Models for Industry, Academia, and Government Cooperation in an Agile Manufacturing Environment

Dr. Emory W. Zimmers, Jr., Vinay Govande, Jennifer Montemurro,
Dr. Roger Nagel, Kristine Laubach, Alice Swanger
Lehigh University/Focus: HOPE

Abstract

This paper describes three learning partnership models among U.S. corporations, government agencies, and Lehigh University's Computer Integrated Manufacturing Laboratory (CIM Lab). These models are described in terms of need, resources and benefits. Two models describe the partnerships among the CIM Lab, the Commonwealth of Pennsylvania's Northeast Tier Ben Franklin Technology Center (NET/BFTC), and private industry. The third model describes a partnership among government, manufacturing industries, six universities, and the Focus: HOPE Center for Advanced Technologies. The three virtual learning models demonstrate the success in combining resources from academia, government, and industry. They exemplify the valuable partnerships formed and the benefits that each participant gains from team work. The models also demonstrate application of the four principles of agility.

Beginning with an introduction of the four fundamental principles of agility, the paper discusses the need for industry, academia, and government partnerships. This paper presents a framework to gain insight in the broadening efforts at the CIM Lab, to implement pilot organizations, and to demonstrate the coupling of industry, academia, and government. For academia these partnerships are recognized as essential in providing case studies and improving problem solving skills for engineering students to help them develop into competent and innovative leaders of the agile manufacturing industry of the 21 st century. Finally, the paper describes the efforts at the CIM Lab in bringing private industry, academia, and government closer for a mutually beneficial technology and information transfer, by using the platforms of advanced engineering, information systems and communication technology.

Introduction

It is generally recognized that to meet challenges of the 21 st century, broadening the interaction between industry, academia, and government is imperative. In order to successfully survive in fierce global competition, corporations across the world are learning to thrive on change and to balance their actions within the framework of agility. [1] These corporations understand the importance of learning and innovation. Adopting the enabling technologies and principles of agile manufacturing has become a condition of survival for such American companies.

Speaking at the Fifth National Agility Conference, Dr. Mary Good, Under Secretary for Technology at the Department of Commerce stated, "Science and technology alone are not enough to generate the manufacturing competitive advantage. Our country needs to have a world-class technology infrastructure, a world-class labor force, and a world-class business environment. "2 With rapidly changing technologies industry, academia, and government need to rethink their roles, methods, and partnerships. The government plays a major role by accelerating the research and transfer of emerging technology from federal laboratories to private industry, encouraging the dissemination of enabling technologies to medium and small businesses, and providing a growth oriented business environment.

Today, with the advancements in communication technology, information is available to all levels of employees, from upper management to workers on the shop floor. With the evolving information systems this knowledge is also synthesized and organized to meet the requirements of various interest groups. The quest for knowledge forms the kernel of a "learning company." Based on the information and knowledge, the learning company moves from reactive to proactive to interactive.[3] The virtual enterprise consists of cross-functional, self-managed teams in a flat-flexible organizational structure which encourages every individual to perform at his or her best. It is founded on human factors such as trust, values, and effective communication. Clearly, there are some gaps between the expectations from employees of such enterprises in this agile paradigm and the skill and training our educational institutes are providing. The virtual learning models described in this paper, and the integration of engineering, information systems and communication technology in a classroom setting will assist in bridging these gaps.

Background of Agile Manufacturing and Virtual Enterprises

Both manufacturing and service organizations are continually rethinking how they function as they strive to compete successfully in today's global, rapidly changing business environment. In this environment a new business paradigm known as agility is emerging. The adaptation of agility principles is an integral part of the strategic relationships between the academia, government and industry. The four main principles of agile manufacturing are:

- Enriching the customer
- Cooperating to increase competitiveness
- Organizing to master change, and
- Leveraging the impact of people and information.[1]

Enriching the customer is accomplished mainly on an individual basis (mass customization). The goal of every agile company should be to make products integrated with services available to the customer to ensure their satisfaction. The company should be supportive of the goals of the customer and willing to aid in every step of the customer's achievement of those goals. Only through cooperation can the company increase its competitiveness. Internally, the company must first have its own culture with objectives and tactics within each department that are coherent with the company's vision and mission. An agile organization also understands that to master change it must maintain a flexible organization that will allow it to profit from change and uncertainty. To successfully exploit the opportunities arising from the change it is extremely advantageous for a company to develop a team working spirit rather than a chain of command. By realizing that each person brings a unique talent to the organization companies can leverage the impact of people and information and react quickly to changes. This positive atmosphere motivates individuals and encourages innovation which results in a more competitive company. To meet the challenges of the rapidly changing market and customer demands, a new agile business called virtual enterprise is emerging. Virtual companies strategically form partnerships (even with competitors) to take advantage of opportunities. These organizations are essentially reconfigurable and customer-oriented enterprises comprised of knowledgeable empowered associates providing customer enrichment.

