relevance in our society. It provides an in-depth study of the core physical, chemical, and biological principles that underlie the synthesis and modification of biomaterials and associated biopolymers into novel materials.
Biomaterials Characterization *(NCAT LEAD):* The objective of this course is to describe the analytical and spectroscopic techniques and tools available for examining molecular and macroscopic structural features of naturally occurring materials with emphasis on the lignocellulosic substrate. The learning outcomes for this course are designed to offer an appreciation of the fundamentals operating behind the available methods. Furthermore, the students will be able to understand the way these methods are applied toward addressing chemical, physical and macroscopic properties of biomaterials.
Thermal Conversion Processes *(NCSU LEAD):* This learning outcome of this course is the development of an understanding of the available methods and processes that are necessary to convert biomass into usable chemicals and energy as part of a biorefinery concept. This work will focus on the application of chemical and thermal processes that can convert biomass to specific end products or to complex mixtures of materials such as syngas or pyrolysis oils.
Biological Conversion Processes *(NCAT LEAD):* The learning outcome focuses on the unique advantage of biomass over fossil carbon feedstocks where biological processes can be used to very selectively carry-out some transformations. This class also highlights challenges of bioconversions in terms of cost, dewatering, and limited thermal and pH ranges.
Solid State Composites *(UT LEAD):* This course involves the physics and engineering required for the manufacture of biocomposites from biomass. It focuses on the micromechanics of the new composites by an emphasis on the physics of interfacial binding and the physical and mechanical properties of biobased plastics and fibers.
Environmental & Policy Studies of Biomass Use *(UT LEAD):* The objective of this course is to elucidate ways in which biomass technological principles impinge upon policy issues, including lifecycle analysis (LCA), management issues, and public policy development. Learning modules will be built around the study of various realistic cases, integrating principles that were explained more fully in the other courses in the series.

Open Access Delivery Model

BioSUCCEED has developed classes with technical input from several different departments at three universities. Using an "open access" approach the classes were developed, taught and improved several times so that the product offered to the biomass community is of high quality and robust. The course material is built around a core of foundational information and concepts the can be expected to remain highly relevant for years to come, but, as part of an open access concept, will be updated as needed based on changes in knowledge. Case studies, which address the most recent developments, are structured in such a way that they easily can be updated or replaced as new technological approaches are developed. These courses contain separable "modules" suitable for insertion into existing courses.

BioSUCCEED diverges from the most usual approaches to pedagogy. In the past, the field of course development at the university level, has retained a high degree of individualism, with the faculty members largely supplying their own fresh content, but not sharing it outside of their own classroom or institution. The freshness and vitality of the many individual efforts, duplicated in different educational institutions, is not without cost, since isolated instruction cannot be expected to meet the urgent needs of society for instruction that is sufficiently broad, deep, and current.

About 5 years ago, the US DOE Agriculture Industries of the Future funded a Biomass Educational effort. This effort led to the funding of projects at six universities and many good results came from these efforts. However, the effort was eventually terminated due to very limited propagation and dissemination of the classes or technology that were developed at the individual universities to the community at large. To try to address this problem, BioSUCCEED has committed to a free dissemination of the educational content developed.

The approach utilized can be compared to the development of open-source software. Because the end goal is to provide course materials that can be made widely available, a policy of open content sharing was practiced by the participating faculty and participating institutions. A corollary of this approach is that each co-developer and user of the course content is free to make improvements, but such improvements are to be shared with the other users of the content, leading to a process that can sustain itself beyond the life of the formal project. It is envisioned that this approach, part of an "open source" software concept, will lead to continual improvements to the content.

The organizational structure utilized to develop the course materials is shown schematically in Figure 1. The leadership team coordinated the inclusion of these new classes into the on-campus and distance education programs at the different campuses. Each course, listed in the previous subsection, had a lead faculty member and lead institution. The lead faculty member reported to the leadership team and was the individual ultimately responsible for that class. The lead faculty member was responsible for monitoring the progress, quality, and academic content for the individual course, and incorporating changes as they were received. The content team included at least one individual from each institute. This team was responsible for evaluating the course content and providing feedback on its overall significance, relevance, and delivery style.

