Determining Essential Components of a College-Level Bioenergy Curriculum Using the Delphi Technique

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Summary

In order to develop bioenergy into a viable industry capable of providing valuable amounts of energy and employment, there is an immediate need for a workforce whose education combines interdisciplinary content knowledge with integrated approaches to innovation and problem solving. To meet this need, it is necessary to identify and prioritize the topics that should be included in a college-level bioenergy curriculum. A three-round Delphi study was implemented to establish consensus among a panel of bioenergy experts. Round 1 consisted of a single open-ended question: **Keeping in mind the future of a commercial bioenergy industry, what content knowledge should a student have upon completion of a college-level bioenergy curriculum?** Results from round 1 were qualitatively coded, resulting in 14 themes. In round 2, experts were asked to rate the importance of including each theme using a 5-point Likert-type scale (1=Non-essential to 5=Essential). Round 3 analysis determined final expert panel consensus and stability. Results will be used to bolster the existing bioenergy education initiative at Oregon State University and provide guidance to other institutions interested in developing similar bioenergy education programs.

Background

World energy consumption is predicted to increase by 56 percent between 2010 and 2040 (www.eia.gov), and there is an undeniable need to find feasible solutions to meet this demand. Heavy reliance on fossil fuels for energy needs has resulted in accelerated climate change, as well as dependence on foreign oil suppliers, which compromises global environmental health and our country's independence and national security. Bioenergy, or renewable energy produced from organic matter, has existed since the first humans began burning wood for heat and cooking purposes, and continues to be a large source of energy used globally (US DOE, 2011). Much research is currently being conducted to improve the process of converting the solar energy stored in living and recently living organisms to a form that can be utilized efficiently and cost-effectively to the benefit of society and the environment (Warnmer, 2007). Technologies developed through this research that advance conversions of biomass to biofuels, coupled with increasing oil prices, strongly suggest that the importance, applicability and utilization of bioenergy will continue to escalate (Pasztor & Kristoferson, 1990).

As the bioenergy industry and job market continue to grow (White & Walsh, 2008), **a well-trained workforce capable of implementing innovations and meeting impending challenges will be required, and education is the key.** However, currently there is a severe deficiency in training programs and courses dedicated to bioenergy (Ransom & Maredia, 2012), and an extensive literature review reveals that virtually no empirical research exists concerning the essential constituents of bioenergy-specific curricula at the college level. The establishment of a general bioenergy education framework can assist in providing students, who will become tomorrow's bioenergy innovators, the tools necessary to contribute to the advancement of this reemerging discipline.

Delphi Method

A three round Delphi study (Okoli & Pawlowski, 2004) was implemented to establish consensus among a panel of experts regarding necessary components of a college-level bioenergy curriculum. This recognized, mixed-methods procedure is popularly defined as a **technique used to "obtain the most reliable consensus of opinion of a group of experts…by a series of intensive questionnaires interspersed with controlled opinion feedback"** (Dalkey and Helmer, 1963, p.458), and has been employed in a variety of curriculum-based explorations (e.g. Osborne, et.al, 2003; Rossouw, Hacker, & Vries, 2011). Delphi operates on the principle that "several heads are better than one in making subjective conjectures about the future…and that experts will make conjectures based upon rational judgment rather than merely guessing…" (Weaver, 1971, p.268).

The Delphi method facilitates an efficient group dynamic process and is differentiated from similar processes such as Nominal Group Technique and focus groups by incorporating the following four characteristics: 1) **Anonymity** among panel experts; 2) **Multiple iterations** of group responses; 3) Controlled, interspersed **feedback to participants**; and 4) **Statistical analysis** of the group response (von der Gracht, 2012, and Rowe & Wright, 2011).

Delphi's sustained attractiveness as a planning and decision making tool relies on its ability to efficiently elicit opinions from experts who bring knowledge, authority, and insight to the problem.

