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Engineering Technology Pathways: The Food and Foodstuff Supply Chain

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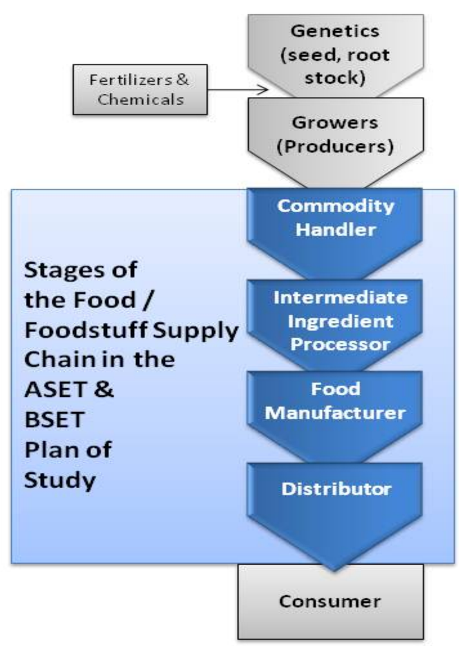
Introduction

The proposed Engineering Technology Pathways: Food and Foodstuff Supply Chain is among the first Engineering Technology program in which a community college and major research university offer articulated degrees with a concentration in the food and foodstuff supply chain. Demand for American foodstuffs has helped the United States maintain its position as the world's largest exporter for food products, or foodstuffs, for over 50 years[1]. Ivy Tech Community College and Purdue University College of Technology recognize that the food and foodstuff supply chain consists of industries that utilize raw material crops in rapidly value-added, markets such as food, feed and non-food (alternative energy) production [2]. The variety of the supply chain is a crucial characteristic to maintaining sustainability through value in commodities and processing industries [3]. However, the supply chain is an increasingly complex field with a critical need for trained engineering technicians. The proposed program provides a comprehensive and streamlined approach for students seeking to understand the entire food and foodstuff supply chain, ranging from regulations and safety standards to quality control and traceability. High school graduates of any age have the opportunity to begin their education in this field by earning an Associate of Science degree in Engineering Technology (A.S.E.T.) at Ivy Tech Community College and then seamlessly transfer credits to Purdue University in order to earn a Bachelor of Science degree in Engineering Technology (B.S.E.T.) at Purdue's College of Technology.

The goal of this ATE Program is to create an informed, multi-disciplinary workforce that can mitigate risks related to the food and food-stuff supply chain. To achieve this goal, there are four key objectives: (i) creating the infrastructure needed for technical program students to transfer to Purdue's B.S.E.T. program from a relevant Ivy Tech A.S. program; (ii) establishing a virtual learning community that promotes persistence by helping to attract and retain students, engage industry into the program and increases student accessibility; (iii) creating a robust pipeline among industry, faculty, staff and students; and (iv) promoting sustainability through ongoing evaluation and dissemination. This approach results in Purdue and Ivy Tech working together to jointly develop two new courses, refine existing courses to ensure one-to-one course articulation, and modify multiple courses so students can fully participate online. Furthermore, ET Pathways responds to proven industry needs, and serve as a model for technical education partnerships between community colleges and major research universities.



The food and foodstuff industry involves complex regulations and standards that require knowledge of the entire supply chain, as well as professional skills such as business writing, teamwork, and leadership. In addition, a highly competitive marketplace is causing the food and foodstuff industry to significantly expand its use of technological innovation, causing dramatic employment growth for engineering technicians. This innovative educational pathway is preparing a technical workforce to address the challenges facing *both* producers and manufacturers in the food and foodstuff industry, which is an expanding but largely unfilled need. [4] Through this collaborative approach, Ivy Tech and Purdue students benefit from a Web-compatible curriculum that encompasses the trans-disciplinary nature of the food and foodstuff industry, incorporating fields such as mechanical engineering technology, electrical engineering technology, food studies, and communication.

