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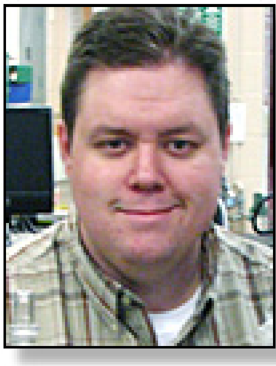

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Abstract

Using biodiesel production as the centerpiece, the efforts of multiple academic programs were combined to achieve a common objective, thus illustrating the importance of cross-disciplinary collaboration. These programs include Chemical Technology, Sustainable Energy, Automotive Technology, HVAC, Biotechnology, and Agricultural Technology. By participating in the implementation of a closed-loop biodiesel supply chain, students learned the significance of communication and the interdependence of the myriad programs.

Introduction

The merit of interdisciplinary collaborations has been well-recognized as a means of solving new challenges in many sectors (Amey & Brown, 2004). As such, one may expect that a broad exposure to related disciplines beyond one's own area of study would facilitate such collaborations upon entry into the workforce. Modeling these types of interactions in the community college classroom can be a challenge due to the limited contact time that instructors have with students as a result of the length of a 2-year program as well as many student's desire to avoid non-requisite classes. By including collaboration within the curriculum, students can gain a better understanding of how their skill sets will intersect with those of future co-workers from other disciplines in a given environment. Furthermore, with careful consideration, only moderate modification of the core curriculum can result in cross-disciplinary education without the necessity for extra courses or loss of core material.

At Ivy Tech Community College in Lafayette, Indiana faculty members are forming cross-disciplinary partnerships by building portions of their curriculum on a common theme: clean energy. Similar partnerships have been formed at other institutions (Koester, Eflin, & Vann, 2006; Mitchell, 2000). Clean energy provides a unique opportunity to bring together disciplines that typically do not overlap in an academic setting. Currently, the Chemical Technology, Automotive Technology, Sustainable Energy, and the Heating Ventilation and Air Conditioning (HVAC) programs have established practical projects that introduce students to clean energy and its application. For instance, Chemical Technology along with Sustainable Energy students producing biodiesel are working closely with students in the Automotive and HVAC departments in order to more fully understand the effects of fuel quality on end use.

Objective

The purpose of this study is to use clean-energy as a mechanism to increase the cross-disciplinary interactions among faculty and students. This report examines the beginning phases of a multiple phase project. Each phase has separate objectives and measures for success; each will be discussed in the *Project Overview* section of this report.

Background

Biodiesel fuel is a substitute for petroleum-derived diesel fuel (petrodiesel) that is produced by a chemical reaction on fats that are either animal- or vegetable-based. The benefits of biodiesel over petrodiesel are economical, ideological, and practical. In terms of economics, biodiesel blends can be less expensive than petrodiesel (United States Department of Energy, 2007). Of great importance to the environment is the fact that biodiesel adds significantly less carbon dioxide to the active carbon cycle when compared to petrodiesel. The carbon in biodiesel is derived from plant matter, a renewable resource. The carbon dioxide generated from combustion of the biodiesel is then, in turn, sequestered by other plant matter to produce more biodiesel feedstock, completing a cycle for carbon. For this reason, biodiesel is said to be *carbon neutral*, not withstanding carbon emissions from production (Johnston & Holloway, 2007). In contrast, the carbon dioxide produced by burning petrodiesel takes carbon that has been an inactive part of the carbon cycle for millions of years and adds it to the presently active carbon cycle. Additionally, biodiesel has better lubricating characteristics than the new low-sulfur mandated diesel now being sold at the pump (Wadumesthrige, Ara, Salley, & Ng, 2009). The direct result of this is longer engine life and enhanced performance.

Due to the reasons listed above, there has been considerable interest generated in biodiesel. This interest has translated into an increase in home-production of biodiesel, as well as an increase in industrially-produced biodiesel. Whether producing tens of gallons in their garage, or millions of gallons in an industrial production facility, both scenarios require that adequate training be provided for those who will be involved in biodiesel production. Ivy Tech Community College—Lafayette began providing this training through the Chemical Technology program as part of a cross-disciplinary endeavor. Recognizing that biodiesel production begins with feedstock and ends with combustion, current efforts have focused on forming collaborations among programs in the Schools of Applied Science and Engineering Technology and the School of Technology that reflect the partnerships that are forged in the industrial production of biodiesel. As such, students involved in this project will experience a broader view of biodiesel production than can be conveyed within their respective programs. For this reason, faculty in the Automotive Technology, Chemical Technology, and HVAC programs began working together to provide their students with biodiesel training that goes beyond the traditional borders of their disciplines. This collaboration will fully include the Sustainable Energy, Agriculture, and Biotechnology programs as it continues to grow.