Expert Panel

Name	Title	Organization
Annabelle Berklund	Instructor	Colorado State University
David Bernell	Assistant Professor	Public Policy, Oregon State University
Dr. Paul F. Bryan	Biofuels & Bio-products Specialist	Independent Industry Consultant
Dan Burciaga	President & CEO	ThemoChem Recovery International, Inc. (TRI)
Mark E. Harmon	Richardson Chair and Professor of Forest Science	Department of Ecosystems and Society, Oregon State University
Russ Karow	Field Crops Agronomist	Crop and Soil Science, Oregon State University
Matt Krumenauer	Senior Policy Analyst	Oregon Department of Energy
Dave Newport	VP, Manager of Projects	ThermoChem Recovery International, Inc.
Brian Karl Richards	Senior Research Associate	Biological & Environmental Engineering, Cornell University
David Smith	Instructor	Wood Science and Engineering, Oregon State University
Timothy Volk	Senior Research Associate	College of Environmental Science and Forestry, State University of NY

Results

Theme Title/Summary	Round 2		Round 3	
	M[1]	*SD*[2]	*M*	*SD*
Energy Basics: Students should understand the fundamental principles of energy	4.50	1.24	**4.73**	0.47
Types of Bioenergy: Students should be familiar with a broad range of available and emerging types of bioenergy	4.50	0.90	**4.64**	0.67
Environmental Impacts (including Life Cycle Analysis[3]): Students should be familiar with positive and negative environmental impacts related to bioenergy production and evaluate inputs and outputs to make informed decisions	4.33	1.23	**4.45**	0.52
Current Technologies: Students should be familiar with current energy production	4.17	0.94	**4.27**	0.47
Societal Issues: Students should recognize the societal consequences (pros and cons) resulting from a bioenergy industry	4.08	0.90	**4.27**	0.47
Logistics: Students should understand the planning, implementation, and coordination required for the bioenergy supply-chain	4.08	0.67	**4.18**	0.40
Policy: Students should be familiar with existing and proposed policies that influence the growth of the industry	4.00	0.95	**4.09**	0.54
Biomass Composition: Students should know the basic biomass components	4.33	0.89	**4.00**	1.00
Non-Bioenergy-Specific Fundamentals: In addition to the above-mentioned topics, students should also have fundamental coursework and skills (Biology, Chemistry, Math, Physics, Writing Skills, Ecosystems, Communication, Data Analysis/Statistics, Process Modeling)	4.23	n/a	**4.00**	n/a
Biomass Production: Students should understand the methods involved with producing commercial quantities of biomass	4.42	0.79	**3.91**	0.94
Conversions: Students should have scientific knowledge of converting biomass to intermediates and end products	4.08	0.90	**3.91**	0.54
Bioenergy Market: Students should be familiar with the current and projected bioenergy market	3.92	1.00	**3.73**	0.65
Business-Related Knowledge: Students should have a basic understanding of business management and strategy (Finance, Economics, Risk/SWOT Analysis, Return on Investment Calculations)	3.75	n/a	**3.65**	n/a

[1]Means (*M*) on a 5-point scale of 1 "not essential" to 5 "essential."; [2]*SD*=Standard Deviation ; [3]Based on panel feedback, Life Cycle Analysis was included under Environmental Impacts during Round 3

Discussion

To date, there is inadequate bioenergy-explicit curricula literature available, exposing the fact that the United States is sorely overdue in this capacity. At a time when the US government is actively funding bioenergy projects with an exorbitant amount of public funds, it is vital that these efforts be augmented by providing our future leaders with a suitable, rigorous education to ensure they are supported for success. **These resulting themes represent the foundational knowledge that students should have in order to begin to contribute prosperously to the field of bioenergy.** By utilizing the knowledge of experts from a variety of bioenergy-related fields (e.g. feedstocks, conversions, policy, business) from across the country, we have established a general bioenergy curriculum framework that may be used as a starting point by institutions looking to launch educational programs in this imperative, reemerging discipline.

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USDA United States Department of Agriculture
National Institute of Food and Agriculture