Figure 1: The Food and Foodstuff Supply Chain and Related A.S.E.T/B.S.E.T Plan of Study (Supply Chain Source: ISO 22006)

The United States has a fragmented food and foodstuff supply chain weakened by organizational barriers such as lack of common standards, regulations, and management practices [5]. This issue is further complicated by the fact that food and foodstuff production and manufacturing is becoming increasingly complex and is requiring more technically skilled employees [6]. The U.S. Department of Labor's *Career Guide to Industries, 2008-09 Edition, Food Manufacturing*, stated:

> "Fierce competition has led food manufacturing plants to invest in technologically advanced machinery to become more productive. The new machines have been applied to tasks as varied as packaging, inspection, and inventory control, but the processing of animal products remains a labor-intensive activity that is resistant to automation efforts. As a result, employment will decrease for some machine operators, such as packaging and filling machine operators and tenders, while employment growth is expected for industrial engineers and industrial machinery mechanics, who are responsible for the design or repair and maintenance of new equipment. Computers also are being widely implemented throughout the industry, streamlining administrative functions, but also requiring that all workers, including production workers, develop technical skills and a comfort level in reading and understanding digital readouts and instructions. This will result in decreased employment for administrative support workers, such as order clerks, but increasing the demand for production workers, such as food batchmakers who have excellent technical skills"[4].

Within the past 20 years, the United States has experienced numerous nationwide food safety recalls, reflecting the weaknesses in the current system. In 2010 alone, there have been 23 nationwide recalls [7]. The urgency for a food and foodstuff ET Pathways driven by improved standards was underscored September 22, 2010, during the Congressional testimony of Austin J. DeCoster, owner of DeCoster Egg Farms, whose operations were linked to the United States' deadliest outbreak of salmonella infected eggs that occurred in 1987, as well as this year's recall of half a billion eggs that sickened thousands of people.[8] Mr. DeCoster told the House Energy and Commerce subcommittee the root problem was that his family operation had become "big quite awhile before we stopped acting like we were small."[8] The DeCoster cases, as well as the recent nationwide spinach and peanut butter recalls [9, 10] highlight the critical need for developing an educational pathway for technicians who have a comprehensive knowledge of the food and foodstuff supply chain (see **Figure 1**).

Foodstuff, defined as any substance that can be used or prepared for use as food or energy, is not produced or manufactured in a way that fits the traditional "silo" approach to advanced technical education. Engineering Technology (ET) falls short in serving the needs of food and foodstuff companies' substantial needs for highly trained technicians. This problem is compounded by the fact that Indiana ranks only 35th in the U.S. in adult population with associate's degrees and 47th in adult population with bachelor's degrees [11]. Furthermore, the aging demographics of Indiana requires a workforce pursuing higher education to adapt to the rapidly changing marketplace to keep Indiana's position as a leader in food production and processing [7].

To successfully operate, a food and foodstuff company must be aware, comprehend, and execute the functions of the supply chain. An organization's business plan is guided by satisfying paying customers, as well as by a group of larger stakeholders, comprising the supply chain. This supply chain consists of customers, suppliers, the organization, and other interested parties, such as state, federal, and non-governmental organizations involved in the management and governance of the named industry. The supply chain operates through inputs, processes, and outputs that guide, manage, and regulate all parties. These functions include industry practices, regulations, and standards for a safe and secure supply chain. The number of food and foodstuff recalls demonstrates a fragmented and disparate supply chain.

The critical need for specialized education in the food and foodstuff industries was emphasized in August 2010, when Ivy Tech Community College and Purdue University College of Technology hosted a total of three roundtable discussions to determine regional food and foodstuff industry leaders' most pressing employment needs. The industry participants' comments are shown below, with their needs summarized into three categories: Technical Skills, such as those developed by associate degree graduates from Ivy Tech; Advanced Technical Skills, such as those developed by bachelor degree graduates from Purdue; and Professional Skills, such as those learned at both Ivy Tech and Purdue, with varying intensity. The industry leaders stated they need employees with the following abilities:

