Abstract
The Greenfield Coalition at Focus:HOPE is a coalition of five universities, three university affiliates, six manufacturing companies, the Society of Manufacturing Engineers, and Focus:HOPE. (a civil and human rights organization dedicated to intelligent and practical action to overcome racism, poverty and injustice in Detroit and its suburbs). The impetus for Greenfield was the sense that most academic studies in manufacturing engineering were devoid of real manufacturing experiences.

The paper describes the unique educational experience under development by Greenfield at the Focus: HOPE Center for Advanced Technologies. It develops Greenfield’s vision, beliefs, and technology strategy to support learning. The paper explores the implementation of Greenfield’s learning tools targeting real-world manufacturing experience, and a set of manufacturing engineering case studies set in Focus: HOPE’S Center for Advanced Technologies.

Focus:HOPE
Focus:HOPE supports an amazing web of programs to underpin its educational objectives. Founded in 1968 after the urban riots in Detroit, it pledges intelligent and practical action to overcome racism, poverty and injustice—to make a difference within the city and its suburbs. Focus:HOPE began by feeding the undernourished needy (women with children and then adding senior citizens), but quickly added programs to enable inner city youth to acquire knowledge to seize opportunities for highly skilled and well paying jobs. Today, an individual may begin the journey by enrolling in First Step or FastTrack. These four and seven week programs use computer-based learning to build fundamental skills in mathematics and English. When the student graduates from FastTrack, they have skills certified at the ninth and tenth grade level in reading and math. This provides the appropriate prerequisite skills for entering the Machinist Training Institute (MTI). Alternatively, students may also choose to pursue a career pathway through Focus: HOPE’s Information Technologies Center.

MTI is a thirty-one week program in which students earn certification in the operation of material processing equipment (machining), metrology, computer-aided design, computer numerical control, and the associated math, computer, and communication skills.

Focus:HOPE Mission Statement
Recognizing the dignity and beauty of every person, we pledge intelligent and practical action to overcome racism, poverty and injustice. And to build a metropolitan community where all people may live in freedom, harmony, trust and affection. Black and white, yellow, brown and red, from Detroit and its suburbs of every economic status, national origin and religious persuasion. We join in this covenant. (Adopted March 8, 1968)
Greenfield presents an opportunity for graduates of MTI to cap their practical experience with further studies toward advanced university degrees. Those students who qualify, enter a 24 week pre-engineering program after completing MTI’s basic machining program. After a series of diagnostic tests and interviews they become Candidates in the Center for Advanced Technologies (CAT)—Focus:HOPE’s manufacturing facility. The Center for Advanced Technologies is a not-for-profit entity which is a first tier supplier of manufactured components and systems to Ford, General Motors, DaimlerChrysler, Detroit Diesel, and the U.S. Department of Defense. The Candidates are employed by Focus:HOPE and work in a broad range of manufacturing, production, and support activities. While this employment provides financial support, more importantly it becomes a real-world laboratory to support their learning.

Greenfield Coalition
The Greenfield Coalition at Focus:HOPE is a coalition of five universities, three university affiliates, six manufacturing companies, the Society of Manufacturing Engineers, and Focus:HOPE. Greenfield was created to develop advanced degrees that articulate to the Focus:HOPE educational pipeline, and are strongly coupled to the Center for Advanced Technologies. The Greenfield learning system is predicated on the belief that students will learn faster, and will become more effective problem solvers if engineering education and practice are integrated, and students actively participate in their learning. We talk about a new breed of renaissance engineer not educated in the traditional academic model, but one re-born in an environment which integrates theory and practice. Experience leverages deeper understanding and deeper understanding supports stronger problem-solving skills. Technology plays a critical role in our ability to provide stimulating learning activities, which enable this integration.

All students in the Greenfield degree programs begin with a common 69-credit Associate of Applied Science in Manufacturing Engineering and Technology program. After completing the associate degree, students elect to follow either one of two branches: the Bachelor of Manufacturing Engineering (137 credits) or the Bachelor of Science in Manufacturing Engineering Technology (132 credits). The associate’s program forms a common feeder for both engineering and engineering technology. Unique in both name and structure, the associate program sets the stage to integrate theory-based and experience-based learning. The difference between the two bachelor programs rests on the depth of mathematics and science, which underpins the course of study.