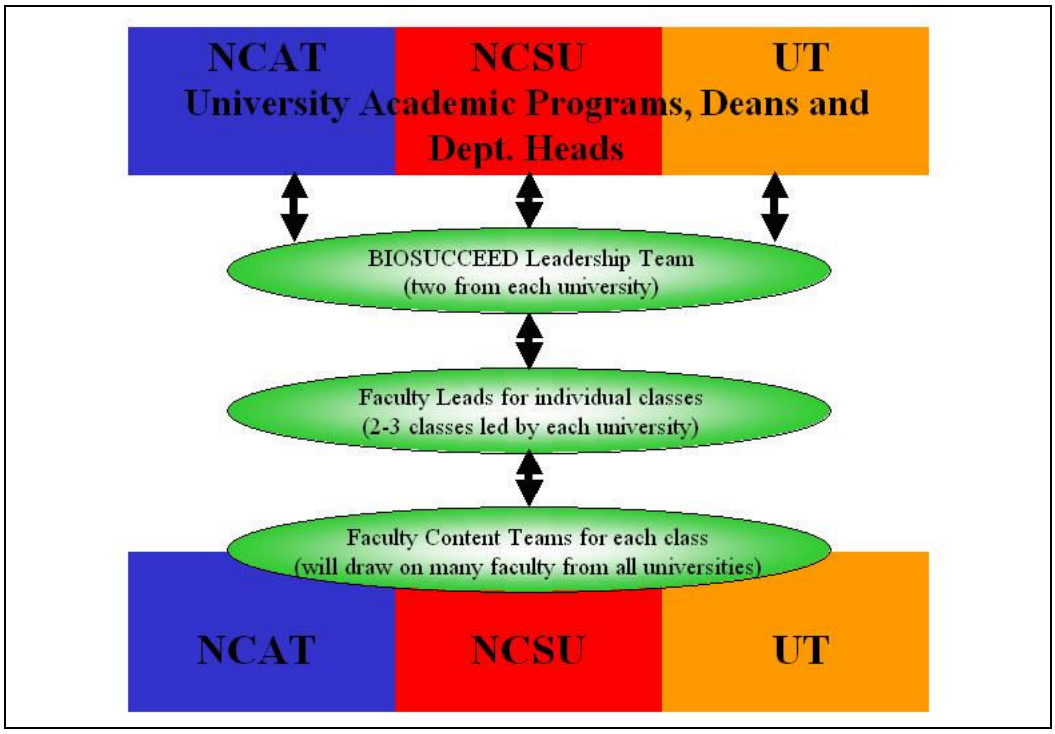

Figure 1: BioSUCCEED organizational structure.

Evaluation

Outcome and impacts from this work are being measured in several ways. The number of other universities that adopt some or all of the classes will be the primary indicator of the overall program impact. A secondary indicator of the program's overall impact will be the number of students who have taken classes developed by the program and have graduated in the graduate programs that have been created.

Individuals desiring to access module material must first register to provide demographic information. They are also encouraged to take pre- and post-surveys that include multiple choice questions with stems such as:

- What does cradle to grave Life Cycle Analysis consider?
- What does biomass/bioenergy refer to?
- Which of the following is not renewable?
- What does carbon sequestration refer to?
- Which is not a step of inventory analysis according to ISO 14044?
- Which of the following are not one of the three main types of pollution?
- What does the term primary raw material mean?

A survey is linked on the BioSUCCEED website that provides feedback on the perceived impact and importance of BioSUCCEED with questions such as:

- Based on the information that you have seen and understood in BioSUCCEED, its work, and any documentation related to it, what difference in the marketability and employability will there be for the following categories of personnel after completing the coursework/materials in BioSUCCEED and offshoots of it?
- Has either BioSUCCEED or some offshoot of it influenced your ability to improve or enhance your job performance/pay/advancement or those of people within your circle of influence?
- Should the concept of BioSUCCEED be pursued in post-secondary learning establishments?

Additional information on the impact of BioSUCCEED is being gathered from the level of activity among social networking sites that include Facebook[6] and a Blog.[7]

Conclusions

Over the past few months the first phase of the BioSUCCEED effort has been accomplished. Course notes have been developed and posted on the BioSUCCEED website. New courses have been approved at the three partner universities, and they are in the process of being taught for the first time. Preliminary data from the instruments outlined in the previous section indicate that students on the three partner campuses are being positively impacted by the BioSUCCEED activities. The impact outside of the partners is not clearly established at this point.

Acknowledgments

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