- Technical Skills - Working with automation, fundamental computer skills (Excel, spreadsheet), knowledge of industry standards, willingness to relocate / commute to rural area, willingness to get dirty, accept non-office jobs, knowledge of basic calculus (mean, standard deviation), ability to handle biologically active products, workplace safety knowledge; and bulk processing knowledge.
- Advanced Technical Skills - knowledge of: biologics, Lean manufacturing, bioprocessing, microbiology, CFR 21, process controls, regulations, operating systems and standards (GFSI, ISO, OSHA, EPA, IDEM), project analysis, risk mitigation, hygienic design, project management, biosecurity and traceability, and industry case assessment also an ability to work with advanced technology and electronics.
- Professional Skills - Problem solving and managerial skills, positive attitude and motivation, business writing skills, communication skills (internal and external), foreign language proficiency (especially Spanish), respect for cultural differences, leadership and supervision skills; human resources knowledge e.g., organizational measurement), an understanding of marketplace differentiators, a mature work ethic with the goal of advancing professionally.

The needs expressed by the industry leaders at the round table are reinforced through peer-reviewed journal articles, such as those published by Akridge (2004) and Urutyan & Litzenberg (2010)[12, 13].

Background

Food and foodstuff is a stable industry poised for significant technical job growth. Between 2004 and 2010, the value of agricultural exports has nearly doubled (94.5 percent), with exports increasing in nearly every commodity except tobacco and dairy between 1999 and 2008[14]. Ivy Tech and Purdue University are located within the heart of "the food and foodstuffs production belt" and well suited to grow in food and foodstuff production and processing. The food and foodstuff industry, which includes agriculture production, manufacturing, and distribution, contributes over $25 billion to the Indiana economy [7]. Indiana is currently ranked in the top 10 in sales value of several commodities, ranking 3rd in egg production, 4th for soybeans for food and foodstuffs, 5th in corn for foodstuffs, and 5th in pork production [14]. As an export state with a total value of $5.3 billion in 2008, food and agriculture products are crucial to this number. Food and agriculture products consist of 12.6% of total export value, and of all export product categories; food and agriculture products are involved in 3 of the top 4 categories [15].

Indiana is a leader in food processing and manufacturing for multiple reasons, including (i) location – Indiana offers access to readily available raw agricultural products: corn, soybeans, milk, eggs, poultry and pork; (ii) excellent transportation systems – Two-thirds of the U.S. population within 1 day's drive of Indiana, many international companies, as well as companies that import food into Indiana and perform value-add processing have food manufacturing operations in Indiana; (iii) low electrical rates – The national average retail price of electricity at $0.0896 per kilowatt hour, and Indiana's average retail price is $0.0511 per kilowatt per hour [16]; and (iv) available water - Many Indiana municipalities have excess water capacity for companies looking to expand or relocate, with available water capacity ranges from 5 million to 25 million gallons per day. An additional contributing factor is the adoption of technology [15]. Indiana's food producers and manufacturers benefit from strong technical assistance from technical education leaders such as Purdue University and Ivy Tech. Finally, Indiana is recognized as a state that is business-friendly, ranking within the Top 10 states for doing business in a 2010 national poll of site-selection consultants[17].

It is due to this strong foundation that Purdue University and Ivy Tech Community College are uniquely positioned to jointly develop and lead this innovative educational pathway. Founded in 1963, Ivy Tech is now the largest single-accredited community college in the United States. Ivy Tech is a full-service community college offering over 200 programs of study (associate degrees and certificate programs) for over 120,000 students and a growing number of affiliations with two- and four-year colleges. Around the state the current growth cycle puts Ivy Tech first in enrollments in the State of Indiana with approximately 111,000 students during the current fall semester. Ivy Tech has 14 unique regions, seven of which offer the Engineering Technology Associate of Science degree.