Project Overview

The biodiesel project was informally initiated upon communication between faculty in the Automotive Technology and Chemical Technology programs. The early initiative allowed students in the Chemical Technology program to produce biodiesel fuel that was consumed by vehicles in the Automotive Technology program. The project was set in motion by a devoted group of Chemical Technology students who, with the support of their instructor, wanted to learn about biodiesel production. Starting with a small-scale production, the instructor noted the enthusiasm that the students displayed for a project that had such clear practical application. It was also noted that the students were very inquisitive about how their homemade fuel would be consumed and how it would perform in comparison to its petroleum-based counterpart. Furthermore, students in the Automotive Technology program expressed a strong interest in the production of biodiesel, despite having no previous chemical training. These observations revealed that students would be likely to connect to the cross-disciplinary nature of biodiesel production. More importantly, biodiesel production would serve as a platform for providing students with a well-rounded education that includes disciplines that are intimately related, but rarely integrated academically. The vision of the biodiesel project can be broken down into four progressive phases (Table 1). Table 2 summarizes the objective of each of the phases.

Table 1. Outline of the Biodiesel Project

	Phase I (Induction)	Phase II (Development)	Phase III (Implementation)	Phase IV (Closed Loop)
Faculty Inclusion	CHMT, AUTC	Phase I + HVAC	Phase II + SUST, AGRI	Phase III + BIOT
Curriculum Development	Develop pilot experiments	Carry out pilot experiments with select students	Scale up pilot experiments to include in curricula	Expand into ethanol production
Community Involvement	Odyssey Day and AFV Day	Phase I + student poster session	Phase II + Biofuel Class	Phase III + Biodiesel Trailer display
Service Learning	None	Testing waste fryer grease	Biodiesel Quality Testing	Workshops and Summer Camps
Equipment	Biodiesel Reactor	Diesel Engines, Furnace, Dyno, Emissions Testing	ASTM Test Equipment, Seed Press	Course Materials
College Service	None	None	Produce biodiesel to be used in tractors on campus farm	Use biodiesel to fuel a generator that powers a building on campus

Note. Those objectives in shaded boxes have been achieved at time of publication. CHMT = Chemical Technology, AUTC = Automotive Technology, HVAC = Heating, Ventilation, and Air Conditioning Technology, SUST = Sustainable Energy Technology, AGRI = Agriculture Technology, BIOT = Biotechnology.

Phase I: Induction

The first phase of the biodiesel project has been named the *induction phase*. This phase served as an opportunity for the core faculty (Automotive and Chemical Technology) to become familiar with biodiesel fuel. The two programs were careful to initially focus their research on understanding the aspects of biodiesel that directly impacted their particular discipline. For the Automotive Program, this involved learning about the fuel efficiency of biodiesel as well as its effects on a modern diesel engine. It was necessary that the faculty be familiar with key concepts such as cold-weather performance, fuel blends, and emissions profiles. Naturally, the initial focus for the Chemical Technology program was placed squarely on the chemical process involved in biodiesel production. It was requisite that the collaborators from this department simply be able to produce biodiesel fuel on a small scale. During this phase of the project, the following major steps were taken to meet the Phase I objectives:

1. Faculty from the Automotive and Chemical Technology programs were able to successfully integrate expertise from their respective disciplines to produce a common body of knowledge concerning biodiesel production and consumption.
2. Chemical Technology faculty, along with a select group of students, successfully generated biodiesel fuel from waste fryer grease that was donated by a local restaurant.
3. Automotive Technology faculty, along with a select group of students, established the viability of biodiesel fuel produced by the Chemical Technology students by combusting it in both a large and small diesel engine.
4. Students and faculty from Automotive Technology, Chemical Technology, and Sustainable Energy participated in a day-long event at the local mall as a part of the National Alternative Fuel Odyssey Day.

