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The Biodiesel Project: A High School Multi-Discipline Class Collaboration and Graphic Imaging Technology Unit Plan

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A thesis project submitted in partial fulfillment of the requirement for the degree of

Master of Art Education

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by

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I would also like to dedicate this thesis project to my mother and best friend, who was diagnosed with terminal cancer mid-September 2006 and passed away February 17, 2007. I love you, Mom; thank you for your love and encouragement to keep writing.
I would also like to recognize my father who was also diagnosed with terminal cancer just a few weeks ago. May God bless and keep you both.

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Abstract

In this thesis project, my intention was to integrate diverse high school courses with poignant subject matter to increase the amount of learning students can achieve. This unit plan explored a Prince George High School (Virginia) multi-class cooperative effort involving biodiesel production. The project involved creating a biodiesel refinery built by Production Systems classes according to plans purchased from the Internet. The research for converting used kitchen oil into biodiesel and the titration[1] of the fuel was conducted by Chemistry classes. Graphics Imaging Technology students created a logo, a poster, and designed brochures that described the processes and benefits of this product. Marketing classes conducted consumer surveys and devised a product distribution plan.

Graphic Imaging Technology, a Career and Technical Education course, has long been linked to art education. For example, graphic design students incorporate art in many phases of their design projects. Specifically, during their preliminary creative thinking, students sketch thumbnails of possible design solutions and regularly use their drawn or painted illustrations in their printed pieces. Additionally, film photography, which is commonly viewed as a fine art, has been used by graphic design students for several years. This art form has been replaced by digital photography in many design studios and school classrooms, but the principles of balance and composition remain the same.

[1]Titration is the testing of used vegetable oil to determine how much catalyst (potassium hydroxide or sodium hydroxide), is required to make biodiesel. The objective is to determine how much of this catalyst or base it will take to neutralize the free fatty acids in a sample of oil. These figures are then applied to the large batch of oil in which the sample was taken. Once these steps are accomplished, the biodiesel refining process can begin.

Other teaching strategies such as interdisciplinary study have also been introduced into graphic design and art class curricula. The rise in cross-curricular studies is indicative of the importance of varying the classroom instruction to offer the most diverse learning environment to students. Math and English are most often combined with unrelated classes in multi-discipline education, but regrettably, science classes typically are not. Since few fields of endeavour do not incorporate other disciplines, a multi-discipline class collaboration and unit plan which included high school Production Systems, Chemistry, Graphic Imaging Technology, and Marketing classes was developed.

This project sought to establish a working relationship among various high school classes while providing a mutual learning environment. Additionally, disciplines that do not ordinarily interact with each other had the chance to take part in an renewable energy project that inspired new ideas and developed an increased consciousness of the environment.

Finally, as students were involved in all facets of this biodiesel project, they experienced a working environment similar to the "real world." Establishing school-to-work programs that facilitate a smooth transition from high school to the work force is one of the main goals of the Prince George High School Career and Technical Education department. Students communicated their thoughts, worked together, and helped one another the same way as if they were employed at a business.

Chapter 1

WHAT IS BIODIESEL?

1:1 Thesis Project background. The focus of this thesis project, was to integrate diverse classes at Prince George High School (Virginia) in an interdisciplinary manner to increase the amount of learning students can achieve. This thesis project emphasizes Graphic Imaging Technology's role in creating art and designs because of its close ties with the arts and art education. The subject of biodiesel, an alternative and renewable fuel, and its production, proved to be a challenging learning experience to teachers and students. The role of high school biodiesel contributors are detailed in Chapter 2.

1:2 What is biodiesel? Biodiesel is a clean-burning alternative fuel that is derived from natural and recycled sources (biodiesel.org, ¶1, n.d.). Specifically, "biodiesel is defined as the mono-alkyl esters of fatty acids derived from vegetable oils or animal fats" (3.me.iastate.edu, ¶1, n.d.). Petroleum-based diesel or "dino-diesel" is refined from oil that is pumped out of the earth, is harmful to the environment, and is in limited supply.

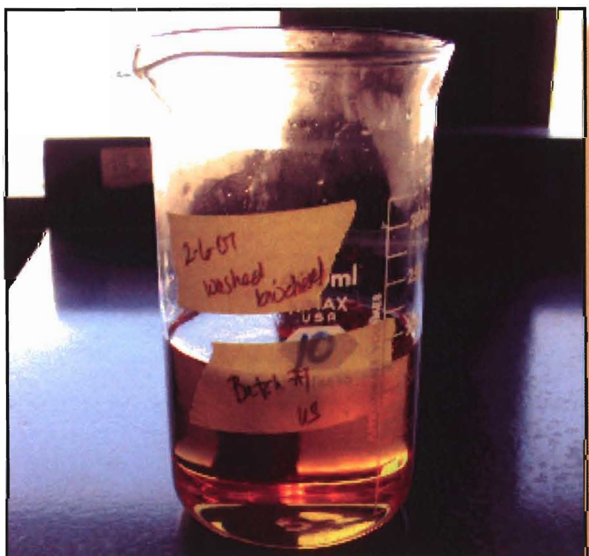

Figure 1.1 Biodiesel sample created in Ms. Schmieder's chemistry classroom at Prince George High School.

Biodiesel, on the other hand, is safer to use and is created from renewable resources such as used kitchen oil, restaurant grease, and oil crops such as soybeans. There are also several other natural resources that are currently being investigated as potential biodiesel raw materials. Yarrow Nelson at California Polytechnic State University is working with Cal Poly Biodiesel Club president, Ian Woertz, on a project to make "biodiesel from algae at dairy waste lagoons" (bakerforum.calpoly.edu, ¶7, 2006). And remarkably, Smithfield, the world's largest pig producer, has begun an effort to build a facility in Utah to covert the 500,000 pounds of pig manure it produces annually into biodiesel fuel (Pig power, ¶1, 2003). Similarly, Mark Whittington reports that Dr. Yuanhui Zhang, a researcher at the University of Illinois, is working on a thermochemical process that would convert the six gallons of waste that pigs produce daily into 3.6 gallons of crude oil (Whittington, 2006).

Figure 1.2. *Used frying oil is gathered from local school cafeterias to be refined into biodiesel.*

While biodiesel fuel can be made by chemically reacting alcohol with vegetable oils, animal fats, or greases, most biodiesel is made up of soybean oil and can be used in pure form or blended with petroleum diesel in various ratios. Currently, the most common blend is eighty percent diesel and twenty percent biodiesel, designated "B20" (NEED.org, p.10, ¶1, 2004). It can be used in unmodified diesel engines using current global distribution locations. Biodiesel contains virtually no sulfur, a pollutant and lubricant common in petroleum-based diesel (eere.energy.gov, ¶4, n.d.). In 2006, government mandates drastically reduced the allowable amounts of sulfur in diesel fuel. Using a biodiesel blend with its superior lubrication properties can restore standard diesel lubricity without the usual negative environmental side effects. (NEED.org, p.10, ¶2, n.d.)

Figure 1.3. *Biodiesel can be poured directly into fuel tanks of newer vehicles that run on diesel fuel with no modification to the engine nor fuel system.*

Many of today's vehicles and equipment run on diesel fuel, which is a non-renewable resource. On the other hand, since biodiesel can be produced from waste products and plants, it can insure a practically limitless supply of this fuel (biodieselcommunity.org, ¶5, n.d.). In Northern Virginia, many schools, governments, and businesses have already made the switch to biodiesel and have greatly reduced air pollution and fuel costs in their area (Kilcarr, 2006). "Biodiesel blends generally reduce emissions in proportion to the percentage in the blend" (biodieselnow.com, ¶5, n.d.). That is, if standard diesel fuel is mixed with 20 percent biodiesel, it is expected that there should be a 20 percent reduction in pollutants (Kilcarr, 2006). Additionally, since biodiesel is made up of organic compounds, it is biodegradable and non-toxic to the environment if spilled. This feature is especially important when fueling in environmentally sensitive areas such as wetlands and other fragile ecosystems (NEED.org, p.11, ¶1, 2004).