Purdue University College of Technology has a total of 10 locations, called Statewide Technology, serving a total of 1,400 students. Statewide Technology is a direct extension of what is offered on the West Lafayette campus. Five Statewide Technology locations offer Bachelor of Science degrees in Engineering Technology. These five campuses represent 25% of the geographic area of the State and approximately 28% of the State population. Four regions within Indiana benefit from both Ivy Tech and Purdue campuses offering A.S.E.T/B.S.E.T degrees, with several additional A.S.E.T/B.S.E.T majors planned at future locations.

Currently, however, the technical degree transfer function between Ivy Tech and Purdue University is limited. In 2010, only 14% of the Ivy Tech students in the School of Applied Science and Engineering Technology fully transferred to a university, and informal student feedback strongly supports the hypothesis that this number of transfers will significantly increase with improved course articulation between the two institutions.

State leaders are also exerting growing pressure for improved course articulation between the institutions. The Indiana Commission for higher education has promoted an agenda that implements a shift of all associate degree education be centered within the community college system. As Indiana's only public community college, Ivy Tech is now responsible for all of Indiana's technical education at the associate's degree level. Consequently, streamlining students' transfer opportunities and providing technical educational opportunities is a priority for both Purdue and Ivy Tech. On February 17, 2010, Purdue and Ivy Tech signed an Articulation Agreement "to provide a basis for a cooperative relationship between the two institutions and to benefit prospective students who desire to complete a Bachelor of Science degree in Engineering Technology at Purdue University-West Lafayette/Statewide." Previously, Purdue University's College of Agriculture also established an agreement in which Ivy Tech students can co-enroll at Purdue in preparation for an undergraduate degree in the College of Agriculture. In the first semester of this program's inaugural year, 21 students have enrolled. This highly successful approach will serve as a model for the proposed food and foodstuff program. A column appearing in the September 19, 2010, issue of *The Chronicle of Higher Education* is directly aligned with Purdue Statewide Technology's commitment to cultivating its expanding partnership with Ivy Tech, stating: "Being good stewards of the baccalaureate degree means providing advice to prospective transfer students about how best to prepare for the upper division; engaging community-college faculty members in good-faith discussions regarding curricula and the transfer of credit; and creating campus communities that embrace transfer students as part of the intellectual life of academe"[18].

To streamline the articulation and joint curriculum development process, the team utilizes the student-centered Wiggins and McTighe curriculum development model [19]. The Wiggins and McTighe model employs a "backwards design" that bases curriculum development on desired learning, or learning outcomes. It is an appropriate model, since course articulation is being based on common learning outcomes. Students transferring from Ivy Tech to Purdue are granted credit for articulated courses based on shared learning outcomes. This model focuses on acceptable evidence of understanding, which helps guide the development of valid and reliable assessment instruments in the curriculum development efforts.

Articulation and joint curriculum development, however, are not the only means for creating pathways for students. Once a student enrolls, there are barriers to student persistence to either a two- or four-year degree as well. Tinto [20] explains that learning is the key to student persistence. In addition, Tinto [21] describes such results of a weaker integration of the student engaged in not only learning, but persisting through to a college degree. Due to student type and the nature of ET delivery, the learning community proposed here will have virtual components that would be the first in the state and a potential model for others. The ET Pathways Virtual Learning Community (VLC) is intended to support students by engaging them with peers, faculty, support staff, and industry in activities that are purposeful (i.e., academic, and social in nature to improve student persistence toward an ET degree.) The VLC contains components that are not geographically specific.

To further promote sustainability, the ET Pathways program builds upon previous ATE resources. Of note, ET Pathways is unique since existing resources would come from multiple ATE clusters, not one. The ATE clusters involved in Agricultural and Environmental Technologies (AET), the Biotechnology, Chemical, and Process Technologies (BCPT), and Learning and Evaluation (LE) are among the prominent ATE clusters from which to identify and utilize resources for the coursework. Teachingtechnicians.org is a website supported by the NSF and administered by the South Carolina Advanced Technology Center (SCATE) for the purpose of supporting faculty development events. It is an additional resource, besides ATE Central, identified to support ET Pathways. For student support, there are ATE initiatives that have developed learning communities that the ET Pathways VLC can build upon. To improve overall program effectiveness and evaluation, the ATE publication of project impacts at http://ateprojectimpact.org is a valuable, additional resource which highlights ATE projects for the purpose of developing collaborative, synergistic efforts that guides the team [22].