Agility and Education

Academia plays a very vital role in developing the thinking, learning, and innovative entrepreneurs that will become tomorrow's leaders and professionals in an agile environment. In the agile paradigm the mass customization is achieved with high information content processing. People are at the core of the agile enterprise in order to continually steer the organization in the ever changing environment. Educators must now be trained to excel in an environment that is continuously changing, demanding more with less people, and accepting alliances, partnerships and virtual organizations as models for survival. The same principles of agility can be adopted by universities and applied to the curriculum to ensure a strong infra-structural development of our future leaders. From the agile paradigm the academia should draw an educational parallel based on the principles of agility.[4] In this parallel:

- Industry and government become universities' associates.
- Universities provide solutions to enrich its customers (students, industry and the government).
- Education becomes a continuous transaction (life-long education).
- Reward to students and universities is based on customer perception of value.

..One of the main goals in education should be to adopt the aforementioned agile principles, and to make them a part of the educational process. By viewing the student as the customer, universities can alter curriculum and become flexible enough to meet each student's individual needs and interests. This kind of flexibility allows students more control over the concentrated area of their maj or course of study thereby allowing each one to specialize in a customized area. This kind of cooperation between students, faculty, and administration increases the competitiveness of the entire university as well as the student, and is a mutually beneficial situation. It allows the university to attract attention for its innovative style of education and to raise the caliber of students in attendance. However, the academic community cannot be expected to blindly direct its activities toward the demands of industry without the enlightened help and guidance of the corporate sector. Colleges and universities must be willing to respond to the suggestions and concerns of business. At the same time, industry leaders must be willing to devote their time and energy to improving the overall educational process that will, in the long run, better allocate the time and money often spent retraining and reeducating the workforce after graduation.

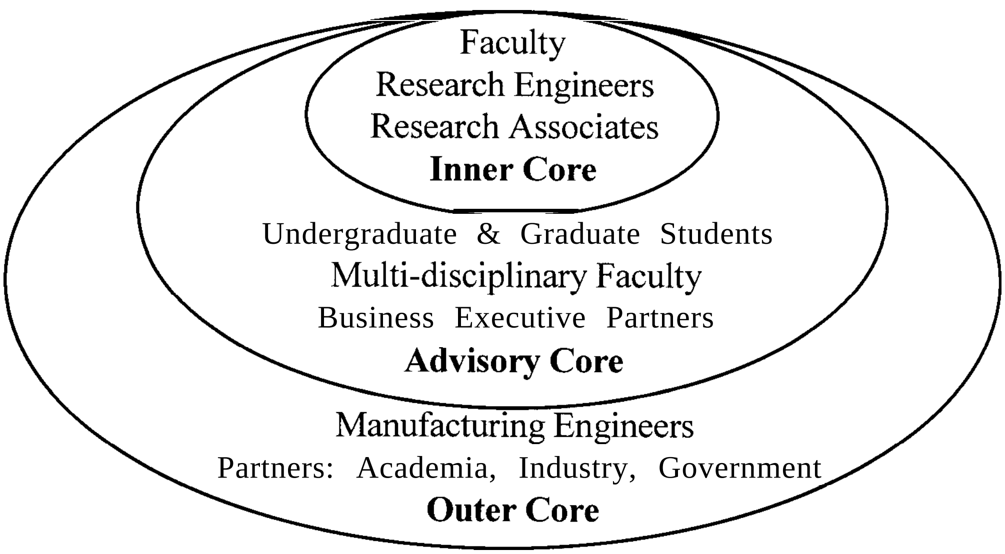
The skills and specific knowledge the student takes away from the university increases his or her competitiveness in the work place and in a career. The change in the organization of the university will allow for future changes as interests of the customer (the student) evolve. The flexibility involved in such an university structure nurtures an entrepreneurial and innovative atmosphere that encourages the creation of mutually dependent relationships. Students will understand the importance of leveraging the impact of people and information while they are undergraduates because of the opportunities available to them to participate in a variety of cooperative relationships. For example, as members of cross-disciplinary teams students can draw on the expertise of individuals from different fields of study. Encouragement from the university on the formation of such diversified teams will demonstrate the university's acceptance of responsibility for the student's success, as well as its own.