Greenfield has created a virtual university. One Greenfield partner awards each degree of the three programs:

- **Associate of Applied Science in Mfg. Engineering & Technology**: Lawrence Technological Univ.
- **Bachelor of Manufacturing Engineering**: The University of Detroit Mercy
- **Bachelor of Science in Manufacturing Engineering Technology**: Wayne State University

While the degree is awarded by a host institution, all Greenfield academic partners work as a virtual faculty to plan, design, and deliver the courses (within constraints consistent with the host

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1 Coalition Members: Lawrence Technological University, Lehigh University, Michigan State University, University of Detroit Mercy, Wayne State University; Affiliate Partners: Ohio State University, University of Michigan, Walsh College.
2 Cincinnati Machine, DaimlerChrysler, Detroit Diesel, Electronic Data Systems, Ford Motor Company, and General Motors Corporation.
institution). Therefore, Lehigh University offers courses in Lawrence Technological University’s associate degree program, and Wayne State delivers courses in the University of Detroit Mercy’s Engineering Program. Making such a system work requires unprecedented cooperation among traditionally autonomous academic organizations. Significant effort was invested in the start-up phase of Greenfield to create an infrastructure of policies and procedures to enable this innovative approach.

**Hands-on Learning in the Machinist Training Institute**

The essential educational objective of the Machinist Training Institute (MTI) is to produce graduates who can read blueprints, set up machining jobs, run machines and inspect products. Graduates are able to do this on three types of machines—lathes, mills, and grinders. MTI emphasizes that it is creating employees who are skilled machinists and not just machine operators. Focus:HOPE’s basic machining training is divided into two parts: *Vestibule*, a five-week introduction, and *Core 1*, which is 40 hours per week for 26 weeks. Both programs require classroom and computer work as well as hands-on instruction in the shop laboratory. Both classroom and lab instruction are geared to prepare students to be skilled machinists, and also to be ready for further training and education in computer numerical control programming, computer-aided design and manufacturing engineering.

In *Vestibule* the students are introduced to the topics and gain experience working on one type of machine (lathes) in the lab. Courses include shop theory, shop math, blueprint reading, technical drawing, communication skills, computer literacy, introduction to technology and lathes, for a total of 176 contact hours of study. Students train for 40 hours per week and punch in their hours on a time-clock.

The *Core 1* program is a rigorous 40 hour per week program that combines classroom instruction with extensive hands-on experience on the shop floor. Core 1 requires 613 contact hours in classroom instruction and 495 contact hours of hand-on instruction in the shop laboratory. Computer literacy moves beyond basic skills and includes instruction in CAD and CNC programming and use. In addition, students learn to master mills, grinders and lathes. Upon completion of the program students graduating having produced their own machinist’s tool box with tools such as a hammer, 1-2-3 blocks, triangle, V-block, punches etc.

Students who choose to continue on to *Core 2 (Pre-Engineering)* are then preparing for study in the CAT’s Engineering Programs. In Core 2 the laboratory is Focus:HOPE’s Center for Advanced Technologies factory floor. The shop floor is a 50 million dollar state-of-the-art facility producing real parts for real industrial contracts. The students receive instruction in math, computer skills, communications, geometric dimensioning & tolerancing, and Unigraphics. Upon completion of the 24 week Pre-Engineering program the students take a series of diagnostic tests and interviews to qualify for entry into the CAT Engineering Programs.

**Experiential Learning in the Center for Advanced Technologies**

Graduates of the Machinist Training Institute become *Candidates* in Focus:HOPE’S Center for Advanced Technologies (CAT) which is a first tier supplier to Ford, General Motors, DaimlerChrysler, Detroit Diesel, and the Department of Defense. The purpose of the Center for Advanced Technologies is education; this education is embedded in a real-world production
facility, and becomes a resource for the Greenfield academic programs. Candidates begin their career in the CAT working on production operations. They may be involved in the loading and operation of CNC machining centers or in materials management. A job rotation system moves Candidates through a broad range of experiences. As they mature academically and build their experience, they move into positions as workcell leader, or they may be assigned to the tool room or the quality management function. As Candidates achieve junior status in the academic program, they are eligible for rotation into the manufacturing engineering function in the Focus:HOPE engineering department. Here they work with the Focus:HOPE engineering staff and are given significant responsibilities under the supervision of a mentor engineer. In the next section of this paper, we describe the way we have crafted work in the Manufacturing Engineering Department into a credit-bearing course in the Greenfield bachelors degree program.