1:3 Benefits of biodiesel. Since its cetane level is higher, biodiesel exceeds diesel in performance rating. This has a similar effect on performance in diesel engines as using high octane fuel in gasoline engines (NEED.org, p.10, ¶8, 2004). Among the other benefits of this fuel is its higher flash point, making it less likely to combust unintentionally. Biodiesel's properties make it superior to diesel in its lubrication role, and it is about the same when it comes to horsepower, acceleration, and torque (NEED.org, p.10, ¶5, 2004). Two small drawbacks to consider may be that vehicles have less range using biodiesel than when using regular diesel, and when used unblended with regular diesel, could have a gelling problem in cold temperatures (biodieselnow.com, ¶10, n.d.). This problem can be alleviated by blending biodiesel with regular diesel during winter weather. There is also a slight increase in nitrogen oxides emissions levels, but considering the overwhelming decrease or elimination of all other pollutants, it would seem to be an ac-

Figure 1.4. Theoretically, a refueling infrastructure for biodiesel currently exists. Ordinary gasoline stations could dispense biodiesel much like they distribute other fuels now.

ceptable trade-off (3.me.iastate.edu, p.8, ¶23, n.d.). Moreover, research is currently being done to reduce biodiesel NO_2 emissions to current regular diesel levels or below. (eere. energy.gov, ¶5, n.d.)

Demand for biodiesel has grown steadily in the last few years. Previously, its costs were higher than diesel, which was been one of the deterrents for pursuing biodiesel on a large scale basis. With the spike in oil prices seen recently, arguably biodiesel has become more cost effective and a viable supplement or possible replacement option for diesel. Flashy technology such as hydrogen fuel cells make the news as an alternative to importing oil (Lowery, 2006), and in 2004, 1.7 billion dollars was budgeted for such research, but practical use of these energy sources are still years away from reality (Crittenden, 2003). There are still many problems to overcome with the hydrogen cell's size and weight, besides the need to create a comprehensive refueling infrastructure.

Figure 1.5. Biodiesel has a long way to go if it is expected to replace regular diesel fuel. There is simply not enough vegetable oil produced to meet both the demand for human consumption and use as a fuel.

Biodiesel technology and fuel, is effectually online now. There is not much that is needed to convert existing fuel stations over to biodiesel delivery and little to nothing to begin using it in newer diesel vehicles (NEED.org, p.10, ¶1, 2004). Ideally, since the gasoline engine in automobiles is the dominant form of locomotion in the United States, there would need to be a method to convert these engines to burn a biodiesel blend, too. At James Madison University in Harrisonburg, Virginia, "The Biodiesel Boys[2]" are attempting to do such a thing (Crittenden, 2003). Biodiesel is being investigated as an additional additive to gasoline

[2]The "Biodiesel Boys" are self-described alternative energy students enrolled in James Madison University's College of Integrated Science and Technology. Their goals include the further development of biodiesel and innovative powerplants.

to reduce emissions, clean fuel delivery systems, and reduce the total amount of overall gasoline consumption in this country much like the ten-percent ethanol-gasoline blend that is currently being pumped at many gas stations now.

Theoretically, since cars use most of the oil that is refined into gasoline, vehicles that run on diesel would need less of the available supply of this fuel. Logically, this in turn could mean that more oil could be allocated to be refined into gasoline. Biodiesel could do its part in replacing some of that oil being developed into diesel fuel. This seems to make sense but, there is a problem with this theory.

If all of the available "vegetable oil and animal fat were used to produce biodiesel, we could only replace about 15% of the current demand for on-highway diesel fuel" (3.me.iastate.edu, p.1, ¶4, n.d.). So, why the interest in biodiesel? According to research at Iowa State University, there are at least five advantages in using biodiesel:

Figure 1.6 **BIODIESEL ADVANTAGES**

1. It provides a market for excess production of vegetable oils and animal fats.
2. It decreases the country's dependence on imported petroleum.
3. Biodiesel is renewable and contributes less to global warming than fossil fuels due to its closed carbon cycle.
4. The exhaust emissions from biodiesel are lower than with regular diesel fuel.
5. Biodiesel has excellent lubricating properties.

- 3.me.iastate.edu, p.1, ¶5, n.d.

1:4 Biodiesel verses ethanol. "A national survey of the public revealed that only one in four Americans has heard of biodiesel. By comparison, nearly nine in ten consumers have heard of ethanol..." (biodiesel.org, ¶2, n.d.). Interestingly, alternative fuels aware-

Figure 1.7. Ethanol, an alcohol derived from crops such as corn and sugar cane, is commonly added to gasoline, much like biodiesel is blended with regular diesel.

ness tends to spike during periods of oil crisis. When cheap fuel becomes less abundant and prices start to rise, some start to panic and look to other new sources of energy. For a considerable time, ethanol has been thought of as the alternative fuel to watch (Lowery, 2006). By converting crops such as corn and sugar cane, pure ethanol can be used to power existing vehicles once their gasoline engines are modified to accept this fuel. Many fueling stations offer ten-percent ethanol in their gasoline, and some areas are using fifteen-percent, designated E85. More than a 15% ratio of pure gasoline to ethanol would require extensive modification to the car's power plant and pose a number of other drawbacks. Biodiesel, on the other hand, can be added to diesel-powered vehicles in any blend percentage with little or no mechanical modification (biodieselnow.com, ¶1, n.d.).

Chapter 2

THE BIODIESEL PROJECT CONTRIBUTORS

2:1 Why Choose the Biodiesel Project? For this thesis project, I considered four interdisciplinary projects that would bring class collaboration to several unrelated academic and vocational disciplines at Prince George High School. Graphic Imaging Technology I, II, and III, are career-track courses, so it is important for students to incorporate the design skills they are learning into actual projects that may be similar to what they would experience in the work force. The ideal project will generate a high level of interest and allow students to enjoy an assignment that may not be considered a standard textbook subject. Endeavours such as coordinating Fine Art and Graphic Imaging Technology classes to produce T-shirts and posters for students at Prince George High School were contemplated. Another project would involve Graphic Imaging Technology, Mechanical Drawing, and Manufacturing classes to design, refine, and produce one-eighth inch scale replicas of automobile chrome wheels.

I chose the biodiesel project because this interdisciplinary endeavour is not only the most involved, but arguably the most important of the four thesis project choices, since it addresses several critical current issues such as energy, renewable resources, and the environment. Specifically, the biodiesel project involves the construction of a biodiesel refinery from a hot water heater and other donated and purchased materials. Once completed, this refinery will be used for the production of biodiesel fuel extracted from, among other

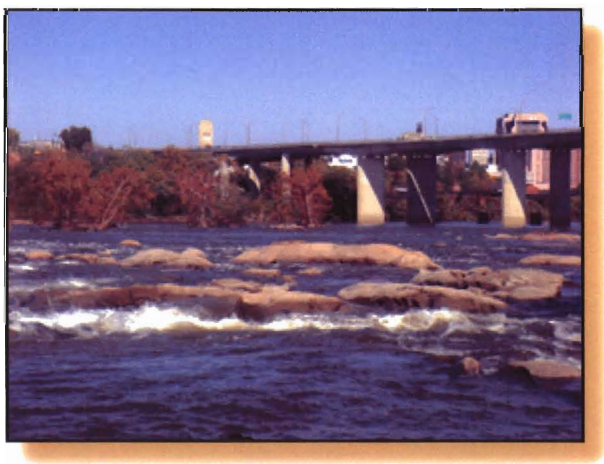

Figure 2.1. Biodiesel biodegrades quickly in the environment and thus, is suited for use in and around water.

things, used kitchen oil. This biofuel project is ideally suited for curricular collaboration, because it is a multi-faceted and broad field of study which has only recently began to be noticed by the general public (biodiesel.org, ¶1, n.d.). Although not necessarily required for actual fuel production, several contributors from various classes will lend their expertise to the project, thereby enhancing the entire learning experience for students and teachers alike (thirteen.org, ¶2, n.d.).

The following is a short synopsis of the role of each of the contributing classes and what was expected to be provided to the biodiesel project. Mr. Randy Bullock's Production Systems class acquired the waste oil and built the biodiesel refinery. Ms. Liza Schmieder's Chemistry class performed titration trials on batches of used oil and provided test results from this chemical testing. Mr. Charles Cimo's Graphic Imaging Technology class designed logos, informational brochures, and wall posters. They collaborated with Mr. Dave Hettinger's Marketing class to promote the final biodiesel fuel product and by-products to the community.

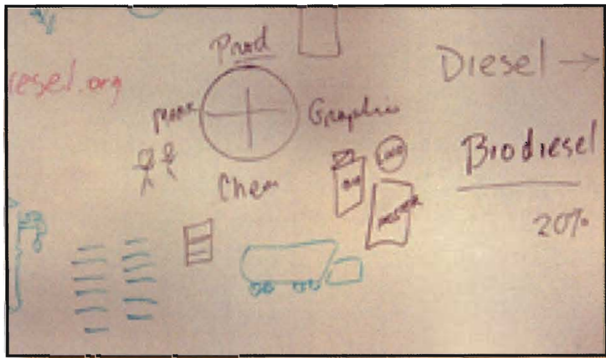

Figure 2.2. This marker board in the Graphic Imaging Technology classroom illustrates the partnership of four distinct disciplines.