The team will proactively retain high school students interested in this field as they earn an associate's degree at Ivy Tech, go on to earn a bachelor's degree at Purdue, and, once working in the field, serve as mentors to future students. This goal is being achieved by fulfilling the following four objectives: objective 1 - Course Development & Articulation: Create the infrastructure needed for technical program students to transfer from a relevant Ivy Tech A.S. program to Purdue's B.S.E.T. program. The following aims will be the building blocks for achieving this objective:

- Aim 1A: Articulate courses system-wide from Ivy Tech A.S.E.T. degree into Purdue's Statewide Technology B.S.E.T. degree. To enhance student access and promote a seamless transition from the associate's to the bachelor's degree, Ivy Tech and Purdue faculty will jointly modify existing courses and develop two new courses. Modification will consist of revising existing courses for distance education. The joint development of coursework will fill in gaps between industry wants and needs, and current degree offerings. It is anticipated that achieving the following aims will increase A.S. students' accessibility to completing a bachelor's degree in Engineering Technology and fulfill industry needs via a concentration to the food and foodstuff supply chain. There are 14 Ivy Tech ET courses which have articulations for Purdue University's B.S. in Engineering Technology. This articulation is basic, but provides a foundation for a comprehensive pathway approach for student transfer from the Engineering Technology A.S. degree at Ivy Tech to the Engineering Technology B.S. degree at Purdue.
- Aim 1B: Purdue and Ivy Tech will jointly develop and institutionally link a course that serves the concentration of Food and Foodstuffs supply to meet industry needs. The co-development of coursework will be in the area of advanced technical skills in the food and foodstuff area. Connecting this supply chain occurs through standards, as noted below:

> "Standards are not only technical questions. They determine the technology that will implement the Information Society, and consequently the way in which industry, users, consumers, and administrations will benefit from it" [23].

Standards may be defined as a body of codified information that enables the effective dissemination of technology through society [24]. Standards not only take technology into account, but also the characteristics of the specific environment within which technology will have to function (NSSF, 2009). The specific environment may encompass codified knowledge, or knowledge embedded in patents, products, and instruments, but tacit knowledge as well (NSSF, 2009). The co-developed courses will be based upon compatibility and quality standards for food safety and traceability including hazard and critical control points (HACCP), food quality management standards based upon the International Organization for Standards (ISO) and the Global Food Safety Institute (GFSI). This knowledge has been increasingly sought after in the state of Indiana. In increasing numbers, companies have been asking for standards training and education from Purdue's Technical Assistance Program (TAP) and the Manufacturing Extension Partnership (MEP) center for the State of Indiana [25]. Technical competence is supported by student success as noted in objective 2: objective 2 - Student Support and Virtual Learning Communities: Establishing a virtual learning community that promotes persistence by helping to attract and retain students, engage industry into the program, and increase student accessibility. Student support is guided by the use of a Virtual Learning Community (VLC). The development and utilization of learning communities have been employed to improve student persistence to degree completion [26, 27]. The VLC assists students' persistence toward an Ivy Tech A.S.E.T. degree and provide a pathway from A.S.E.T. to a B.S.E.T. degree from Ivy Tech to Purdue.

The VLC incorporates active and collaborative learning to promote involvement through shared knowledge [21, 27, 28]. Tinto [28-31] and others [32, 33] state that since classrooms are at the center of educational activity, what occurs in the classroom is the dominant feature of the student experience. The interaction between students and faculty are the dominant factors in student success [28, 33-35]. Student learning is the key point; consequently, important characteristics of the proposed VLC will be active learning experiences shared with peers and faculty and allowing students to be engaged academically and socially in a learning environment [26, 27, 29-32, 36]. Based on prior research, students involved in this manner persist at a higher rate than comparable students in a traditional curriculum [31, 37]. Aim 2A further describes this interaction.