The North East Tier Ben Franklin Technology Center

The North -East Tier Ben Franklin Technology Center is an economic development organization that strives to create and retain j obs to enhance the competitiveness of Pennsylvania manufacturing. The center accomplishes this by developing early stage technology oriented manufacturers, helping to creatively apply new technology and business practices in small to medium-sized manufacturers, and by developing a highly skilled and competitive 'work force. To help initiate projects, the center provides funding and assistance to link companies to universities for technological support. Projects implement new technologies and practices or ~~apply~~ already existing technologies to meet the needs of the companies. Partnerships with universities are essential when companies require additional resources to aid in technically oriented projects. University employees benefit from the work experience with private industries and the opportunity to work in a real-world business setting. The company gains additional team players who work to solve company problems without interrupting the normal flow of operations. This kind of work force development brings together businesses and educational institutions in partnerships to rethink education and to develop programs that meet the needs of businesses. These partnerships lay the ground work for future economic prosperity.

The Computer Integrated Manufacturing Laboratory (CIM Lab) at Lehigh University

Lehigh University's mission is to *'Enhance learning, through the integration of teaching, research, and service to others.* '[5] Over the past 18 years the CIM Lab has made a continuing effort to develop competent engineers through engineering technology programs and partnerships with regional industries and government. The CIM Lab is one example of the integration of academia, industry, and government. The CIM Lab is a laboratory affiliated with the Iacocca Institute at Lehigh University and is operated through the Industrial Engineering and Manufacturing Systems Department. The CIM Lab is practicing the virtual enterprise strategy with a planned structure.



The CIM Lab has three core groups. The inner core is comprised of faculty members and researchers. The advisory core includes these members and draws on the specific knowledge areas of faculty and students from other disciplines to partner with business executives. Once this virtual learning partnership has been formed, the industry and/or government provides funding, additional professionals and technical experts required for the learning partnership.

The CIM Lab has embedded learning company concepts in its organizational structure. Through alliances and partnerships, the CIM Lab has leveraged the knowledge of different experts from various technology transfer projects and has ensured a hi-directional flow of learning. An important element of these virtual learning partnerships of the CIM Lab is the students. Students of various academic disciplines and experience are assigned to work on self-managed, cross-functional team projects under a research engineer who serves as the project manager. Through these teams students learn to share information and gain valuable problem-solving knowledge. These teams avoid the non-value added operations typical in a vertically integrated organization and provide solutions to customers with a sense of urgency and quick responsiveness. A high level of communication between the teams and team members is ensured by the state-of-the-art communication and information technology such as group-ware and video conferencing. Maximum synergy is obtained with the cross-functional and cross-corporate teams (government, academia, and industry). To enable a virtual classroom setting, a vast array of case studies from various projects in diverse disciplines are made available to the students. These case studies reflect the current market trends and technologies. Video conferencing, summer internships, guest lecturers, work study programs, and plant tours provide continuous industry interaction. This unique learning opportunity enables students to get the feel for the professional atmosphere of industry while still an undergraduate at Lehigh. The team work the students are involved in further develops communication, interpersonal skills, behaviors and values that have become as necessary as the “hard skills”, needed to succeed in the professional environment. Also such real-world experience clearly benefits the student by enabling him or her to test potential career paths before actually accepting a full-time position in that area.

In the agile manufacturing and virtual organization paradigm the emphasis shifts from product to solutions, from vertical integration to a flatter organization, from managers to leaders, from sales to continuing transactions and from supplier to associate. The employees use their motivation and knowledge to work with the customers to find mutually beneficial solutions and ways to continuously improve the products and processes. Agile organizations are people-centered, value learning, and leverage the skills of their employees carefully. To perform effectively in this learning and thinking environment while promoting flexibility and entrepreneurialship, the engineering programs need to emphasize leadership development. Lehigh Universit y’s CIM Lab has an ongoing leadership development program. To produce the “best and the brightest” of these leaders, general objectives of knowledge, values, and behaviors have been identified for the students and professors in the agile manufacturing engineering program. Graduating engineers with these skills, goals, and virtues will be assets to an agile organization willing to excel in the global economy.