Figure 2.3. Using a biodiesel blend could possibly be a cost-saving measure to Prince George County schools.

2:2 ***Mr. Bullock's Production Systems class***. Production Systems class has performed a preliminary investigation of the steps involved in obtaining used frying oil from eight county schools. Individually, each school spends about 100 dollars a month for waste oil removal by a commercial disposal company. An estimated cost savings to Prince George County is approximately twelve hundred dollars a year per school. According to Mr. Bullock, initial estimates of the cost to produce biofuel is approximately eighty to ninety cents a gallon. Currently, diesel fuel prices are running between $2.35 and $2.45 a gallon, locally. If the Production Systems class were to sell biodiesel for $1.80 a gallon, there would be a 100 percent mark-up and county school programs would quickly realize a profit, plus the added benefit of savings in disposal costs.

Figure 2.4. In mid-February 2007, diesel at this central Virginia station sold for almost $2.36 a gallon and prices were heading upward.

Some questions that would need to be addressed are licensing issues and methods of distribution. Consideration would have to be made for the storage of refined fuel, disposal of unwanted by-products, methods of used oil collection, and container storage on site. Federal Environmental Protection Agency guidelines, state regulations, and questions pertaining to fuel testing and ratings would also need to be investigated. A brief description of used oil titration, creating a sample batch of biodiesel, and the refinery building process is covered in Chapter 3.

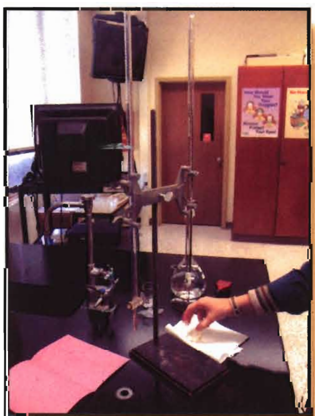

Figure 2.5. Titration of used oil, an intricate part of biodiesel production, will be conducted in Ms. Schmieder's chemistry classroom.

2:3 Ms. Schmieder's Chemistry class. Ms. Schmieder's Chemistry class explored the science behind the biodiesel refining process and performed titration on small batches of used oil. This process is required of each batch of oil that is collected, since the level of certain fats and other properties vary from each batch. The variations and the amount of alcohol required to neutralize them will have to be ascertained at the sample level and this information is forwarded to the Production Systems students for use on a large scale.

2:4 Mr. Cimo's Graphic Imaging Technology class. Students took on the task of researching the subject of renewable resources, and in particular, biodiesel development from the Internet. They needed to become well acquainted with the subject and apply the knowledge they have obtained to carry out the requirements of a three-part assignment.

Part 1- Students designed a logo that suggests the process of recycling used kitchen oil into a useful product such as biodiesel fuel. Some suggestions given to students were that they incorporate oil images, "green" images, transition images, and fried food images into the design. These were simple and concise one or two-color designs that quickly gets the entire message across to the viewer.

Part 2- Students designed an informational brochure or "slim-jim" (tri-fold pamphlet) detailing the process of converting waste oil into biodiesel fuel. The subject matter for the brochure included the process of collecting oil from county schools, storing the oil, steps involved in refining the waste oil into biodiesel, fuel cost savings (or profits), benefits of recycling, and reduction of foreign petroleum dependency.

Part 3- Students designed a poster that incorporated elements of the first two parts of the biodiesel project such as the newly designed logo and brochure. Deft manipulation of type and images were used to "tease" and evoke viewer reaction. These posters are expected to educate and inform the public as to what exactly biodiesel is and to the origin of turning natural substances into fuel. The student posters investigated the progress and development of the fuel throughout the years and what may be expected from short-term research as well as future biodiesel research. Posters demonstrated the current proliferation of biodiesel and its ability to potentially reduce foreign oil dependence. They touched upon alternative products that may be used in conjunction with biodiesel. Copy includ-

Figure 2.6. *A Graphic Imaging Technology student uses his design skills to create a logo, informational brochure and wall poster for the biodiesel project.*

ed information about how much fuel can be produced from the available supply of oils in this country and in what ways production could be increased. Students collaborated on design ideas with other classes individually and in small groups. Additionally, the notion of a design contest to inspire creativeness was explored. Once the optimum publication design was selected, it was produced in color for local distribution. A detailed Graphic Imaging Technology Biodiesel Unit Plan is laid out in depth in Chapter 4 and selected student designs are located in the appendix.

2:5 Mr. Hettinger's Marketing class. The close collaboration of Marketing class with-Graphic Imaging Technology class was needed to develop a viable marketing strategy for biodiesel fuel in the local area. Students conducted research of county demographics and the number of diesel vehicles and machinery that could benefit from the use biodiesel. They investigated the current demand and the expected growth of biofuel usage in the surrounding community. Marketing classes distributed selected Graphics Imaging Technology student informational brochures. They determined the most expeditious method of conveying the biodiesel message, such as posting and handing out literature. These classes conducted informal surveys of individuals and canvased local businesses which possess diesel vehicles. Points were made about the advantages of using a biodegradable, lower cost fuel over the expense of buying hazardous regular diesel at refueling stations. Marketing class developed a "plan of attack" to increase chances of a successful conversion program by bringing ideas such as cost savings, environmental issues, and helping school programs, into the public eye. They even discussed such issues as offering incentives to local businesses for collection of their used oils and government tax credits for using alternative fuels (irs.gov, n.d).

Chapter 3
TITRATION AND PRODUCTION OF BIODIESEL

3:1 Titration of a small sample batch of oil. Simply stated, titration is the testing of used vegetable oil to determine how much catalyst is required to make biodiesel. The catalyst is usually potassium hydroxide (KOH) or sodium hydroxide (NaOH). The objective is to see how much of this "base it will take to neutralize the free fatty acids in the sample of oil" (utahbiodieselsupply.com, ¶2, n.d.). This process is required for every batch of vegetable oil, since its properties can vary depending on age, how much it was used, and other factors (schnews.org, ¶10, n.d.). Once this data is recorded, the results can be replicated on a large-scale basis in the biodiesel refinery.

The following is not necessarily a tutorial on oil titration and refining, but would give some idea as to how the processes take place. There are several differing procedures to go about titrating oil, but according to the Utah Biodiesel Supply web site, this may be one of the simplist ways to perform the process (utahbiodieselsupply.com, ¶1, n.d.).

The process begins in Ms. Schmieder's Chemistry classroom (Figure 3.1), where pure vegetable oil and used oil are to be titrated. Ms. Schmieder tested both new and used oil to compare the amount of reactors that are required for color change. She discovered that since pure oil is lower in fats, very little titrate is needed as compared to well-used school cafeteria oil.

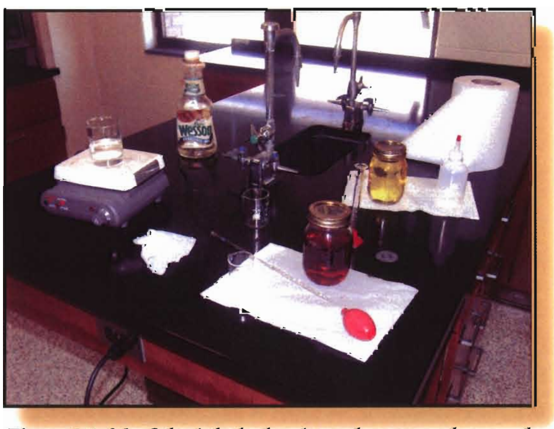

Figure 3.1. *Ms. Schmieder's chemistry classroom where used oil (foreground), and pure vegetable oil (background) are compared for differences in the amount of reactors required for titration.*

Titration

Figure 3.2. *Since there was not a significant reaction from fresh oil, the steps that were taken with used oil are shown here. A small amount of used oil is drawn from its mason jar using a pipette.*

Figure 3.3. *Ms. Schmieder is careful to measure the exact amount of oil that is needed, in this case 1 mL, and deposits it into a beaker.*

Figure 3.4. *She pours isopropyl alcohol into a separate container, to the measured 10 mL mark.*