- Aim 2A: Tailor the VLC to meet the needs of a diverse population by utilization of Web 2.0 technologies to develop VLC web space. Student diversity is not just an issue with regard to ethnicity or background. Geography is also a characteristic that is a challenge for access to higher education. This proposal concerns students that are scattered across a wide state region, located in widely dispersed urban areas and separated by a rural landscape. ET students also exhibit wider variety in age, presenting an environment for which "traditional" college age students are to interact with older adults pursuing a degree. This extends to diversity in background, creating a scenario for full time college students to learn along with older peers working full time and handling multiple obligations. For those students with multiple obligations outside the classroom, the classroom may be the only place for the commuter student to learn and interact with peers and faculty [29, 31, 38]. The diversity of these students may also lend itself to an enhanced learning experience [35]. Based on previous research [37], VLC activities in a commuter campus environment resulted in higher student persistence than comparable students. Students built their own supportive groups based upon friendships built in the classroom, and continue outside the classroom setting [31, 37].

Due to geographic distance and rural setting of many ET degree locations, the VLC includes a virtual/digital learning environment for delivery. As stated above, Blackboard is a digital learning environment that both Ivy Tech and Purdue University utilize and are used for the VLC, as well. Courses modified for distance incorporates features and activities for the VLC. This includes: a discussion forum, chatroom, email, and wiki. According to Leuf and Cunningham [39], a wiki is a Web 2.0 technology and is unusual among group communication mechanisms in that it allows the organization of contributions to be edited in addition to the content itself. This VLC web space serves both Ivy Tech and Purdue students to interact for socialization and peer monitoring among student populations as a community of practice outside of Blackboard. These contributions serve social learning among ET students by utilizing distance education theory through web-based technology [40]. While many types of information technology (IT) may be incorporated, the overall goal is learning by online or digital means in a common communication manner, allowing for a general technology platform [41]. The ET Pathways program brings the technical competence and student support together in a pipeline noted in objective 3: objective 3 - Student and

Industry Outreach: Create robust pipeline among industry, faculty, staff and students. This objective is supported by the following aims.

- Aim 3A: Increase networking opportunities for student, faculty and industry networking. The ET Pathways team recognizes the importance of promoting opportunities for students, faculty and industry leaders to interact and learn from one another. An annual ET Pathways Career Summit is hosted alternately at an Ivy Tech or Purdue University campus each spring, in which students host poster sessions, participate in roundtable discussions with industry specialists, and learn from guest speakers. The Virtual Learning Community also incorporates extensively into the ET Pathways Career Summit. For example, all of the information presented in the poster session have the opportunity be displayed on the VLC website with the students' contact information, offering industry members not attending the summit to review the students' work. Thus far, two summits have resulted in over 100 attendees.

Conclusions

The efforts of this program will result in an E.T. model that can be replicated across the region. Indiana is uniquely positioned for this program because of its status as an agriculture production state. Regionally, Indiana is part of a larger regional grain belt that is the "breadbasket" of the country [7]. Replication of this model would be appropriate for those states that are also agriculture production states with similar workforce needs. Additionally, Indiana has attracted food and foodstuffs processing companies also because of the region's traditional manufacturing base. Formally known as the "Rust Belt", this manufacturing center has suffered more than one third of the job losses of the entire country over the past decade [42]. Replication of ET Pathways could support a rejuvenation of the region. Ohio seems specifically positioned for the next phase of this program, as the state is most closely related to Indiana as a production and manufacturing state.

Future Plans

As the world's largest exporter for food products, or foodstuffs, for over 50 years[1], the United States has a remarkably complex and rapidly changing supply chain. We envision this ATE Program to serve as the foundation for an ATE Center that will integrate the expanding complexities of food and foodstuff as well related energy sources, such as ethanol. As the first Engineering Technology program in which a community college and major research university offer articulated degrees with a concentration in the food and foodstuff supply chain, our team will strive to make this a model program that can be replicated and expanded throughout the region and the nation.

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