Table 1: General Objectives for the Agile Manufacturing Education Prom-am

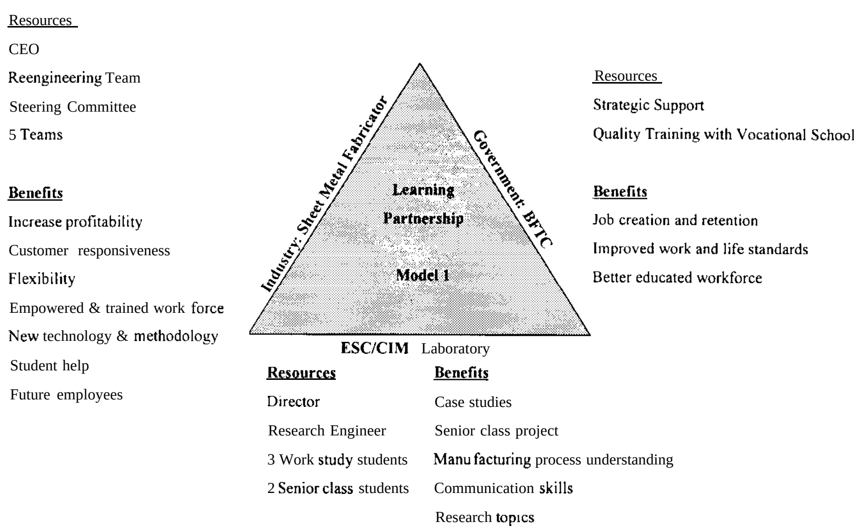
KNOWLEDGE	VALUES	BEHAVIORS
Students **.Goals** To Understand . The advantage of coupling teamwork with independent work • The notion that the engineers’ essential role in society is an integrated one, To Know • In-depth science and engineering principles	Students **Goals** From the Belief That • My education ends after my senior year • To the Belief That I need to prepare for a career of life-long learning.	Students **Goals** • Begin to think across a variety of disciplines functionally (laterally) as well as in-depth (vertically) • Be able to understand the functional core of the engineering process
Professors **Goals** To Understand . The advantage of enhancing educational process through industrial partnerships • That students must be emerging professionals with the knowledge base and capability of life-long learning To Know	Professors **Goals** From the Belief That • The focus for undergraduate engineering education should be the development of students as completely trained engineers • The “good old boy” method of peer view is good enough To the Belief That	Professors **Goals** • Begin to couple experience with abstract description • Be able to enlighten students on the functional core of engineering • Engage students in engineering from the day they matriculate

• How to complement **the theoretical** with **understandable industry applications and** examples	• The focus for undergraduate engineering education should be the development of students as emerging professionals • The "good old boy" approach tends to "invent a cure for no known disease, "	• Begin to unify the functional core and its connection to the liberal arts

Virtual Learning Models

The following three virtual learning models demonstrate the success in combining resources from academia, government, and industry. They exemplify the valuable partnerships formed and the benefits that each of the participants gains from the team work. The contributions of each of the three segments are depicted in each of the virtual models below. The first two virtual learning models described provide an insight into the structure and strategy adopted by the CIM Lab in enhancing government, academia, and industry partnerships. The third model describes a partnership with Focus: HOPE to which the CIM Lab has contributed significantly by leveraging its core competency, knowledge and curriculum development.

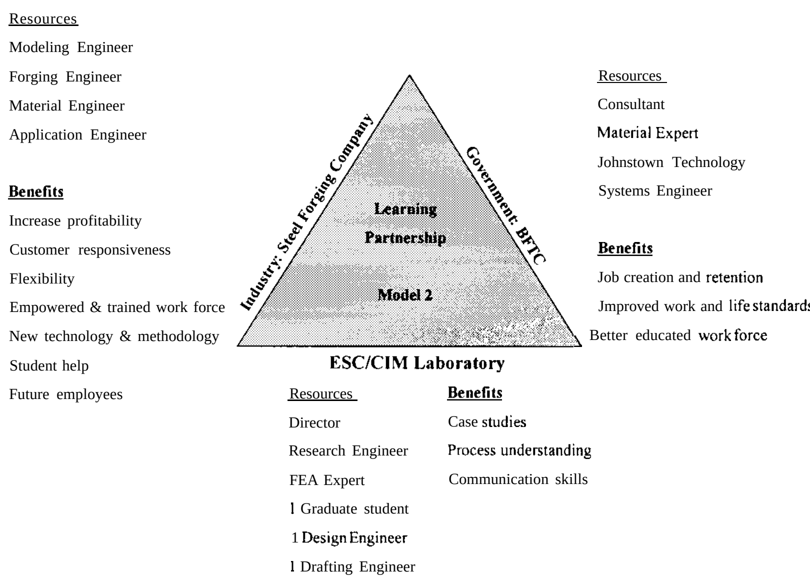
Virtual Learning Model 1



The industry in this model is an industry leader in medium-sized contract manufacture of sheet metal enclosures. The company is trying to make a comeback with a reengineering effort. To support this effort the CIM Lab established a virtual learning model between the industry, Lehigh University, and North East Tier Ben Franklin Technology Center. The participants described in this model bring diverse expertise required for this reengineering effort. The project involves systems analysis, constraint management, development of a factory-in-a-factory layout, implementation of demand flow technology, value-added engineering analysis, and set-up time reduction. The project is critical to the company in order to survive in the changing market place. It is important to the local government as it will ensure employment for a significant work force and develop competency of the" work force through training on world-class manufacturing practices. Several graduate, undergraduate, and work-study students participated actively in this project and gained valuable problem solving experience. The case studies on different topics were brought back to the classroom setting. Video conferencing was used to get the industry partners and student learners to communicate effectively, and transfer information and solutions. -

