THE GREENFIELD COALITION: PARTNERSHIP FOR CHANGE IN MANUFACTURING ENGINEERING AND TECHNOLOGY EDUCATION

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Abstract *¾ The Greenfield Coalition at Focus:HOPE is a coalition of five universities, seven manufacturing companies, the Society of Manufacturing Engineers, and Focus:HOPE. (a civil rights organization dedicated to intelligent and practical action to overcome racism, poverty and injustice in Detroit and its suburbs). Greenfield was formed to create a revolutionary educational experience leading to bachelor degrees in engineering and engineering technology. The Coalition is funded by the National Science Foundation; it aims to integrate academic studies and manufacturing skills learned in the workplace. The Greenfield vision leverages technology to enhance and accelerate progress toward the degree. The paper describes the program of the Greenfield Coalition and the framework of the supporting partnership. It develops the theoretical underpinning of workplace-based learning expressed in terms of learning objectives and outcomes. Several examples of implementation of the model are presented.*

Index Terms— experiential education, ,Focus:HOPE Greenfield Coalition, manufacturing, engineering,

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 them with the appropriate prerequisite skills for entering the *Machinist Training Institute (MTI*). (Students may also choose to pursue a career pathway through Focus: HOPE's *Information Technologies Center.)*

In this twelve-month program (including six-months of hands-on experience), students earn certification in the operation of material processing equipment (machining), metrology, computer-aided design, 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 three-month pre-engineering program toward the end of MTI. 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, the U.S. Army and U.S. Air Force. The Candidates are employed by the CAT 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

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 at Focus:HOPE. 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 strengthen active learning to enable this integration.

The Focus:HOPE instantiation of Greenfield has three academic components. All students begin with a common 69-credit *Associate of Science in Manufacturing Engineering and Technology* program. After completing the

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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. Both programs build on 9 credits of Technical Mathematics and Calculus Foundations. The engineering program completes the math sequence with 12 credits of Engineering Calculus and Differential Equations, while the engineering technology degree program caps the study with 5 credits of Applied Calculus. Both programs share several general education requirements, and 13 credits of technical courses. Both bachelor programs count the majority of credits earned in the associate's degree.

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

- *Associate of 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 Univ.

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 institution). Therefore, Lehigh University offers courses in Lawrence Technological University's associate degree program, Wayne State delivers courses in the University of Detroit Mercy's Engineering Program, etc.

Making such a system work has required 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.

Curriculum

Courses are one credit packages of learning in the Greenfield curriculum. Unlike traditional academic programs, courses do not represent the fundamental packaging of learning. Rather, the module, which is concept-focused (and problem-centered) is the fundamental component of learning. Modules are packaged into one-credit courses to interface with university delivery systems, and courses are contained in meta-objects that we call *Knowledge Areas.* Knowledge Areas form a platform for integrating conceptually related material. Finally the collection of *Knowledge Areas* form the *Curriculum.* The concept-centered module is subdivided into sessions. For example, a session may be a set of activities that the learner pursues as a computer-based learning activity. It may represent a group problem solving session led by the faculty, or it might represent experience-based learning, which is completed within a work assignment. This uniquely Greenfield view of Curriculum is depicted in Figure 1.

Curriculum
- Curriculum_Objectives
- *Knowledge Area*
  - Knowledge_Area_Objectives
  - *Course*
    - Course_Objectives
    - *Module*
      - Module_Objectives
      - *Session*
        - Session_Objectives
        - *Activity*
          - Activity_Objectives
          - Activity_Contnet

FIGURE 1 GREENFIELD LEARNING HIERARCHY

Vision and Pedagogy

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.

From the very beginning of the Coalition, computer-based technology was seen as an enabler, which can deepen understanding and accelerate progress toward the degree. The emerging model of a Greenfield course is one that has three linked streams of learning:

Learner-Centered Open-Learning Environment: The Greenfield model provides a leamer-centered open-learning environment implemented using web-centric technology. Computer-based tools provide an active environment to enhance learning.

Experiential or Workplace-based Learning: Central to the Greenfield concept is experiential learning-- non-traditional academic learning that is embedded in workplace experience.

Faculty Facilitated Learning: This is Greenfield's interpretation of the classroom. Here the faculty role as lecturer gives way to value added functions of guiding and integrating knowledge. As mentor-coach, the instructor plays a pivotal role in helping students develop deep rather than rote learning. Deep learning occurs when a student actively participates in knowledge acquisition and integration. Critical to Greenfield is the role that the faculty plays both in supporting students as they use computer-based learning

tools, and integrating experiential knowledge into the academic framework.

EXPERIENTIAL EDUCATION

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 competencies of 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. Both cultures recognize the value and relevancy of the other but have no tools, or system level procedures to facilitate the translation. Typically, the recognition of credit for learning outside the academic classroom is negotiated with a professor, chair, or dean on a case-by-case basis.

