

Educational Capabilities Study
For a
Regional Center of Excellence for Packaging Operations

Conducted by:
Keith S. Campbell



CAMPBELL MANAGEMENT SERVICES

Manufacturing Technology Planning - Benchmarking – Organizational Development

6 Highland Drive
Palmyra, PA 17078
717-832-0115
Ks.campbell@verizon.net

Prepared for:
Lancaster County Workforce Investment Board

January 15, 2005
Version 1.1

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Executive Summary

This document reports on a study with the objective to develop preliminary information in support of the development of a regional Center of Excellence in Packaging Operations by exploring the educational capacity of local educational programs to train industrial electricians or industrial maintenance personnel in the additional skill sets that are related to the more sophisticated process controls being required by local manufacturers. The information about the needs of local manufacturers was gathered in a companion study by Mr. Stan Telson of QSPP Group who has both contributed to and reviewed this document.

Mr. Telson's study identified a significantly wide range of existing capabilities and perceived future needs among the survey participants, all of whom were packagers. With such a wide range of capabilities and perceived needs, the question arises, as to the level of capability and needs for which a potential center of excellence should be targeted. Focusing upon the typical or "average" need may be no more useful than focusing upon the typical or average temperature of one's fingers with one hand in boiling water and the other in ice. As an economic development mechanism, a focus on best practices and the more advanced needs in the region could be more useful, resulting in recognition of the region as a place where manufacturers should locate or expand their operations in order to take advantage of the advanced capabilities available here. These capabilities would include a workforce supported by a focused educational initiative, along with other publicly supported programs to drive innovation and productivity for packagers and others.

The study has adopted the assumption that the region should be taking a leadership role relative to the best practices and advanced technology already found and in use here. Since the number of companies at an advanced level is relatively small, the study has been supplemented with additional information gathered beyond the region.

The conclusions reached support the region's educational capabilities to meet these advanced needs with some enhancements to existing programs. These enhancements are deemed as practical to achieve and fit well with the objectives of at least a subset of the study participants. A number of specific recommendations to achieve these enhancements will be found throughout this report and summarized on pages 27-28. In addition, joint recommendations from Mr. Telson and Mr. Campbell are found on the following page.

Joint Recommendations

Associated with

Food Packaging Company Survey

And

Educational Capabilities Study

For a

Regional Center of Excellence for Packaging Operations

The following are the joint recommendations developed by Mr. Campbell and Mr. Telson in conjunction with the two above referenced studies.

Among existing packagers within the region has been found a vast range in:

- Use of advanced manufacturing technology

- Capability to support advanced manufacturing technology

- Intentions with respect to future use of advanced manufacturing technology

- Intentions with respect to capital improvements in general

- Intentions with respect to upgrading the skills of the incumbent workforce

Given this situation, there is an imperative to support companies in the region by broadening the application of available best practices in support of organic growth, innovation, increased profits and sustained or increasing employment levels.

By implementing a limited number of practically achievable enhancements (as outlined in the full reports), the region would have the educational capacity to stand as a leader and to meet the current and future needs related to the positions of industrial electricians and maintenance personnel that were targeted by the study.

Furthermore, the educational organizations are encouraged to establish multiple educational foci that encompass operators, helpers, crafts people, technologists, engineers, supervisors / managers and company executives to broaden the benefits and appeal of a Center of Excellence. Along with establishing these foci, increases in the number of students availing themselves of 2+2+2 education should be sought.

Establishing a reputation for the region as a seat of world-class best practices in packaging operations; supported by a suitably educated and trained workforce; and supported by an appropriate business-favorable climate; should result in sustainable economic development and growth for the region.

Study Background

Study Sponsors

This study was sponsored by the South Central Workforce Investment Board representing the counties of Adams, Cumberland, Dauphin, Franklin, Juniata, Lebanon, Perry, and York; the Berks County Workforce Investment Board; and the Lancaster County Workforce Investment Board. A separate but related study was sponsored by Reading Area Community College. The study contract was issued through the Lancaster County WIB with Mr. Scott Sheely, Executive Director, as the official study contact and sponsor.