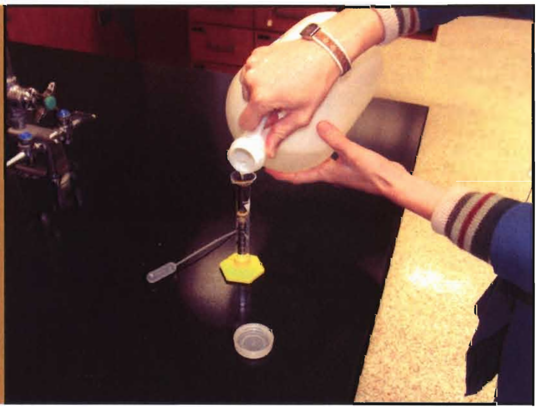

Figure 3.5. *She then combines 1 mL of oil with 10 mL of alcohol and swirls it around to dissolve the mixture.*

Figure 3.6. *Ms. Schmieder heats the oil and alcohol combination to help it mix together easier.*

Figure 3.7. *She adds two drops of phenolphthalein, a pH indicator.*

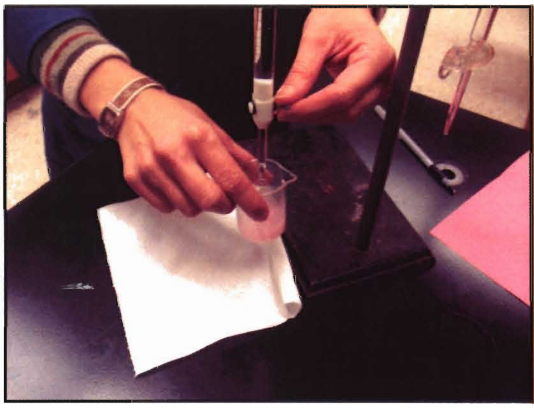

Figure 3.8. *Titrating occurs when the sodium hydroxide solution is added. The color changes to pink which indicates a rising pH level.*

Figure 3.9. *Results of the titration are a pink mixture. Titration data and figures are recorded.*

Biodiesel

Figure 3.10. *Ms. Schmieder prepares to make a small batch of biodiesel as a demonstration for Production Systems and Graphic Imaging Technology classes. She starts by mixing methanol and sodium hydroxide to create a methoxide catalyst.*

Figure 3.11. *As Mr. Bullock looks on, she then pours used oil into a beaker to measure the needed amount.*

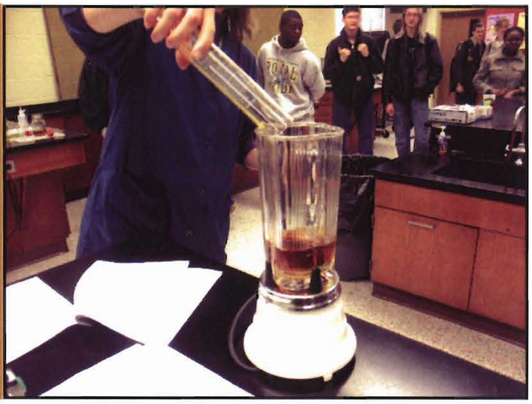

Figure 3.12. *Ms. Schmieder pours the measured oil into a blender.*

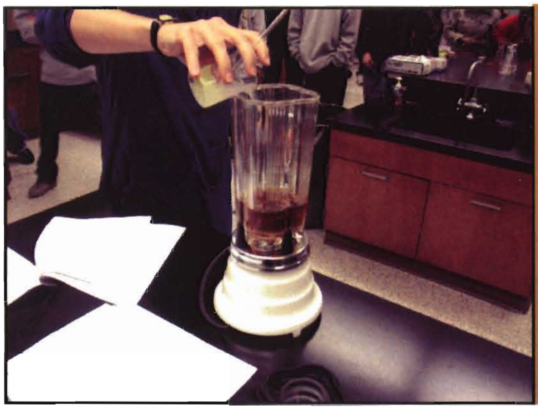

Figure 3.13. *She then adds the methoxide mixture.*

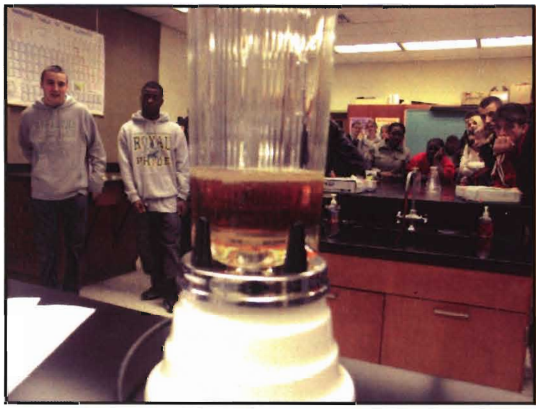

Figure 3.14. *The methanol and oil components await mixing.*

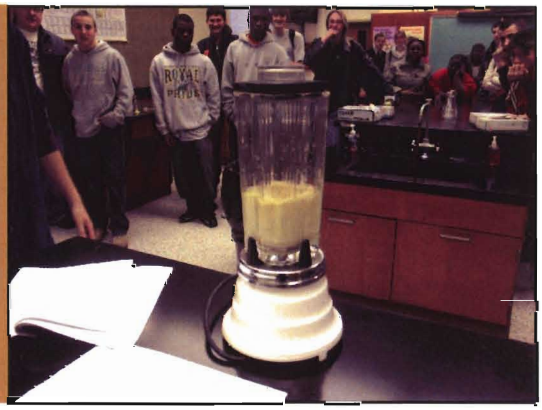

Figure 3.15. *Ms. Schmieder turns on the blender to thoroughly mix the ingredients.*

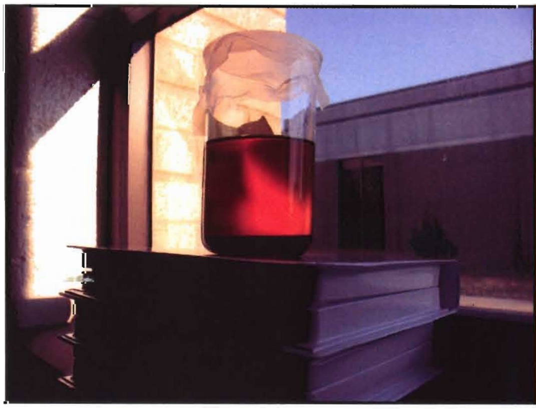

Figure 3.16. *A chemical reaction occurs and the parts of the oil mixture begin to settle and separate.*

Figure 3.17. *Ms. Schmieder drains the parts that have separated and labels them "washed biodiesel" (foreground) and "glycerin" (background).*

Figure 3.18. *To rid the unwashed biodiesel of impurities, it is then washed with water and allowed to separate again. The water is drained off, leaving pure biodiesel fuel ready to use.*

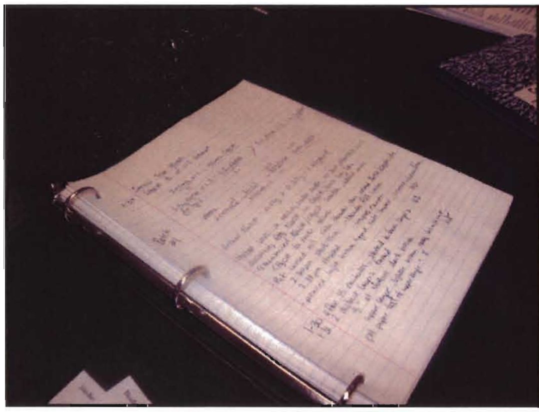

Figure 3.19. *Ms. Schmieder, like any good chemist, keeps excellent notes of her progress. She records that through trial and error, it takes several attempts to properly titrate the used oil and then to produce a biodiesel sample.*

3.2. ***Biodiesel and its by-products.*** Transesterification is the process in which biodiesel is made. Literally, the vegetable fats and oils that are used to make biodiesel, are separated from glycerin which can be made into soap and other products (biodiesel.org, ¶2, n.d.). Glycerin is purified and scented oils are added to produce a pleasant smell. According to Utah Biodiesel Supply, soap made from glycerin is "especially effective at cleaning and has a noticably smoother texture than 'store-bought' soap" (utahbiodieselsupply.com ¶1, n.d.). Production and sale of this soap locally could increase profitability in the biodiesel project's bottom line.

