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A Sustainable Technologies Certificate Designed for Engineering and Engineering Technology Students (EESD2020)

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Abstract

This paper will examine a Sustainable Technologies Certificate for undergraduates that began in 2013 to teach engineering, engineering technology, and other majors about sustainability and sustainable development. The certificate was created by multiple faculty in several departments in the Indiana University Purdue University Indianapolis (IUPUI), School of Engineering and Technology. While sustainability is incorporated and more well known in other parts of the world, the subject is increasingly important to the State of Indiana and U.S. businesses, industries, municipalities, and citizens. The Sustainable Technology Certificate introduces students to sustainability and many different sustainable technologies.

1 About IUPUI

Indiana University Purdue University Indianapolis (IUPUI) is Indiana's premier urban research university located in Indianapolis, Indiana, U.S. IUPUI offers more than 450 undergraduate, graduate, and professional programs including certificates. IUPUI has two colleges and 17 distinct schools. Student who attend IUPUI are conferred degrees or certificates from either one of the top universities in the state, Indiana University or Purdue University. Graduates of IUPUI can receive degrees or certificates from both universities. The two universities have a unique partnership in Indianapolis. The main campus for Purdue University is located in West Lafayette, Indiana about 60 miles north of Indianapolis. The main campus for Indiana University is located in Bloomington, Indiana about 60 miles south of Indianapolis. The two universities are combined in Indianapolis, the capital of the state of Indiana. Indiana University has the majority of schools than its partner Purdue University at IUPUI. There are two Purdue schools on the IUPUI campus, the School of Science and School of Engineering and Technology. IUPUI has approximately 30,000 undergraduate and graduate students and offers Certificates, Bachelors, Master's and PhDs. IUPUU has a significant number of online classes, programs, and degrees (IUPUI, 2020). The state of Indiana is located in the Midwest of the United States. The authors of this paper both teach at the Purdue School of Engineering and Technology at IUPUI.

2 The U. S. Midwest and Indiana

IUPUI's location in the U.S. is important to understand what the need is for the Sustainable Technologies Certificate. Sustainability has had very slow progress in the State of Indiana and the Midwest. A typical state in the Midwest, like Indiana, is mostly made up of a few large cities (some major) and a lot of small towns and farming communities. Sustainability in the U.S. took off more rapidly on the East and West coasts in the late 60s and early 70s. Cities on the West coast are constantly ranked high in sustainability cities lists. Now major cities in the Midwest are looking to be more sustainable. Sustainable cities "can be thought of as places that are planned and managed with consideration for social, economic, environmental impact, providing a resilient habitat for existing populations, without compromising the ability of future generations to experience the same" (Citizen Centric Cities, 2018). The Sustainable Cities Index is based on people (social), planet (environment) and profit (economic). In 2018, London was ranked number 1 on

the Sustainable Cities Index, New York the first U.S. city listed on the rankings was number 14. Indianapolis was ranked number 64 (Citizen Centric Cities, 2018).

However, in Indiana many small and large cities now have a sustainable commission or a sustainable office, which evaluates the city on sustainable initiatives. Another example of promoting sustainability is the Earth Charter Indiana group, which has information about sustainable activities in the state for climate change in Indiana. The Earth Charter Indiana was established in 2001 based after the Earth Charter that was established in Hague, Netherlands in 2000. The Earth Charter is a proclamation of fundamental principles for building a just, sustainable and peaceful global society in the twenty-first century. The Earth Charter Indiana is trying to do the same for the State of Indiana. There are a number of other groups and activities in the state that are also promoting sustainability activities. However, this is a Republican state and many rural and farm towns, do not adhere to sustainable practices, for example, the state legislators just proposed a new bill to the use of coal in Indiana, even though it is less expensive to use natural gas and look at sustainable energy. This is typical of the "red" (Republican) state in the Midwest.

Wind and solar development started late in Indiana. Large scale wind power started in 2008. Wind energy growth in the state has continued since 2008 with about 15 projects. In 2017, Fowler Ridge Wind Farm in three counties in northern Indiana was ranked one of the largest wind farms in the world (Wikipedia Indiana State wind power, 2019). In 2017, Indiana ranks 12th in the U.S. in installed wind capacity and number of wind turbines, yielding almost 5% of the state's energy needs. (Wikipedia-Wind Power in Indiana, 2019). The year 2009 was the first year for Indiana to see photovoltaics at any scale in the state. Indiana ranked 23 out of all the states for solar power. In 2019, only .042% of the state's electricity is powered from solar (Wikipedia - Solar Indiana, 2019).