Study Objectives

The objective of the study was to develop preliminary information in support of the development of a regional Center of Excellence in Packaging Operations by exploring the educational capacity of local educational programs to train industrial electricians or industrial maintenance personnel in the additional skill sets that are related to the more sophisticated process controls being required by local manufacturers.

Study Methods

The study was conducted in collaboration with Mr. Stan Telson of QSPP Group who was separately hired by the Lancaster County WIB. Mr. Telson's role was to lead the inquiry with a representative sample of local packagers to ascertain their present and future plans for incumbent worker training around increasing skill requirements. Mr. Telson and this author joined in key visits to orient ourselves to each others methods of study and collaborated on the assessment of the current state of technology and corresponding skill requirements within these companies.

This author was asked to identify matches and gaps relative to identified skills and knowledge requirements by reviewing the existing curricula offered by consortium educational partners Reading Area Community College, Harrisburg Area Community College, Stevens College of Technology, Lancaster County Career and Technology Center, and the Industrial Maintenance Program of the Manufacturers Association of South Central PA. The Berks Career and Technology Center, Penn State Berks, and Millersville University were later added to the list. Millersville participated late in the study resulting in version 1.1 of this report.

A primary contact was identified by the sponsor for each of the organizations listed above. Initial email contact was made by both Mr. Sheely and the author, briefly explaining the study and requesting that a time for a personal visit and tour be established. This was followed by phone calls to schedule meeting times. Three documents were prepared and provided during or prior to each interview. These were: 1) a Mindmap entitled *Educational Capacity Study for a Center of Excellence in Packaging Operations* (appendix 2); 2) a set of interview questions (appendix 3); and 3)

the skills and task analysis provided by a local packager with all references to the source omitted (appendix 4). Web sites and preliminary information from the organizations to be interviewed were reviewed. Interviews with tours generally lasted 2 to 3 hours and often included additional staff members from the participating organization. Meetings generally followed a similar agenda; introductions; review of the background and purpose of the study by walking through the Mindmap; walk through of the questionnaire and recording of the participants' responses; exchange of documents such as course catalogs; and a tour of the laboratory facilities accompanied by discussion of how the labs and equipments are used in teaching. Additional information was sometimes forwarded after the meetings.

Concurrent with the ongoing gathering of information from consortium educational partners, the author gathered additional related information via internet, reading, personal contacts and personal files. One such set of information is a yet-to-be published survey of 140 US packagers recently conducted by *Packaging World Magazine*. The survey was on the general subject of the packaging workforce. I am indebted to the Editor, Pat Reynolds, for granting permission to cite some of the results of their survey in this report prior to its planned December 2004 publication. (This information was published subsequent to the release of version 1.0 but prior to the release of version 1.1 of this report.) All such additional information is woven into the report primarily as context and support for recommendations.

Responses to the study interview questions were summarized into Tables 2 – 9 which are presented at the end of the report. These tables, without conclusions, were emailed to the principal contact at each participating organization to permit clarification or correction of the contents prior to publishing of the final report.

Recommendations have been based upon review of Mr. Telson's report and analysis of all of the information available to the author. Mr. Telson's findings are not repeated here, but are referenced from time to time within the following pages.

Findings and Recommendations

Achieving Focus through Segmentation

No educational organization can adequately satisfy the needs of all of industry. Some focus is required in order to provide the best services. Otherwise the breadth and depth of knowledge are too great and student, employer and teacher expectations will not be aligned. However, we tend to speak of manufacturing as a single entity and operations support as having the same needs everywhere within manufacturing. There are several ways to cut up the industrial pie to help provide a focus on particular target segments. We will look at three segmentation approaches, treating each as bipolar for clarity, even though this may exaggerate the reality.

Segmentation by Technology vs. Jobs

Many programs are organized around a technology, such as electrical engineering or mechanical engineering. College programs are often accredited in conjunction with organizations such as the Institute of Electrical Engineers (IEEE) or the American Society of Mechanical Engineers (ASME). The more highly technical the job, the more likely it is to fit into such a technology silo. However, many jobs require multi-disciplinary skills. Thus, the hyphenated programs appear such as electro-mechanical technology.