Elements of the four agility principles can be demonstrated as well. The cooperation to enhance competitiveness is obvious as the partners work together to make the company stronger within the industry. Alliances with the customer, supplier, and even competitors are being developed to improve the service to the customer. The customer is enriched through the changes in the organization (team building, vertical to flat) and implementation of a demand-pull system. A strategic decision to create a special short-run factory-within-the-factory will ensure rapid response to customer requirements. A team working spirit was developed with the formation of several cross-functional process improvement teams working with the steering committee. This reduces the chain of command and control, and promotes an entrepreneurial environment. Leveraging the -- impact of people and information can be-seen through the life-long training commitment, flexible workforce, team work, and application of computer programs for the demand-pull system.

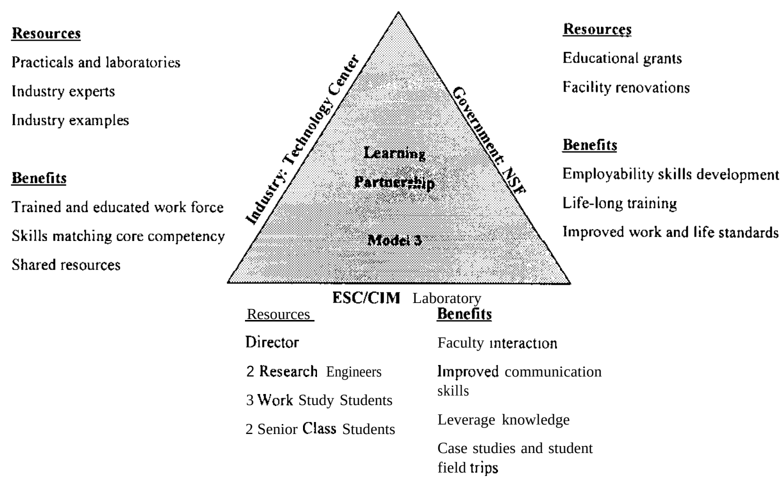
Virtual Learning Model 2



The industry in this model is a medium-sized steel forging company that needs to rapidly respond to the changing needs of the customer by implementing modeling and simulation of its forging process. If the company does not react to the unique customer requirements it may loose a significant market share to foreign competition. To support the integration of this modeling and simulation methodology into the rapid product development process and to facilitate the required technology transfer to the industry, the CIM Lab established a virtual learning model with the industry, developers of the enabling technology, material research institute, " BFTC, and Lehigh University. Independently, it is extremely difficult for a medium-size company to develop such a cross-disciplinary program. The project involved research and development in technology areas such as Computer Aided Design (CAD), Finite Element Analysis (FEA), material science, computer hardware benchmarking, and the modeling and simulation of the forging process. Finally it is critical to hand over the methodology and tools developed in the program to the engineers and technicians of the company to successfully implement the technology. Technology transfer was performed by tightly coupling the participants through the interaction of information via meetings, training sessions, E-mail, electronic file transfers, and video taping. Through this virtual learning model a cross disciplinary team of individuals brought their expertise to the table and learned from others' core competencies. The process knowledge of the forging experts was captured in scientific language and brought back to the class room setting as case studies for a collaborative learning experience.

The principles of agility can be seen in the partnership formed by Lehigh University, the BFTC, and the company. The customer is enriched through the use of new materials, the reduction in product lead time, and the continuous flow of innovative ideas and latest technologies. In addition, improved scientific analysis is a much more efficient way than trial-and-error to examine different-situations and client demands. The developers of the enabling -technology and a material research institute were critical in the success of this partnership. This partnership exemplifies the cooperation necessary to enhance competitiveness. Efforts to leverage the impact of people and information include gathering practical knowledge from the forging experts, and training employees in the state-of-the-art computer modeling technique. The information used in the project would be stored in a database and utilized to rapidly respond to customer demands.