Experiential learning is at the heart of the Greenfield paradigm. This is the place where the learning that occurs in the context of becoming competent in a job is captured and matched to learning in the Greenfield academic program. Achieving this vision is difficult. Academe and industry are two distinct cultures that organize and value knowledge differently. University faculty most frequently organize learning with a topic-specific focus, while production engineers and managers typically integrate across many disciplines and frame learning using a situation-specific point-of-view.

Experiential learning at Greenfield takes two forms. The most powerful realization of experience-driven learning occurs when a job activity can substantially frame the learning experience, and assessment of student learning can be made within the context of the job experience. We will present two examples of this kind of experiential learning. The second type of experience-supported learning emerges when real-world problems and manufacturing experiences can be brought into the academic classroom. In this second model, Greenfield is not only creating experiences for the students at Focus:HOPE, but is also creating web-based learning materials so that students within traditional manufacturing engineering programs can benefit from experience-driven Greenfield learning.

**Academic Learning Embedded in Job Experience:** The experience which our Candidates have within the manufacturing engineering department at Focus:HOPE is rich with learning for which academic credit can be granted. Here the candidates become involved with the process of evaluating and responding to requests for quotes to manufacture parts for the Department of Defense and the automotive OEMs. A candidate is assigned to an engineer who becomes a mentor in a real-world learning experience. The job description involves: reviewing the Request for Quote (RFQ), determining if the job fits within the capabilities and business strategy of Focus:HOPE, preparing plans and cost estimates and developing the operations plan.

Greenfield’s approach to creating an academic framework focuses on the articulation of clear and consistent goals and objectives for learning in work-related activities. The academic course we created to frame this learning experience is entitled: *The Management of Manufacturing Engineering Projects*. There are nine learning objectives that describe the learning.
Table 1: Objectives: Management of Manufacturing Projects

<table>
<thead>
<tr>
<th>Objective</th>
<th>Description</th>
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<tbody>
<tr>
<td>O1</td>
<td>Prepare and maintain project management plans and documentation.</td>
</tr>
<tr>
<td>O2</td>
<td>Monitor projects. Establish milestones and advise the program manager of the progress of assigned projects.</td>
</tr>
<tr>
<td>O3</td>
<td>Meet quality and spending objectives, and target dates for assigned projects.</td>
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<tr>
<td>O4</td>
<td>Screen potential production projects proposed by major customers.</td>
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<tr>
<td>O5</td>
<td>Prepare macro level process plans.</td>
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<tr>
<td>O6</td>
<td>Prepare cost estimates used to compile bids for proposed projects.</td>
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<tr>
<td>O7</td>
<td>Prepare micro level process plans.</td>
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<tr>
<td>O8</td>
<td>Coordinate the use of production machinery for assigned projects.</td>
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<tr>
<td>O9</td>
<td>Ensure all operating procedures and safety regulations are followed.</td>
</tr>
</tbody>
</table>

Rather than giving examinations to test the achievement of learning objectives, we use performance-based evaluations embedded in a real engineering job. For example, Objective 1 (Prepare and maintain project management plans and documentation) is decomposed into six tasks. For each of these tasks, there is a work product produced by the student, which is used in the evaluation. In this example, the task: Write a Project Vision Statement references the Project Vision Statement Document prepared by the student as the object to the evaluated.

Table 2: Objective Subtasks and Metrics

<table>
<thead>
<tr>
<th>Objectives/Tasks</th>
<th>Work Product to be Measured</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>O1: Prepare and maintain project management plans and documentation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.1 Write a Project Vision Statement</td>
<td>Project Vision Statement Document</td>
<td>+</td>
</tr>
<tr>
<td>1.2 Establish Project Priorities</td>
<td>Project Priorities Document</td>
<td>+</td>
</tr>
<tr>
<td>1.3 Establish Project Goals</td>
<td>Project Goals Document</td>
<td>+</td>
</tr>
<tr>
<td>1.4 Develop a Work Breakdown Structure</td>
<td>Work Breakdown Structure Document</td>
<td>v</td>
</tr>
<tr>
<td>1.5 Develop a Project Dictionary</td>
<td>Dictionary Document</td>
<td>v</td>
</tr>
<tr>
<td>1.6 Develop a Project Network Diagram</td>
<td>Project Network Diagram Document</td>
<td>+</td>
</tr>
</tbody>
</table>

Summary: Plans are well done, but it is obvious that the Work Breakdown Structure and the Dictionary were overlooked in the initial concept development and added at the end.