3 History of Sustainability in the U.S.

Sustainability started in the U.S. around 1969 with the National Environmental Policy Act (NEPA). (Note: President Donald Trump recently announced the overhaul of the NEPA – unfortunately to the detriment of the environment.) This law was enacted in response to a number of events including a devastating oil spill near Santa Barbara, California, which had a damaging impact on wildlife and the natural environment (Stofleth, 2015). In addition, the U.S. public became more aware of the consequences to land and water due to industrial pollution, especially with the publication of a book by Rachel Carson, *The Silent Spring* Rachel's book highlighted the destruction of birds and wildlife due to the use of DDT (Carson, 1990). This was also a time in the U.S. when there was a push for great concerns about the health of the environment. Soon after, followed the U.S. Clean Air Act, Water Quality Act, and a push to ban DDT. In addition, in 1972, the United Nations had a conference on Human Environment, which outlined the rights of humans to have adequate food, sound housing, safe water, and access to family planning.

Unfortunately, the U.S., as a whole, has not embraced sustainability and has not moved forward with sustainability activities in a timely manner such as in other countries. However, some cities in the U.S. are actively pursuing sustainable agendas. Portland, Oregon leads the list for the most sustainable city in the U.S. with half of its energy coming from renewable sources (Light, 2013). Other U.S. cities are leading the way with large scale recycling and composting programs. San Francisco, eliminates 80% of the city's waste through its recycling and composting program. In addition, the San Francisco has approximately 700 LEED-certified building projects (Light, 2013). In order to have a greater and long-lasting impact, sustainability issues need to be addressed at the national, state, and local levels, such as in Germany and other European countries. At the corporate level, companies such as Interface, Inc. have made tremendous contributions to the movement of sustainability in the U.S. (Anderson, 2011). In the early 1990s Interface

embarked on a sustainable journey after its leader, Ray Anderson, was asked by its suppliers what was the company doing for the environment? On its way, it changed from a heavy petroleum-based product to recyclable carpet tile all the while on the goals of zero land fill and zero environmental footprint (Anderson, 2011). Other companies need to step up to pursue sustainable agendas like Interface., however, many tout some corporate social responsibility activities without really pursuing a sustainable journey.

In the early 2000's sustainability has regained some importance in the U.S. in business, industry, government, non-profits, higher education, and in the general public's consciousness. The goal of meeting today's needs without harming future generations' ability to realize their potential is a hallmark of sustainable practices. There is widespread interest from many disciplines and sectors in developing, enhancing, and integrating sustainability into aspects of organizations. Thus, the need to equip students with the knowledge and skills to make contributions to sustainable initiatives has never been greater. Green jobs are being created in the U.S. as the economy embraces sustainable, energy efficiency, and low-carbon practices. The driving forces behind the development of green jobs are businesses that desire to maintain cutting edge technology, eliminating waste, becoming more energy efficient, lowering carbon footprint, and/or becoming entirely carbon neutral.

4 Rationale for Certificate

IUPUI adopted the Sustainability Technologies Certificate because, in recent years, sustainability and sustainable development have gained prominence the U.S., in the State of Indiana, and in the general public's consciousness in the United States. Sustainability is being incorporated into industry, business, education, municipalities, as well as the daily lives of people. There is a growing demand for individuals with knowledge in sustainability in organizations across the for-profit, nonprofit, and government sectors. Individuals sought by these groups include consultants, coordinators, managers, and/or advisors for organizations seeking to introduce a sustainability component to their managerial, administrative, or programmatic operations.

IUPUI, through its Office of Sustainability and the Academic Sustainability Committee, recognized the importance of sustainability to the future of Indianapolis and the surrounding communities, the state as a whole, and its current and future students and residents. Sustainability is not a particular set of knowledge, skills, or abilities, but is an approach—a way of thinking—that spans disciplinary boundaries. Students draw strength in their careers and their personal lives by learning to think sustainably from the multiple disciplinary perspectives as required in this certificate.