Virtual Learning Model 3



The third virtual learning model is different from the previous two described. It involves manufacturing industries, six universities, Focus :HOPE Center for Advanced Technologies, and the government working together to provide students at the center with the academic curriculum and the practical knowledge of machining, and gives them the opportunity to receive a bachelor of science degree in engineering. Major funding for this program comes from the National Science Foundation (NSF). Lehigh University is currently involved in several aspects of the curriculum development for learning modules that are presented via a multimedia format that allows the students to access the necessary information and help screens to fully understand the concepts and lessons presented.[6,7]

'—Iii this dynamic partnership, the agility principles are exemplified in many ways. The customer, or the student in this case, is enriched-by the ability to learn at his or her own pace and time, and have computer access to examples of practical experience on video. E-mail correspondence and video conferencing are two additional examples of the technology available to the students. This virtual model demonstrates how the universities and companies organize to master change as they continually build and dissolve associations with regards to the area currently being developed.

The partnerships illustrate leveraging the impact of people and information with the life-long training support offered, the distance learning practices used, and the packages developed by experts at each of the universities involved. Cooperation between the partners to enhance competitiveness between the three automobile manufacturers, -as well as that between the participating universities, to promote the best possible -- technology and education is a driving force behind this project. Faculty, research engineers, graduate and undergraduate students working at the CIM Lab have gained valuable experience in several manufacturing disciplines, multimedia development, and distance learning. The main element behind this cooperation is the development of a capable workforce able to handle any aspect of the production line process.

Table 2 provides a comparison of the three models across the agility principles. This comparison highlights the efforts undertaken by the partnerships in providing an agile infrastructure for the participating industries.

Table 2: Comparison of the three models across the agility principles

Agility Principles	Model 1	Model 2	Model 3
Enriching the Customer	• Implementation of demand-pull • Special short-run factory • Improved quality • Rapid product development	. Application of new materials . Reduction in product lead-time • Innovative ideas and technologies	. Self-paced learning • Computer access to examples of practical experience . E-mail correspondence . Video con ferencing
Cooperating to Increase Competitiveness	• Strengthen company within the industry • Virtual model	. Virtual model	• Promote technology and education . Virtual model
Organizing to Master Change	• Process management • Flatter organization • Process improvement team	• Virtual model • Concurrent engineering	. Build and dissolve associations as needed
Leveraging the Impact of People and Information	. Long-term training involvement Flexible work force . Team work • Steering committee • Promotion of entrepreneurial environment	. Gathering practical knowledge from forging experts • Software training for employees	. Life-1ong training support . Distance-learning practices used • Packages developed by experts at each university . Develop capable workforce

Table 3 identifies some of the benefits to industry, academia, and the government in working together in such virtual learning partnerships.

Table 3: Benefits of virtual learning partnerships

Benefits to Industry -	Benefits to Academia	Benefits to Government
• Extra pair of hands • Latest technology at no risk • Test new technology or philosophy before investing • Test-bed of new employees • Multi-disciplinary assistance • Access to information services, databases, libraries	• Awareness of new technology and systems • Research topics • Access to industry research and databases • Testing of new hypothesis, philosophies, and technologies in different sectors of private and public organizations • Student employment • Source of additional faculty income • Case studies, plant tours, expert guest speakers	• Increased knowledge and awareness • Life-long training for workforce • Improved work and life standards • Employability skills development • Specific skill training for core competencies • Cross-functional applications of new technology and philosophies • Realization of new research and technologies for public usage through product and process improvements

Partnership through Technology

Several projects were undertaken by the CIM Lab through the 13 FTC during the year 1994-95. A cross-functional team of research engineers, student consultants, and work study students was put together to work on a specific technical thrust area for each project. Table 4 describes the virtual learning partnerships in terms of the project description, technical thrust area, enabling technology used, and resources . As the projects progressed the information and knowledge was brought back into the classroom setting to share the experience with other students. This secondary impact is significant and important for the engineering educators.

Table 4: Virtual learning partnership between the CIM Lab. BFTC., and industry

Project Description	Technical Thrust Area	Enablers	Resources	Secondary Impact
Manufacturer of forging components	• Rapid product development • Modeling • Simulation FEA	• Antares, • AutoCAD • FEMAP	• 2 research engineers • 2 graduate students • 1 summer student • 2 work study students • 1 full time student	• Case studies • Process knowledge
Sheet metal specialty jobs	• Machining, new product development • Layout Models • Reverse Engineering	• AutoCAD • DFM/A • SmartCAM • CATIA • MAZATROL • AutoCAD • CMM • AutoCAD • CADAM	• 1 research engineer • 1 summer student • 9 senior class students	• Senior class project • Process knowledge • Case studies • Seminars and presentations for industries
Plastic Tube Manufacturer	• Quality improvement • Inventory	• DOE • TAGUCHI • StatGraphics • Bar coding	• 1 research engineer • 2 senior class students • 1 work study student • 1 full time research	• Senior classproject • Process knowledge • Case study