Overall Performance Rating for Objective 1: +

Performance on each task is evaluated using a three-level scale: (+) excellent, (v) good, (-) less than satisfactory. In addition to rating each task, the instructor writes an integrated evaluation (the Summary) and assigns an Overall Performance Rating for the objective.

A second example of an experiential course is a project-based course. Greenfield requires two capstone project courses. The first is at the end of the Associates Degree. Here a one credit project which documents a real experience in the production facility at Focus:HOPE is presented for credit. A three-credit design project forms a capstone for both the engineering and engineering technology program. Yaprad [1] (presented in this session), highlights the Greenfield’s capstone project methodology, and provides some examples.
Learning Activities Embedded in a Real World Production Facility: Greenfield courses are designed to embed examples from the Focus:HOPE production facility and other real-world manufacturing environments. Our strategy is to create web-enabled activities which support learning. Several of these e-learning activities are described here, and will be discussed in other papers in this session.

Production Experiments to Support Learning in Probability and Statistics: Many courses in probability and statistics present simple examples to illustrate basic principles. The problem is that many students cannot see the real world application to support and motivate learning. Mandrekar and Tummala [2] have created a set of experiments set in the Focus:HOPE Center for Advanced Technologies, and presented in a web-based environment. The first experiment targets the concept of a histogram, the mean, and standard deviation. An engine head is shown in a machining operation, and sources of variation are discussed. A particular feature is identified, and product specifications and tolerances are presented. The machined part is then shown fixtured in a coordinate measuring machine. Data is presented from a sample of production parts. Using modern software to support statistical analysis, the mean and standard deviation are computed, and a histogram is plotted. The probability of a production part falling out of specification is related to the area under the histogram and then compared to production data.

Time and Motion Study: Professors Zimmers and Tonkay [3] are developing two courses targeting Manufacturing Systems. One important topic in this course sequence is the role of the human as part of an operations system. One e-learning activity involves the integration of a human operator with production equipment. The setting for this activity is the production process to machine a spline on the hub of a turbo charger sub-assembly produced by Focus:HOPE for Detroit Diesel Corporation. The learning activity describes the production operation, and introduces a methodology to segment the work process into its component tasks. A web-embedded QuickTime video shows a broach machine operator loading, running, unloading, cleaning, and gauging the part. The learner views the operation and is led through the definition of the tasks, which form the elements of this process. Using a web-embedded timer, a number of cycles of the operation are viewed. The learner is led through an understanding of the variation in tasks and models each task by its mean duration. Clearly, the most effective learning would occur if each learner could go to a production facility and perform such a time and motion study. The web-based tool introduces the concept in an efficient, yet meaningful way to introduce the concept to the learner.

Capstone Case Study: Engineering Economics: Plonka, Schuch-Miller, Khasnabis, and Ellis [4] have crafted an innovative case study to cap Greenfield’s course in Engineering Economics. In their web-enabled case, they present a production problem faced by the Center for Advanced Manufacture. A production process to produce automotive pulleys is experiencing evidenced unacceptable rejection rate for final product. The case presents a situation, not the problem and points the investigation toward the balancing operations. There is a suspicion that the problem may arise from outdated balancing equipment. The learner is led through a set of resources which include: production data, cost breakdowns,
logs of operations, interviews with key stakeholders, process plans, a documented photo essay of the production process, and links to the vendors of balancing equipment. The first task for the student teams: define the problem. A solution must be presented, and supported by a financial analysis to justify any purchase of capital equipment.

Transferring the Greenfield Experience
Greenfield is a unique educational experiment. The opportunity provided to the Candidates at the Focus:HOPE Center for Advanced technologies is unparalleled. A reasonable question to ask is how can the Greenfield experience impact traditional university offerings in manufacturing engineering? Greenfield’s products focus on learning activities that embed real-world manufacturing situations. Although the student in the traditional classroom does not have the hands-on experience afforded to the students enrolled at Focus:HOPE, they can participate vicariously in our learning factory. Greenfield makes its courses and individual learning activities available for access by faculty and their students. Greenfield’s products are available at our website http://www.greenfield-coalition.org. Here faculty will also find descriptions of a broad suite of interactive reality-based learning activities to bring a real-world focus back to manufacturing engineering education.

Summary
The essence of Greenfield is the integration of real-world experience in developing graduates of manufacturing engineering and technology programs. In the Center for Advanced Technologies, Focus:HOPE Candidates experience this integration first hand. Greenfield’s strategy is to package these real-world experiences and make them available to students in more traditional academic programs using web-based technologies.

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References
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