Refinery Construction

Figure 3.20. *Building a biodiesel refinery in Producton Systems class begins with detailed plans from the Internet and a donated new hot water heater.*

Figure 3.21. *Mr. Bullock assists his Production Systems students as they assemble and plumb the pump that will carry fluids into and out of the converted hot water heater refinery.*

Figure 3.22. *Student built wooden stands with casters from Internet plans to enable the wash tanks (blue containers) to be positioned along side of the refinery.*

Figure 3.23. *Mr. Bullock and students inspect the plumbing and installation of fluid pump, and then adjust pipe valves.*

Refinery Construction

Figure 3.24. *Students pour tap water into the refinery to check its capacity and look for plumbing leaks.*

Figure 3.25. *While Mr. Bullock looks on, students check the siphoning action of the pump by filling a pail of water and adjusting valves.*

Figure 3.26. *Students assemble an integral part of the biodiesel refining process: the wash tank. When biodiesel is separated from glycerin, it is cloudy from impurities.*

Figure 3.27. *A bubbling and misting system cleans unwashed biodiesel and then it is allowed to dry by air or heating to evaporate the water.*

Figure 3.28. *Mr. Bullock checks the functionality and direction of fluid flow of the pump to the wash tank.*

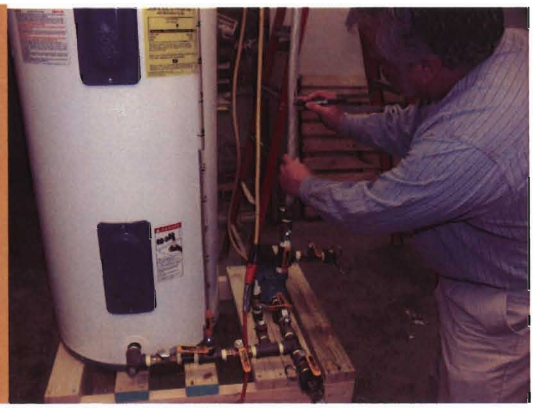

Figure 3.29. *He then marks the direction of flow on a previously calibrated plastic tube.*

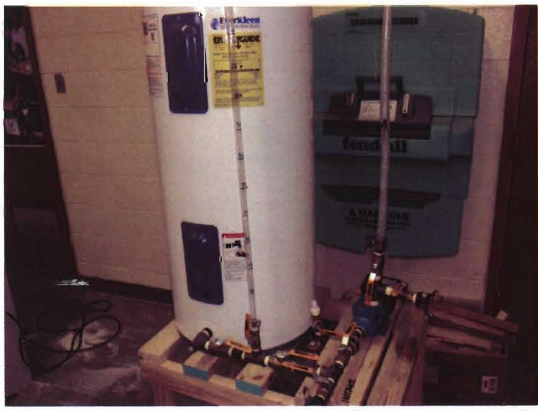

Figure 3.30. *The refinery is then plugged in, water is heated, and the pump is turned on. The closed system cycles the water in a continuous loop to check for trouble spots and to make valve adjustments.*

3:3 ***Biodiesel production.*** With the refinery on-line, Production Systems students were able to start making biodiesel fuel from used oil.

Chapter 4
THE ROLE OF GRAPHIC IMAGING TECHNOLOGY

4:1 Biodiesel assignment background. Graphic Imaging Technology class has an important role in the biodiesel project. Since not much is known by the general public about this renewable resource, Graphic Imaging Technology students will be responsible for conveying pertinent information to the public in printed form, and also in an easily understood manner (biodiesel.org, ¶2, n.d.). The class will obtain information about the refining process through research obtained from the Internet and other sources. These sources could include the school's Library Media Center and gathering information from Mr. Bullock, the instructor of the Production Systems class. Fortunately, his classroom is conveniently located next to the Graphic Imaging Technology classroom, so there would not be much of a trip involved for data collection.

Figure 4.1. *Graphic Imaging Technology students collect research on biodiesel from the Internet.*

At the initiation of this project, students were given a short thirty-minute introduction by Mr. Cimo, the Graphic Imaging Technology instructor, to biodiesel fuel and the process of obtaining it from recycled kitchen oil and other sources. They were shown the refinery in the Production Systems classroom and allowed to interact with those students involved in producing the fuel. Questions were fielded by both Graphics Imaging Technology and Production Systems instructors and all students were allowed to study in depth, all facets

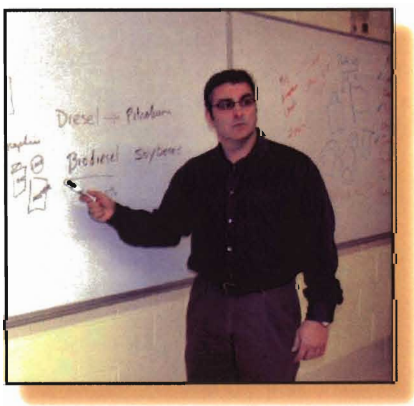

Figure 4.2. *Mr. Cimo generates interest in biodiesel by discussing its merits with the class.*

of the biodiesel industry. They then went to Ms. Schmieder's Chemistry class to view first-hand the actual process of titrating raw vegetable oil; the initial step in the biodiesel process.

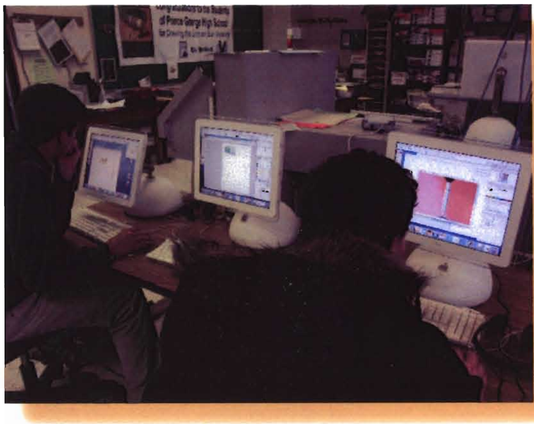

Figure 4.3 *Graphic Imaging Technology students use the Adobe PhotoShop skills they have learned to design their biodiesel logo.*

4.2 Logo, Brochure, and Poster design. Graphic Imaging Technology students use the page-layout software Adobe InDesign and the image manipulation program Adobe PhotoShop. They used these programs to design their biodiesel projects on G4 and G5 Apple IMac computers located in the Graphic Imaging Technology classroom. Students at Prince George High School attend classes on an alternating-day block schedule, so a sufficient amount of time was allocated to give them the needed time to complete their work. Approximately one to two class periods was necessary to acquaint the students with the biodiesel topic and receive feedback from them. Research of the fuel and digital photography took another one to two days. Once the graphics students obtained this information and their took their photographs, they began creating the layout of their logo design. This logo incorporated simple, iconic imagery that represented the transformation of used vegetable oil into biodiesel fuel. Logo designs were produced in one or two colors to reduce printing expenses.

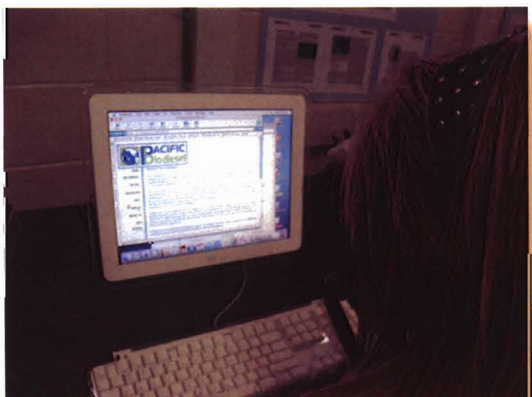

Figure 4.4 *A student uses the Internet on a Apple IMac G4 computer to research biodiesel for her assignment.*

Upon completion of a logo design, students moved on to the brochure and then to the wall poster. Specifications for the biodiesel brochure was as follows: overall size would be eight and half by eleven inches in a horizontal format. Two folds would be made to divide the paper into three equal-sized panels that would allow the end panels to fold in on itself. Students used the design and typography skills they have learned in previous lessons to create a brochure with a unique visual impact that conveys the biodiesel message. Suitable information was obtained to write comprehensive copy and when finished, the brochure or "slim jim" was distributed to the local community by Mr. Hettinger's Marketing class. This brochure included information about the benefits of using biodiesel fuel and the process of obtaining it economically. Additionally, it contained environmental impact and emissions reduction data. Students were encouraged to employ graphic elements and digital photography into their brochure to generate public interest in biofuels. Some of the digital images included the biodiesel refinery and production process, Production System's student activities and involvement in creating the fuel, environmental impact, and cost savings to consumers.