	Management • Database development	• Alpha-4	associate • 1 summer student • 2 work study students	
Sheet metal enclosure company	• Modeling and simulation • Constraint management • Factory-in-a-factory • Demand Flow Technology • Quality Training • Systems analysis	• ProModel	• 1 research engineer • 1 senior consultant . 1 graduate student . 1 undergraduate student • 3 work study students	• Senior class project • Case study • Research topics
Paper/Book Publication Manufacturer	• Modeling and simulation	. ProModel	• 1 research engineer 1 work study student	• Case study
Sheet metal fabrication company	• Lay-out improvements for cellular manufacturing . Process improvements • New product development	• CADKEY “	• 1 research associate • 3 summer students • 1 work study student	• Process knowledge • Case study
Cardboard Manufacturer	. Decision support system	• Access	• 1 research associate • 3 work study students	• Case study
Truck Manufacturer	• Multimedia diagnostic system	• Expert System	• 1 research associate • 2 work study students • 2 summer students	• Case study • Seminars and presentations
Composite material lamination company	• Process improvement • Product development	. AutoCAD • MSC-NASTRAN	• 2 consultants • 2 research associates • 2 work study students	• Case study
Spraying Equipment Company	• Product improvement • Process improvement . Layout improvement	• AutoCAD	• 2 consultants • 1 research associate • 2 work study students	• Case study
Cryogenic Container Distributor	• New product development	• AutoCAD • MSC-NASTRAN	• 2 consultants • 1 research associate . 2 work study students	• Case study

Apart from the virtual learning partnerships described in the Table 4 the CIM Lab has also undertaken several projects with industry and government that leverage information and communication technology. The CIM Lab at Lehigh University, in cooperation with industry and government institutions, realizes that in an agile enterprise one of the most important resources of a company is its human resources. An effectively trained workforce is the resource most greatly in demand in the existing marketplace. Universities can respond to meet the needs of industry by providing its students with the best possible education available. To accomplish this task, input from industry is essential. Through various partnerships, Lehigh University is incorporating distance-learning concepts through asynchronous and synchronous technologies.[8] Virtual classrooms are areas and facilities specifically constructed and dedicated to meet the students' educational needs with distance-learning capabilities, video conferencing, and lectures. These classrooms provide both collaborative and resource-based learning by integrating asynchronous and synchronous multimedia communication with electronic learning resources.[9] They provide a more demanding type of education because of the interaction of the students with professors, industry professionals, government representatives, and other students. The technological capabilities available in virtual classrooms allow for more extensive forms of information to be accessible to students, and in turn, make them better prepared to face the challenges in the professional arena upon graduation.[10]

Video conferencing, high speed digital communication, enterprise support systems, decision support systems, and multimedia technology are being effectively applied in the virtual classroom at the CIM Lab. This state-of-the-art technology is an effective tool in forming the mutually beneficial virtual learning partnerships between industry, government, and the academia. The following project descriptions demonstrate the use of this technology:

- As part of a laboratory for one of the Industrial Engineering classes, an expert on application development tools spoke to the class and answered their questions from his home in New Hampshire. The session was held on two separate occasions and lasted for three hours. Twelve students were able to take part in this beneficial resource of learning. Another expert will come into the classroom for the hands-on portion of the lesson.

- Pathfinder 2005 is an Advanced-Research Projects Agency (ARPA) and Air Force funded project headed by Arizona State University.[11] The project is designed to demonstrate how communications technology can be used to facilitate transition among Department of Defense industries from a JIC ('just in case) inventory model to a JIT (just in time) inventory model. Lehigh University became involved in the project to provide assistance and development of a pilot project in Pennsylvania. The objective of the Pennsylvania project was to decrease the lead-time delivery of circuit boards. The incompatibility of the CAD packages forces manual checks and greatly slows down the process. With the implementation of video conferencing and the ability to share files and the white board capabilities of the software package, cycle time has been decreased by about forty percent. The key organizations involved in the Pennsylvania pilot project are Tobyhanna Army Depot and four regional manufacturing industries. A research engineer, three student consultants, and four work study students have participated, and a case study was presented to the senior class I.E. students.

- To enhance the effectiveness and efficiency of the learning process Focus: HOPE has implemented the use of multimedia in the classroom. Research indicates students involved with interactive, " visually-based materials outperform, make significantly larger gains in achievement, learn faster, have better retention, and report significantly more positive attitudes toward learning. CIM Lab has created learning modules for the students in Detroit in the areas of Manufacturing Systems, Machining Processes, Measurements, and Communications. These modules are communicated through multimedia resources, in the form of computer generated programs that allow for access to additional information, explanations, and help screens.[6] Video conferencing is also being tested for bringing the case studies to the classroom setting. The application of this technology will ensure cooperative development, on-going user feedback, and development of flexible and dynamic learning modules reflecting the needs of the students, industry and advances in technology.