Greenfield's approach focuses on the articulation of clear and consistent goals and objectives for learning in the classroom as well as learning in work-related activities. Suppose we wanted to develop experiences so that learners would become proficient in the development of tools, jigs, and fixtures to support machining operations. If we were to create two independent teams—one comprised of faculty and the other involving production engineers and supervisors—and gave them the task of describing learning outcomes for such an experience, each team would use different language, and each team would address the task with different emphasis. Each team though tasked with the same objective, crafts a solution consistent with its beliefs and its system of values. Our approach brings together a multidisciplinary team and allows them to cross-fertilize each other, looking for ways in which work experience in the Focus:HOPE Center for Advanced Technologies supports, transforms, or even replaces traditional classroom approaches. This approach creates a translation between experience-based learning and more traditional classroom learning. We believe that it is the basis for the development of the renaissance engineers we often refer to in Greenfield.

How do we begin this process? Before crafting learning objectives, Greenfield's strategy was to identify target areas in which there would be strong articulation between experiential and traditional academic approaches. We employed *Quality Function Deployment* (QFD) to establish these areas of strong linkage. Quality Function Deployment is a design tool that helps identify the voice of the customer and translate "desirable attributes" into functional specifications. In other words it translates subjective opinion into quantifiable indicators. We created a multidisciplinary team of faculty, production engineers/managers, and students. A group process was constructed to answer the question:

Job X has the potential to support learning in course Y.

We indicated that both the job and the course could change in this process—neither was fixed. Traditional QFD (1,3,9) weights were used to indicate weak, moderate, and strong correlation. This was not simply a polling process; the discussions and the building of consensus were the most important part of the activity. The results of the activity are not surprising, illustrating strong relationships in courses like *Machining Processes* and *Tool Design and Construction*. Other areas ripe for experiential integration included: *Operations Management*, *Quality Management*, *Facilities Design*, etc. A highly regarded QFD professional consultant conducted this exercise over two days. The results of the exercise established targets for coalition action. The next phase of the effort was to put together task teams to drill into the content at the intersection of the job and subject material that have scored high on the QFD relationship matrix. In this phase, the cross-functional team was comprised of knowledge area experts as well as job area experts. The outcome will be to find and commit to credit allocation for outcomes measured while performing a job.

The first Greenfield course implemented using this paradigm is *Management of Manufacturing Engineering Projects*. This three credit hour course is taught in the third (junior) year in the bachelor program. It provides an introduction to the technical and business practices supporting manufacturing engineering. Including:

Business Processes

- Purchasing process
- Quoting and bidding process
- Business reporting
- E-Commerce

Engineering Processes

- Project management
- Quality management
- Technical reporting
- Process planning
- Technical reviews

This course has been designed to link formal learning and practical job experience. Tutorials support job performance and the experience of bidding and quoting production jobs supports and deepens learning. Job assignments are directly related to Focus:HOPE Manufacturing Engineering activites. The course has an Instructional block of 45 classroom hours and a Work assignment block of a minimum of four months. Learning objectives are crafted in performance language:

Upon completion of this course the candidate will demonstrate the ability to perform the following manufacturing engineering functions:

Project selection:

- Screen potential production projects proposed by major customers.

Project management:

- Prepare and maintain project management plans and documentation.
- Monitor projects. Establish milestones and advise the program manager of the progress of assigned projects.

Quality management:

- Meet quality and spending objectives, and target dates for assigned projects.

Manufacturing Plan:

- Prepare macro level process plans.
- Prepare cost estimates used to compile bids for proposed projects.
- Prepare micro level process plans.

Operations Plan:

- Coordinate the use of production machinery for assigned projects.
- Ensure all operating procedures and safety regulations are followed.

The primary mechanism for evaluating candidate accomplishment is the assessment the quality of the work product resulting from assigned manufacturing engineering projects.

Teaching in a Real-World Production Facility

There is a structure for the gaining of experience in the Center for Advanced Technologies (CAT). We often refer to our production facility as the *"manufacturing equivalent of the teaching hospital."* In the CAT we engage our candidates (students) in actual manufacturing activities while simultaneously providing the academic substance that will justify the granting of Associate and Bachelor degrees from the partner institutions. No such model exists in manufacturing today. It has required the development of an extensive infrastructure capable of meeting manufacturing production needs for human resources as well as offering the candidate a robust educational opportunity. Capturing these experiences is critical to justifying credit and protecting the integrity of all parties. In order to sustain the paradigm long term, a structure had to be built that could track and monitor the system regardless of the individuals involved. With an eye to the future we have developed:

- A job rotation system that requires four "core rotations" in tooling, quality, machining, and turning within the Associate degree timeframe.
- A rolemap of identified candidate positions within the manufacturing enterprise
- A job task analysis of those jobs that articulate the competencies and learning opportunities that begin to address the relationship of job knowledge to academic knowledge
- The development of an infrastructure that sets specific performance objectives for each candidate on each rotation and keeps a log of activities during the rotation.
- A performance evaluation system based on those performance objectives set at the onset of the rotation, and that includes academic performance as an equal voice in the ranking and pay of the individual
- The requirement of an "Executive Summary" written by each candidate at the end of each rotation as individual evidence and personal reflection by the learner.
- The ability to produce an individual "Job Transcript" that parallels an academic transcript. It displays the history, time and outcome (grade / performance evaluation) of each rotation.

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