Table 2. Objectives for each project phase

Phase	Objectives	Measures
Phase I: Induction	• Integrate efforts among programs at college • Increase student participation through community outreach	Student participation at a public event for National Alternative Fuels Odyssey Day
Phase II: Development	• Increase student collaboration between programs through research	Student participation in a research poster presentation
Phase III: Implementation	• Create credit-based platform for interdisciplinary collaboration by developing a biofuel production class with little prerequisites	Number of students and variety of backgrounds

During this time, a biodiesel reactor was purchased to allow for a scale-up of biodiesel production in order to produce quantities that were amenable to utilization by the Automotive Technology program in their courses. Furthermore, this reactor served as centerpiece in community outreach programs that displayed the biodiesel project. The purpose of these programs was to educate the public about the work being done at the college, as well as imparting information about biodiesel production.

Phase II: Development

The second phase of the biodiesel project is considered the *development phase*. During this phase, it was imperative that the knowledge obtained in Phase I be developed into models for inclusion into pre-existing curricula. While there was clearly opportunity for fusing the biodiesel project with the curricula in place for both Automotive Technology and Chemical Technology, general community interest indicated that the HVAC program should be integrated into the biodiesel project as well since members of the community were also interested in utilizing biodiesel as a fuel in residential furnaces. Furthermore, due to the growing market for biodiesel furnaces, it was deemed appropriate that HVAC technicians gain some exposure to biodiesel, should they encounter it in their careers at some point. During Phase II, the following key steps were taken to meet the Phase II objectives:

1. The Chemical Technology program developed a service learning lab module whereby waste fryer grease from local home-biodiesel producers is quality-tested.
2. Chemical Technology students successfully scaled-up the biodiesel production process to generate 20 gallons of biodiesel per batch.
3. The Automotive Technology program successfully procured diesel vehicles for testing the horsepower and torque output of biodiesel vs. diesel fuel. Select students in the program began gathering data to create a model for curriculum development. This data is being measured on a dynamometer.
4. The Automotive Technology program purchased engine stands and outfitted them with diesel engines for continuous run experiments along with other performance testing.
5. The HVAC program began developing pilot experiments with select students to create a model for further development. This work was done with a pre-existing furnace in the HVAC laboratory.
6. Students currently involved in the biodiesel project agreed to present posters at local community outreach events.

Phase III: Implementation

Phase III of the biodiesel project has been named the *implementation phase.* This phase of the project is devoted, as the name suggests, to implementing the technology developed in the first two phases by fully infusing the project in current curricula. This was done in two different ways. First, the Sustainable Energy program created a biofuels course that will provide both traditional students and members of the community with an opportunity to gain meaningful in-depth knowledge about the production of biofuels. This course focused primarily on biodiesel and ethanol production and ran for the first time in Fall 2009.

Biodiesel projects are also being integrated into the curriculum of the Automotive Technology, Chemical Technology, and HVAC programs by modifying current lab courses to include modules that examine biodiesel usage. The goal is not to add extra course material, but rather to use existing experiments as a vehicle for comparing the performance of biodiesel to petrodiesel. Cross-disciplinary information will be included in lab handouts. In addition, pre- and post-tests have been developed to gauge the students knowledge of biofuels before and after the lab module. This data will be used to gauge the depth of knowledge retained by the students.

The American Society of Testing Materials (ASTM) provides standards for testing methods for many materials, including biodiesel. Additionally, ASTM indicates the points at which a material does and does not "pass the test" for specific properties. The focus of the Chemical Technology program will shift to quality testing of the biodiesel being produced to ensure that passes ASTM quality testing. This is necessary because a poor batch of biodiesel could potentially lead to failures in the experiments being carried out within other programs.

At this stage of the project, a considerable amount of effort will be focused on creating a *closed-loop system* (Phase IV, Figure 1) at our institution. This means that inclusion of the Agriculture program will supply the project with an independent source of soy bean oil for producing biodiesel. The Agriculture program has purchased a diesel-powered tractor that will be used to cultivate the fields on our campus farm. In the near future, the tractor will run on ASTM-quality biodiesel and be maintained by diesel mechanics trained in the Automotive Technology program. Simultaneously, the Chemical Technology program will be providing the HVAC program with ASTM-quality biodiesel that will be burned in a furnace to heat a campus building. In addition, the biodiesel fuel will also be used to fuel a Caterpillar Generator Set that will provide cooling for said building. It is envisioned that the building being powered on biodiesel house those programs involved in the project.