Conclusions

As the businesses around the world recognizes the new paradigm, agility, partnerships among the industry, government, and academia become essential. During the last 15 years, the CIM Lab at Lehigh University has demonstrated the success of such virtual learning partnerships through more than 150 successful projects. The platform of advanced engineering technology, information systems, and advanced communication technology is being successfully implemented to further bring the three worlds (industry, academia, and the government) together. With these technology tools, the world of interactive television, information factories, and Internet academic institutes does not seem too far away. Moreover, it should be noted that although the issues explored in this paper are centered on the manufacturing environment and the manufacturing engineering academic discipline they are equally applicable to other industries and fields of study as well.

References

1. Goldman, Steven, Roger Nagel and Kenneth Preiss. Agile Competitors and Virtual Organizations: Strategies for Enriching the Customer. Van Nostrand Reinhold: New York, 1994.

2. Good, Mary, Under Secretary for Technology, U. S. Department of Commerce. "Manufacturing Industries: Engines of Growth." Keynote address: Proceedings of the Fifth National Agility Conference. Boston, MA, March 1996.

3. Kovac, Frederic J. "Virtual Enterprise Strategy," Agility Forum and The Good Year Tire and Rubber Company. Publication # AR94-02.

4. Zimmers, Emory W., Jr., and John C. Leidner, Jr. "Agile Manufacturing Curriculum Development for Undergraduate Students." Proceedings of 1994 ASEE Conference, Session #3557, 3027-33.

5. Lehigh University Homepage, World Wide Web. http: //www.lehigh.edu

6. Zimmers, Emory W., Jr., Alice Swanger and Jennifer Montemurro. "Development of Manufacturing Systems Curricula in the Greenfield Paradigm." Frontiers in Education. Session IS 11, 1995.

7. Zimmers, Emory W., Jr., Alice Swanger and Jennifer Montemurro. "Distanced Delivery and Multiple Teaching Methods for Manufacturing Engineering Education." Proceeding of 1995 ASEE Conference, Session #2263.

8. Robeson, Philip E. and Gaurav Mehrota. "Agile People: Realizing and Training a Highly Mobile Workforce." Proceedings of the Fourth National Agility Conference. 2(1995):165-9.

9. Watabe, Kazuo, Matti Hamalainen and Andrew B. Whinston. "An Internet Based Collaborative Distance Learning System: CODILESS." Computer Education 24.3 (1995): 141-55.

10. Silverman, Barry G. "Computer Supported Collaborative Learning (CSCL)." Computer Education 25.3 (1995):81-91.

11. Shunk, Dan L., Wallace Patterson and J.G. Ames. "A Report on the Results of an Agile Pilot Project: The Nationwide Electronics Industry Sector Pilot (NEISP)." proceedings of the Fifth National Agility Conference. (March 1996):487-94.

Biographical Information

DR. EMORY W. ZIMMERS, JR., has a Ph. D., MS, and BS in Industrial Engineering, and a BS in Mechanical Engineering. He is the director of the Computer Integrated Manufacturing Laboratory/Enterprise Systems

Center and Professor of Industrial and Manufacturing Systems Engineering at Lehigh University. His experience of more than 25 yearn includes consulting, teaching, and industry practices.

DR. ROGER NAGEL is head of the Iacocca Institute at Lehigh University. He is an expert on agile organizations and manufacturing systems engineering, and has been recognized by a wide variety of professional societies and organizations for his accomplishments. He has written over fifty papers and addressed several hundred audiences on the concept of "Virtual Corporations."

VINAY GOVANDE has a MS in Manufacturing Systems Engineering and a BS in Mechanical Engineering. Mr. Govande is a research engineer at the CIM Lab of Lehigh University. He has worked on several projects in implementing CIM systems, including simulation, plant layout modification, machining, rapid product development, modeling, and finite element analysis and 1S0 registration.

ALICE SWANGER is the training manager at Focus: HOPE and she works closely with the coalition partners to help coordinate academic programs and facilitate coalition-wide development activity.

JENNIFER MONTEMURRO has a BA in Journalism and Government and an MA in Government from Lehigh University. She is program development officer at the Iacocca Institute where she is involved with the development and marketing of several educational programs.

KRISTINE LAUBACH is a senior English major at Lehigh University. She has worked on various projects with consultants and students at the Computer Integrated Manufacturing Laboratory, and has gained both technical and engineering experience through her participation in multi-disciplinary teams.