There is a growing need for recognized degrees in sustainability, including certificates. Sustainability is already incorporated in Indiana and Indianapolis, which are moving slowly toward a green economy. According to the U.S. Department of Labor, Bureau of Labor Statistics, there were more than 3.4 million "green goods and services" jobs in the United States in 2011, including 70,156 in Indiana. Indianapolis is home to many innovative projects that are producing green jobs from storm water management, energy efficiency projects, tourism, to recycling (Ellis-Lamkins, 2012). Indianapolis has established an Office of Sustainability, charged with overseeing the greening of the city/county government's operations.

5 The Sustainable Technology Certificate

This certificate was proposed by three faculty members in three different departments in the School of Engineering and Technology. The certificate was approved in 2011. The faculty received an IUPUI curriculum development grant to design all six courses. Several of the courses were first presented in the fall semester of 2013 in a rotating method offering two course per semester. Now, three courses are

offered each fall, spring, and summer semesters giving students the ability of earning the certificate in one year. Students are required to successfully complete a total of 6 courses (18 credit hours with a grade of C or better) to earn the certificate. The pre-requisite for the certificate is a basic undergraduate level English course. No more than 9.0 units of transfer credit can be applied towards the certificate. The courses, titles, and credit hours for the certificate are listed below:

Course Number, Course Title, and Credit Hours

OLS 20000	Introduction to Sustainable Principles and Practices	3credits
TECH 30100	Renewable Energy Technologies	3 credits
TECH 30200	Introduction to Green Building Technologies	3 credits
TECH 30300	Energy Efficiency and Auditing	3 credits
OLS 30200	Economics and Leadership Aspects of Sustainable Technologies	3 credits
TECH 40200	Emerging Green Technologies	3 credits
Total Hours		18 credits

All of the certificate courses are offered on-line and were new to this program. Per the terms of the IUPUI Curriculum Enhancement Grant, awarded through IUPUI's Center for Teaching and Learning, the following courses were all developed over two summer sessions. The course descriptions are listed below:

(1) OLS 20000 - Introduction to Sustainable Principles and Practices – This course introduces students to sustainability and its principles; it focuses on how and why sustainability is important. The course covers: principles, history, definitions, and historical economic aspects of sustainability. It also covers principles of sustainability to design, building, energy, and commerce. The book, *Sustainability- Principles and Practices second edition* by Margaret Robertson, is used in the course. In addition, videos and articles are supplemented for each chapter.

(2) TECH 30100 - Renewable Energy Technologies - This course provides the student with an introduction to renewable energy. Topics include photovoltaic, solar thermal systems, fuel-cells, hydrogen, wind power, waste heat, bio-fuels, wave/tidal power, geothermal power and hydroelectric. Discussions of economics, environment, politics and social policy are integral components of the course. The text, *Renewable Energy: Power for a Sustainable Future*- third edition, by Godfrey Boyle, is used for this course. In addition, videos and articles are used to supplement the text.

(3) TECH 30200 - Introduction to Green Building Technologies - This course examines, discusses and analyzes buildings. Building systems and assemblies (both residential and commercial) will be discussed and will include topics such as the principles of: thermal efficiency and comfort, climate, shading, site design, day lighting, efficient building envelopes and mechanical equipment. Chapter 1 - *Overview of Green Building* by J. Culllen Howe is used for this course as well as supplemental articles and videos.

(4) TECH 30300 - Energy Efficiency and Auditing - This course introduces energy audits and methods to improve energy usage in commercial/industrial systems. Topics include energy audit process, energy bill analysis, economic analysis, survey instrumentation, building envelop, electrical system, HVAC system, waste heat recovery, lighting, cogeneration, and other prevalent industrial systems. Current videos and articles are used to teach this course.

(5) OLS 30200 - Economics and Leadership Aspects of Sustainable Technologies - The main focus of this course is to learn how organizations make sustainability function in their organizations. Students learn about the triple bottom line (environment, social and economic aspects of business decisions) and how to make "sustainability" thrive in an organization. The book, *Making Sustainability Work: Best Practices in Managing and Measuring Corporate Social, Environmental and Economic Impact – second* edition by Epstein. and Buhovac (Greenleaf Publishing), is used for this course. The online modules are supplemented with videos and articles.

(6) TECH 40200 - Emerging Green Technologies - This course will examine, discuss, and investigate new emergent green technologies in renewable energy, green building, sustainable design, and other green technology emerging in the marketplace. Current videos and articles are used for this course.

The certificate in Sustainable Technologies provides a unique and innovative academic alternative at IUPUI for the following reasons:

1) The certificate is multidisciplinary. It cuts across the disciplines of science, engineering, technology and leadership in order to provide a comprehensive approach to education in sustainability.