Future collaborations will involve utilizing the expertise of the Biotechnology program to explore ethanol production through fermentation as a means of supplementing the biodiesel project. At the same time, the Sustainable Energy and Agriculture programs will be exploring cellulosic feedstock, such as switchgrass and miscanthus, as a source of ethanol. Short courses and workshops will be developed to educate local producers of biodiesel about good production techniques, along with legal and ethical considerations. Summer camps will be developed to educate middle school and high school students about biofuel production as well.

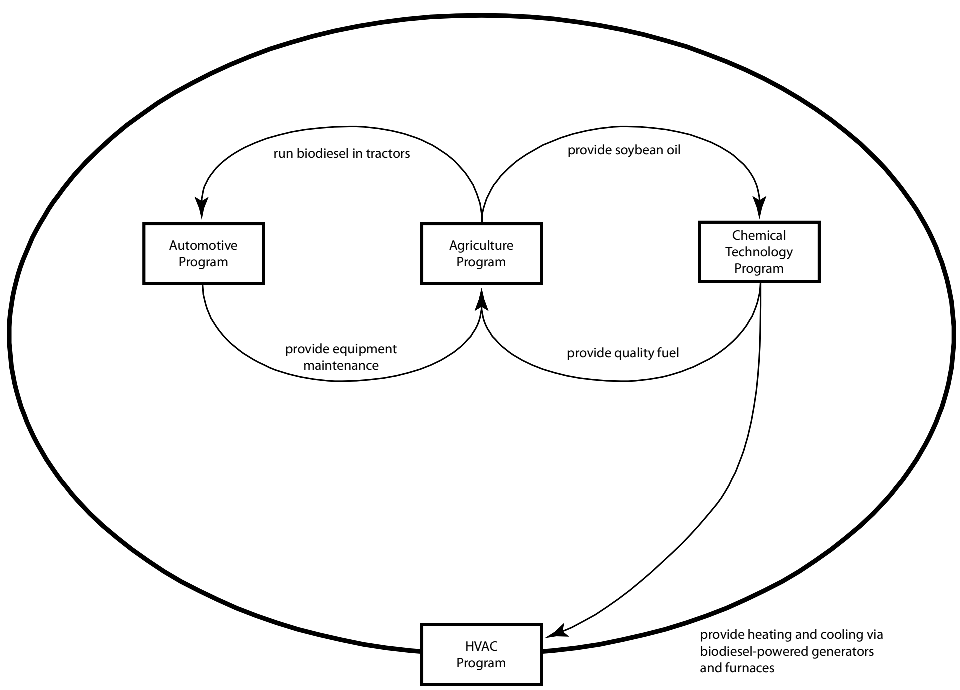
The project will culminate with the development of a biodiesel display vehicle. This display vehicle will consist of an electric-powered vehicle that is charged by a biodiesel-fueled generator. The generator will rest on a trailer that carries a full biodiesel display and will be transported to campuses within the community college system as well as fairs throughout the state of Indiana.

Results and Conclusions

The overall objective of this study was to use clean energy as a platform for increase interdisciplinary collaboration among students and faculty. This objective was met. The entirety of the project, to date, has included faculty and students from Automotive Technology, Chemical Technology, Sustainable Energy, and HVAC.

Phase I sought to increase faculty collaboration and increase student participation through community outreach. A public event was held at the local shopping mall as a part of the National

Figure 1. Illustration of a closed-loop system, whereby the biodiesel feedstock is produced on-campus, with the resulting biodiesel fuel being consumed on-campus as well.



Alternative Fuels Odyssey Day. In order to do this faculty from Automotive Technology, Chemical Technology, and Sustainable Energy each organized student groups to prepare displays and exhibitions.

In Phase II research activities were used to bring about collaboration among students from Automotive Technology, HVAC, Chemical Technology and Sustainable Energy. These activities included biodiesel vehicle testing, biodiesel fired furnace testing, biodiesel production, and biodiesel quality testing.

For Phase III, a new course, Fundamentals of Biofuel Production, was developed to integrate biodiesel production with program curriculum. This course has students from varying backgrounds take if for degree credit. These backgrounds include: Automotive Technology, Sustainable Energy, Chemical Technology, and Liberal Arts.

This exposure is intended to prepare students for the modern workplace environment whereby collaborative efforts are often invoked to address challenges. Thus far, the faculty at our institution has made significant strides toward implementing strategies to include this collaborative model in their respective curricula. Future plans will better prepare our students for entry into the workforce and educate the local community about alternative fuel production.

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