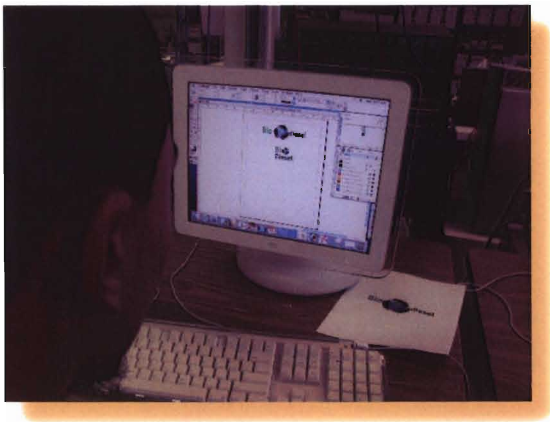

Figure 4.5 *In his biodiesel logo, a student uses an earth icon to emphasize the environmental benefits to using the fuel.*

A wall poster, eleven by seventeen inches in size, was designed by students using the data obtained from the previously developed logo and brochure. Images and typography were reused and reconfigured to facilitate continuity of design. These posters are intended to inform the public of the uses and benefits of biodiesel fuel, so skillful placement of elements in the design was needed to attract attention from the viewer. Both the brochure and wall poster employed the logo that was previously designed by the student.

Figure 4.6 *Photographic images that students have taken with a digital camera will be used in their brochure and poster.*

When they were finished with their designs, students printed their logos, brochures, and wall posters on the HP color laser printer in the classroom and submitted their work for a grade. The specific Graphic Imaging Technology Tasks/Competencies that were accomplished in this biodiesel assignment are provided on page 27.

4.3 Grading and Project Variant. Key grading factors of all three parts of this project would be the clarity of the message, continuity of design, and the deft use of typography and images. Other factors that was considered in grading was information accuracy as well as proper spelling and grammar. Students were instructed to make their pieces both informative and interesting by carefully selecting the typography, graphic elements, photography, and other images they used. They also needed to apply design skills such as element balance, proportion, and scale, that they have learned from previous graphic design assignments.

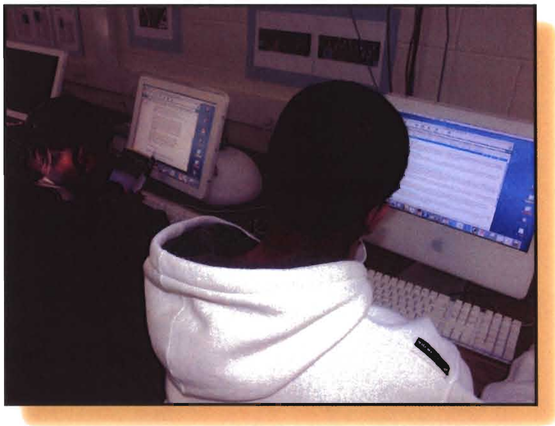

Figure 4.6 *Design inspiration may come from various sources. On the left, a student examines a professionally designed slim-jim brochure for the Beacon Theater in Hopewell, VA.*

A possible variant of this assignment that could have been considered was to set up small groups of three or four student designers to develop the three phases of the biodiesel project. Members would decide who would be in charge of delegating certain tasks to each student such as taking digital photographs and topic research. They would also give each other input on the layout and collaborate on the final design. A challenging drawback of this idea is determining how much work was performed by each student. This problem could be overcome by requiring each student in the group to evaluate his or her work and the work of the group as a whole. These assessments would be reviewed by individual students and the teacher, then compared to the finished products to determine each student's final grade.

Assuming each individual student would be responsible for his or her own design process and final pieces, they would be allowed three weeks or seven class periods to complete the project. In addition to the preparatory time of two to three days given to research the subject and gather imagery, this project could conceivably cover half of the nine-weeks grading period.

With the completion of a product logo, an informational brochure, and wall poster, students will be well informed of the development and refinement of biodiesel fuel, renewable sources of energy, environment impact of fossil fuels, and cost savings to consumers. Graphic Imaging Technology students will have the opportunity to experience the benefits of working on real-world projects in an interdisciplinary manner. Their education would involve the step-by-step processes that occur in graphic design studios, product marketing, and advertising agencies when these businesses take projects from concept to completion. The interdisciplinary knowledge the students acquire in this assignment may very well translate to what they will see as an employee after they graduate from high school.

4:4 GRAPHIC IMAGING TECHNOLOGY LESSON PLAN OUTLINE

DATE: Second Semester

NAME: Mr. Cimo

I. TOPIC

Lesson Title/Theme: High school student collaboration on interdisciplinary biodiesel production project.

Goals: Students will learn how to work with other disciplines in a high school environment which is expected to translate to a better understanding of a cooperative work environment which may be experienced after graduating from high school.

II. OBJECTIVES/ EXPECTED LEARNER OUTCOMES

To give high school students the opportunity to receive a better under standing of what it takes to produce and market a product. To help them take part and contribute their skills and experience the rewards of using their creativity in a real life endeavour.

III. STANDARDS OF EDUCATION

Students will accomplish vocational competencies #24, 28, 31, 107, 111, 129, 131, 133, 138, 139, 140, 141, and 142.

IV. STUDENT GROUP TARGETED

Students are roughly sixty percent male and forty percent female. Approximately five or six students require an IEP.

V. TIME REQUIRED

Depending on class progress in all disciplines, up to one 9-weeks grading period. This project could take place on an intermittent basis much like what is experienced in real life. Classes meet for one and one half hours on a block schedule every other day.

VI. MATERIALS AND RESOURCES

Apple Macintosh IMac computers, Adobe PhotoShop 7.0 and Adobe InDesign software, black & white and color laser printers, clip art. Digital cameras will be used to document project development.

VII. ITINERARY AND STRATEGIES (PROCEDURE)

Students begin design strategies by developing ideas for logo designs for a biodiesel project then move onto producing an informative brochure and wall poster. Competitiveness among individuals and design groups will be encouraged as well as originality of student ideas..

VIII. ASSESSMENT

Students will be continually assessed by the instructor and given feedback from other students who are involved. Students will be asked questions by the instructor to aid their comprehension at all levels. How closely instructions were followed as far as format and accuracy of final work will also be addressed. Clear presentation of message will be especially noted.

Student Competency Record
Graphic Imaging Technology I, II, III
Task/Competency

Preparing Digital Images

#24- Set text with appropriate margins, formatting, gutters, guides, trims, and folds.
#28- Import an image in a page layout program.

Understanding Reproductive Photography

#31- Describe the use and operation of a digital camera.

Understanding the Basics of Digital Image Preparation

#107- Demonstrate the operation of digital image preparation.
#111 - Prepare a dummy for a multi-page signature.

Performing Page-Layout Functions

#129- Select appropriate page-layout software for a given job.
#131- Demonstrate the use of computer menus and palettes for the software at hand.
#138- Design and produce a document, using desired fonts, styles, margins, indents, and tabs.
#139- Proofread, edit, and make corrections/adjustment to copy on screen.
#140- Place graphics from an existing file into a publication.
#141- Demonstrate the procedure for cropping graphics electronically.
#142- Create a two-sided, three-panel brochure, using graphics and text for publication.

Chapter 5

BIODIESEL AND INTERDISCIPLINARY EDUCATION

5:1 Related Interdisciplinary Education. Teaching interdisciplinary lessons is beneficial to those who teach, as well as to those who learn. According to Heidi Hayes Jacobs (1989), "Today, interdisciplinary learning has become a widely accepted tool for curriculum design." Hayes goes on to write: "Interdisciplinary learning has proven to have a positive impact on teaching styles and on relationships with both colleagues and students" (thirteen.org, ¶2, n.d.). Interdisciplinary education has also been used across the country to teach students of various learning abilities. At-risk students in the East San Gabriel Valley (California) Partnership were taught to use their academic skills in real-life situations and nearly doubled their grade point average in one year (Adler, 2000). Teachers are also encouraged by the National Standards for Arts Education to help students make interdisciplinary connections. "Many state curriculum guides likewise encourage educators to integrate curricula and find common ground between different subjects" (Rogers, 2004).

5:2 Biodiesel Interdisciplinary Education. An interdisciplinary project that was initiated at the University of Colorado, lead to production of biodiesel for use in campus shuttle buses and also produced a promising career in alternative energy for one student (Carlson & Sullivan, 2006). Colleges are not the only institutions that have explored renewable resources education. High school teachers have many curricular sources they may consider when designing interdisciplinary biofuel lessons. A curriculum guide is available for "biotechnology, with curriculum connections for these activities" (Harms, Swernofsky, & Reisman, 1998). There is also a mini-curriculum available that is designed to teach environmental education which incorporates "science, visual arts, technology education, and business education" (Hren, 1996). In 2002, the federal government got on board by "creating the first wide-scale government-funded biodiesel education program of its size" (biodiesel.org, ¶1, n.d.). Specifically, Title IX of the bill authorized the Biodiesel Fuel Education Program which states that "Educating our nation's youth is a unique, but important, component of the Biodiesel Education Program. The Biodiesel Curriculum Guide, a guide for teachers to implement a basic biodiesel education program at levels K-12, was developed" (biodiesel.org, ¶9, n.d.). The guide may cover basic biodiesel instruction, but it is teachers who continue to look for ways of making biodiesel projects more in-line with real-life experiences. For example, students at one school received a "mock memorandum from the U.S. National Park Service to develop a synthesis to make biodiesel" (Clark, Casey, Brown, Oneyma, & Donoghy, 2006). This would be much like the way they would have received an assignment from an employer or client in normal businesses.