2) The certificate is interdisciplinary and transdisciplinary. It mixes course content from traditional disciplines into individual courses, allowing students to see the relationships between concepts and theories in one discipline in the context of others.

3) The certificate is an undergraduate program. This will build the foundation for future degree programs and will provide an entry point for those interested in sustainability, yet who may lack the advanced education to apply to a more advanced level degree.

4) The certificate will encompass practical application courses so that students are not solely exposed to theory but will be engaged in hands on experience with sustainable technologies.

5) The certificate will be globally focused. The curriculum will provide an opportunity for international experiences (students may substitute a sustainability study abroad course – GO GREEN for one of the courses in the certificate) as well as discussion of international topics that will encourage a focus upon the world outside of Indiana and the United States.

6) The certificate will involve an opportunity for community and service related projects into the curriculum so that students have an opportunity to see the impact of green technologies within real life situations.

7) The certificate will provide the opportunity to learn about emergent technologies that will place the graduates at the forefront of cutting-edge ideas and concepts in an era struggling to come to terms with the impact of technology.

8) The certificate will develop graduates with specific skills that are needed to advance in a competitive green job market.

9) The certificate will build upon the success of pilot courses and initiatives in green technology already at IUPUI (e.g., GO GREEN study abroad program)

This certificate was designed for students who wish to study and work in what is currently called the "green jobs" sector. It was designed to serve students enrolled in Architectural Technology, Interior Design, Construction Management, Electrical Engineering Technology, Mechanical Engineering Technology, and Organizational Leadership, as well as, General Studies, Liberal Arts, Science, Public and Environmental Affairs, and Informatics, however, the program is open to all majors. The certificate is designed to be completed on a stand-alone basis or in combination with a degree.

One of the faculty members who designed the certificate has taught other sustainability courses at IUPUI since 2003. One such course is a study abroad titled, Green Organizations: Global Responsibility for Environment and Economic Necessity (GO GREEN). The study abroad is eight days in Germany visiting businesses, industries, and municipalities to look at sustainable practices. This study abroad course has been offered for 18 years. Students do pre-and post-work at IUPUI in addition to traveling to Mannheim, Germany. Certificate students can substitute this course for one of the certificate courses.

6 Certificate Progress since Fall 2013

The student enrollment numbers in the certificate courses started out with very low numbers beginning in fall of 2013. The enrollment numbers were as low as 3 to 8 students in the courses offered. Since about spring 2015 a large number of these course are at full capacity with a wait list and others are almost full. Some courses went from enrollment of 3 to 23 the next semester offered. Authors believe that this was due to efforts of marketing and advertising the certificate to interested students. For low enrollments courses in the early years where the administration would normally cancel the class. Several of the faculty, who had developed the certificate, taught those under-enrolled courses for no credit towards their teaching load. The certificate is now in its sixth year of being offered. Since the fall of 2019, three of the courses have been offered every semester. There are 22 students currently enrolled in the certificate. While the number seems low, relatively speaking, many students in engineering technology take a sustainability course (one of the six offered), which is a requirement for their major. This is one way the enrollment in the courses has increased. Another key note, two of the faculty who initiated the certificate have left the university. However, one is still teaching and updating courses as an adjunct faculty. Another faculty member lost interest in the certificate courses and has gone on to teach in another area. The certificate is now overseen by the Technology Leadership and Communication (TLC) Department, where it should get more visibility.

7 Conclusions

The certificate has not increased in numbers as the faculty had hoped. However, given the state's mandates for total number of credit hours in a major, certificates generally do not do well unless a large number of the courses in the certificate are required for the major. This is not the case with these courses. Many of the certificate students are from the School of Public and Environmental Affairs (SPEA), because the curriculum in SPEA is mainly focused on public policy and not sustainable technology. In

addition, the certificate attracts students in the Organizational Leadership major, where students need a foundation of technical credits in their degree program. A very small number of engineering students have completed the certificate due to the nature of the technical credits in that program being prescribed by their programs. Faculty need to outreach to the counselors in the engineering technology and engineering departments to help increase the numbers applying for the certificate. In addition, reaching out to continuing educational program and the SPEA counselors. The certificate is advertised on the website of the Sustainability Office at IUPUI. Faculty see the numbers increasing so the certificate should continue to grow.

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