As with secondary schools, biodiesel education has also made its way into college curricula. Notably, two regional schools of higher education in North Carolina, Central Carolina Community College and Appalachian State University, offer courses in alternative fuels. At Central Carolina Community College, interested students may sign-up for a course entitled "Introduction to Biofuels" (biofuels.coop/education, ¶4, n.d.). Even further along in alternative fuels development is the work being done at Appalachian State University which strives to close the loop on biodiesel production by making the process entirely self-sustaining. Faculty and students have constructed a biodiesel facility on campus from donated items and use solar electricity and biodiesel generators to run the equipment. They recycle the wash water, sell the waste as compost and fertilizer, subsidize local oil crop farmers, make glycerin soap, and sell biodiesel for a profit (appstate.edu, ¶5, n.d.).

5:3 Innovation in Technology. Biodiesel and its refining process is in its infancy and there is still plenty of room for innovation. At Oregon State University, chemical engineers "have developed a tiny chemical reactor for manufacturing biodiesel that is so efficient, fast and portable it could enable farmers to produce a cleaner-burning diesel substitute on their farms using seed crops they grow on their own land" (Kleiner, ¶1, 2006). The reactor, which is approximately the size of a thick credit card, would replace the bulky refineries currently being used. Although the amount produced from each reactor is miniscule, when attached together in series, they have the capability to produce a respectable quantity of biodiesel fuel to use or sell (Kleiner, ¶3, 2006).

The process of finding new ways of refining biodiesel is only one of many areas of research that is currently taking place. As stated earlier, pig manure and algae are among the substances being investigated as raw material to make biodiesel. Research is being conducted for other ways to gain the resources necessary to make biofuels. Michigan State University and DaimlerChrysler are examining the possibility of converting "brownfields" into land that is suitable for growing oil crops. Brownfields are useless, contaminated, industrial dumping grounds that do not grow anything. Researchers would like to see if crops that can be made into biodiesel and ethanol can successfully be grown on a small-scale basis. If this procedure is found to be feasible, they are hoping to aggressively duplicate the process on other wastelands. As an added benefit, researchers are hoping these crops can eventually cleanse the soils of hazardous materials (Roach, 2006).

5:4 The Future of Biodiesel Multi-discipline Education. Such promising initial results from current research could help foster additional interdisciplinary studies in all facets of biodiesel for various school subjects. For example, in Manasses, Virginia, The NEED Project has developed a biodiesel curriculum that incorporates activities for science, social studies, math, and language arts in grades four through twelve. A teacher's guide, correlations to National Science Standards, and student worksheets are also included (NEED.org, pp.4-7, 2004). As with the multi-discipline biodiesel project at Prince George High School, other educational institutions could involve various classes depending on their particular school's curriculum offerings. This could help keep this part of educational instruction relevant and current since energy and environmental issues touch all of our lives every day. It is conceivable that since biodiesel technology is an ever-changing science, it may continually provide subject matter for an almost limitless multi-discipline learning experience, which could prove particularly beneficial to students and teachers alike.

5:5. Conclusion. Biodiesel is a renewable resource that is made from used kitchen oil and other substances. When used oil is heated and mixed with certain chemicals, the molecular structure changes, and it becomes biodiesel and glycerin. Biodiesel can then be used almost immediately as a fuel, either uncut or by blending it with regular diesel. The glycerin by-product can be made into soap and detergents. This alternative to harsh petroleum-based fuel is gentle to the environment and is becoming an increasingly cost-effective fuel as regular diesel fuel prices again begin to rise.

When I chose to introduce a biodiesel multi-discipline assignment into my Graphic Imaging Technology class, I did not quite know what to expect. But, I must say that I have personally continued to enjoy the learning experience, and I believe my students have, too. Before this project was undertaken, most of my students and I had not heard of biodiesel. I could sense their interest beginning to peak as we watched used oil being titrated and the biodiesel refinery being built.

In their assignments, students started researching information on alternative fuels on the Internet, which inspired them to take the initiative in their designs. They snapped digital photographs of the refinery building process and integrated what they learned about the biodiesel process into their work. Graphic Imaging Technology students incorporated art and design into their projects by using Apple IMac computers to create original artwork. They also accomplished the technical tasks and competancies that are required for Career and Technical Education coursework by placing their art in page layout software. Students asked questions of Ms. Schmieder and Mr. Bullock about the steps involved in oil titration and refinery construction. Mr. Hettinger's Marketing students visited the Graphic Imaging Technology classroom in order to develop a biodiesel marketing plan.

Initiating a multi-discipline class collaboration posed a number of problems. Getting all the participants on the same page was not difficult, but coordinating the steps to biodiesel production had a few glitches. For example, there were delays in refinery construction because of parts delays. Students were taking standardized tests at the time and were occasionally called out of the classroom, and because of a new firewall installation, the Internet was unavailable for two weeks in the Graphic Imaging Technology classroom. In future interdisciplinary projects, a flexible schedule, back-up assignments, and a larger block of time for completing class work may be needed to avoid these problems. I am looking forward to the next endeavour being as interesting and informative as The Biodiesel Project.

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Appendix

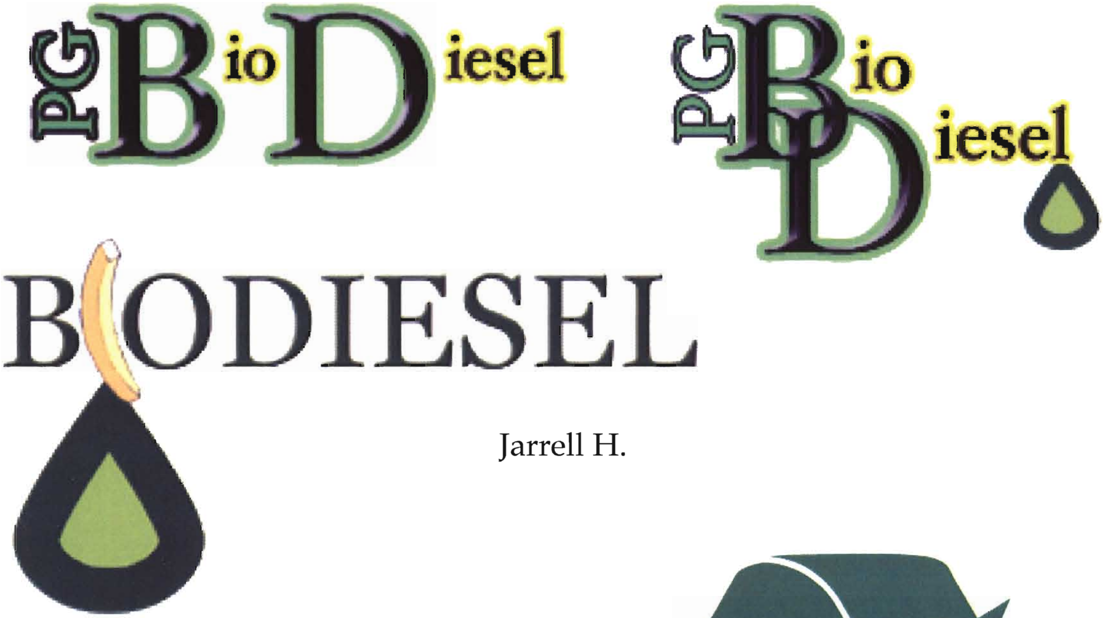
Student Biodiesel Designs

Darnell G.

Evan S.

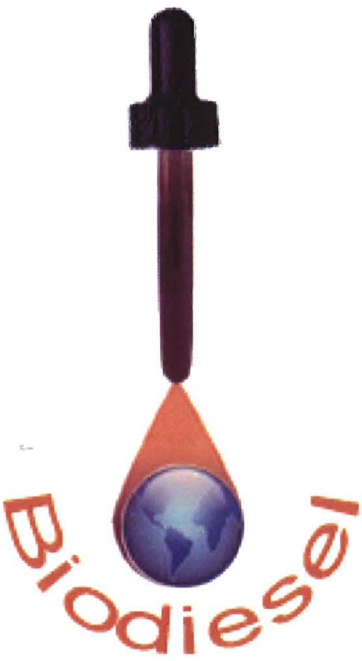
Shanta E.

Danny K.



Jarrell H.

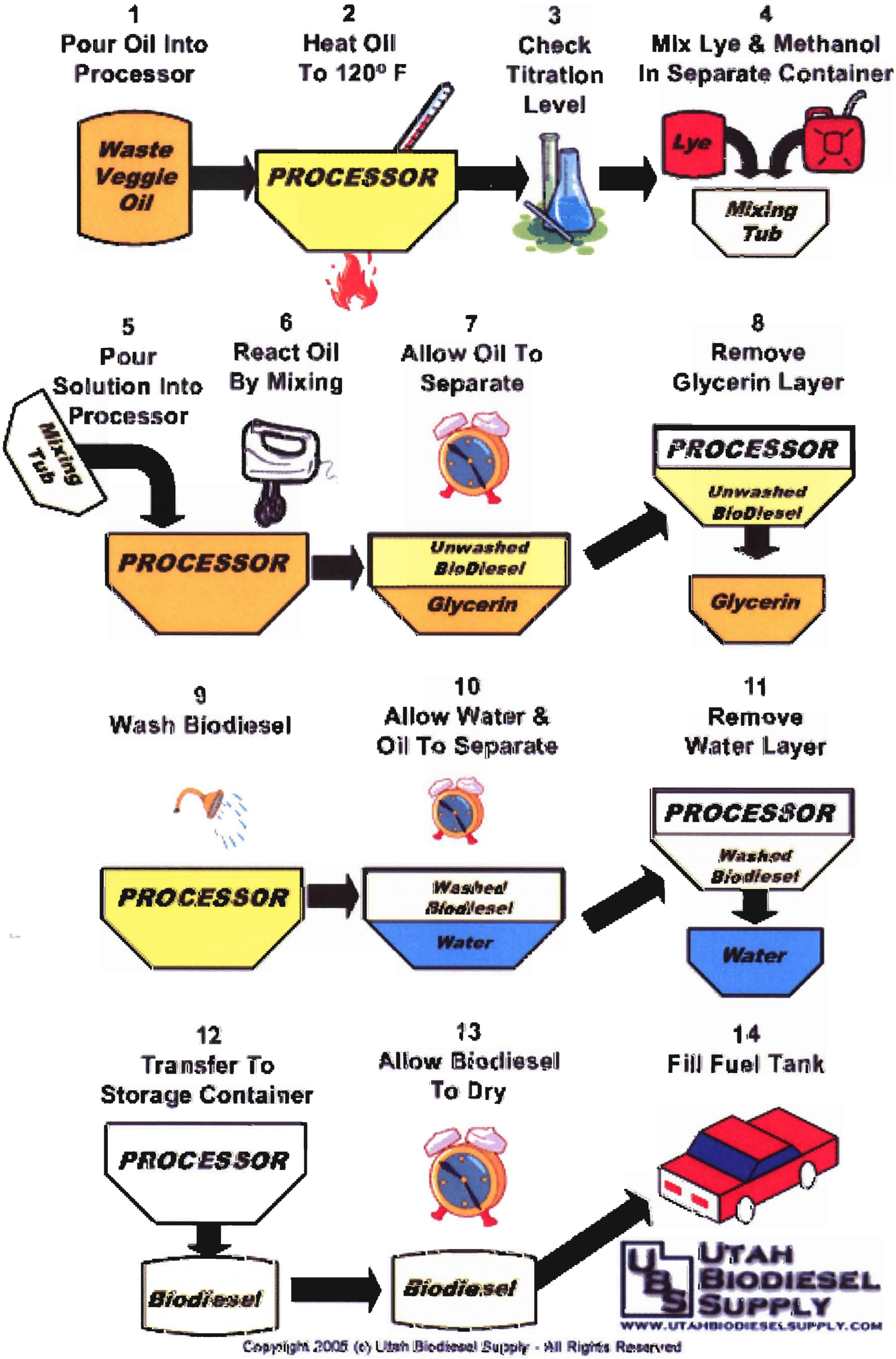
Marissa M..



Tripp W.

Amanda H.

UTAH BIODIESEL SUPPLY BIODIESEL PROCESSING STEPS



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BIO-FUEL >> Efficiency

Elizabeth Shields
Staff Writer

The fluctuating fuel cost, higher demands for money, new clothes, car payments and the everyday expenses of a typical teenager are rising. It's on every teen's mind on how to pinch their every last penny in the hopes of being able to go to the movie this weekend. Thankfully a few teachers in our school staff, along with the help of some members from our student body, are trying to ease that part of our lives.

"With gas prices rising I was looking around for better alternatives," teacher Randy Bullock said.

Bullock, along with the classes of Liza Schmieder and other teachers are making a collaborative effort to help get the gears turning in the minds of our generation. They are looking for ways to help with not only their environment, but the economy and their own personal budget. Of course they also hope to be teaching the students chemistry at the same time.

"I think it can be a valuable source to the students," Bullock said.

The process begins with collecting used cooking oil from companies with whom Bullock has set up business. This is a product that businesses and our school pay to get rid of. The students get the oil and begin the process of changing one useless thing into a vital part of our everyday lives. The end result is a way to create a cheaper and less harmful bio diesel fuel.

"I bought a set of plans off the Internet. We used an old water heater to get us started," Bullock said.

Bullock explains that anyone who knows what they are doing can easily turn cooking oil into their very own bio diesel fuel, that they will be able to use on their diesel fuel vehicle.

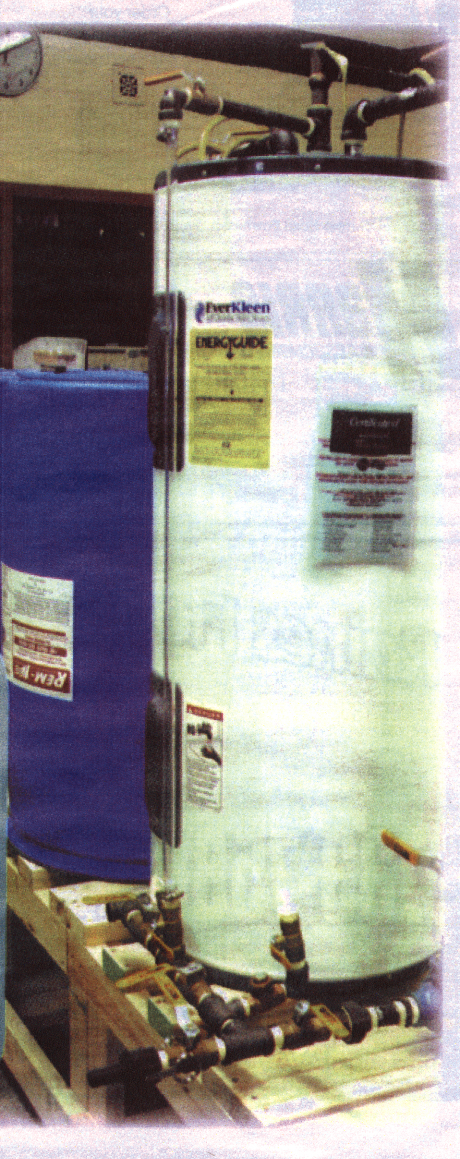
With the rising knowledge and concern for our environment this can also help. This will reduce our dependence on farms and the dumping of harmful oils into our earth.

"It helps farmers ambitions, and we become less dependent on farm oil. Also it is estimated that about 80 million gallons of waste oil are dumped into landfills," Bullock said.

By getting the cooking oil from businesses and turning it into gas it reduces the amount of oil that is dumped into these land fills. By doing so this procedure helps protect our environment from any future damage and helps reduce the damage being done today.

Those who fear the major energy crisis feel that this process and study is beneficial to all. With the students being able to get the cooking oil the businesses dispose of it saves money.

This project is a great opportunity not only for our teachers and the students, but it helps to get us started towards a new and improved future. It shows us a new way to use something that has been discarded for many years.



Vita

Charles Cimo graduated from Virginia Commonwealth University in 1993 and holds a bachelors degree in Communication Arts and Design with an emphasis in Graphic Design. He currently teaches Graphic Imaging Technology and Digital Photography courses at his alma mater, Prince George High School in Prince George County, Virginia. Prior to making his career-switch to teaching, he was employed as an Art Director at an advertising agency in Richmond, Virginia.