It is a credit to the PA Department of Education that there is an approved instructional title for secondary career and technical education programs of “Electromechanical Technology / Electromechanical Engineering Technology. The program description includes the following: “An instructional program that prepares individuals to apply basic engineering principles and technical skills in *both the mechanical and electrical fields*. Instruction is planned to provide preparation in the design, development and testing of electromechanical devices and systems such as *automatic control systems, servomechanisms*, vending machines, elevator controls, missile controls, tape-control machines and *auxiliary computer equipment*.” (*Italics added*) Such a program is aimed at jobs requiring knowledge of multi-disciplinary technologies. Programs in support of packaging and mechatronics programs would fit under this definition. See Appendix 1 for a definition of mechatronics.

Several anecdotes were related to the investigators that are relevant to this discussion. Penn State Berks described efforts to have an Electro-Mechanical Bachelors degree program accredited. The accrediting organization uses IEEE and ASME in the accrediting process. Somewhere in the process it was suggested that the program be renamed ‘Mechatronics’. The problem is that there is now a turf issue over which society would accredit the program. Some schools might also find it problematic to determine in which of their departments such a program would fall. Education and training programs leading to meaningful jobs must not be held hostage to our conventional technology classification silos. The region is fortunate in having one of only four colleges in

the nation offering a bachelors degree in electro-mechanical engineering. This program at Penn State Berks would be a good fit for the proposed center of excellence.

Employers in Mr. Telson’s study cited the fact that it is often difficult to migrate a mechanical person to electrical / electronics / software skills and that someone with these skills may be unwilling to migrate toward the mechanical tasks. No doubt this problem relates to a combination of factors including early education experiences and stereotypes that have been created around our technology silos.

Schools and training programs need to strike the proper balance between teaching from a technology focus and teaching from a job focus. All of the schools in the study have some sort of industrial advisory group that assists in maintaining a job focus. The schools in the study seemed to have a good focus on jobs. **A Center of Excellence for Packaging Operations needs to focus upon education and training for jobs with multidisciplinary technologies.**

Segmentation by Industry Type

One of the useful ways of dividing industries into segments for purposes of automation and control is along the process (also called continuous) – discrete continuum. This continuum is depicted below along with a table of characteristics of the two extremes and the so-called hybrid industries (sometimes referred to as batch industries)

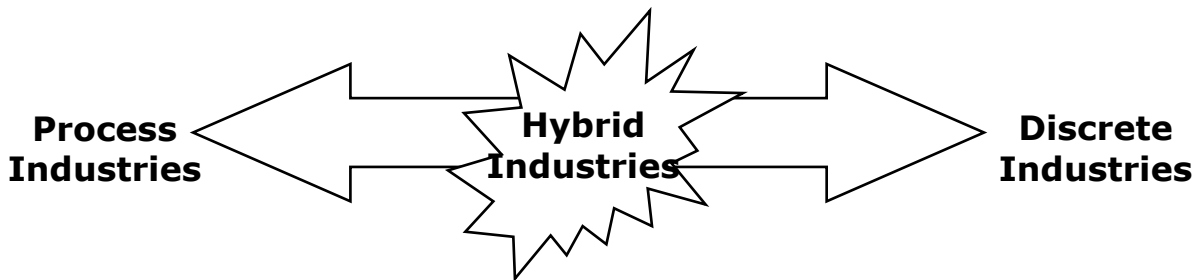


Figure 1

Process / Discrete Continuum

Characteristics by Industry Type

Characteristics	Industry Type		
	<u>Process</u>	<u>Hybrid</u>	<u>Discrete</u>
Industries	Refining Steel Making Pulp & Paper Power Generation	Food & Beverage Pharmaceuticals Soap & Cosmetics Fine Chemicals	Automotive Electronics Machining Aerospace
Example Companies	Exxon Mobile Alcoa Gladfelter GPU	Hershey Foods Masterfoods Unilever Bayer	Harley Davidson York Industries JLG Boeing
Societies	AICHE ISA	OMAC ISPE	ASME SAE
Equipment	Pumps Control Valves Evaporators Flow Meters Process control DCS controllers Instrumentation Pneumatics Proportional actions Highly integrated unit operations Much process data collection P&ID's & Loop Diagrams Stick-built processes	Combinations of both No CNCs Batch processing Scales	CNC's Material handling conveyors AGV's Robots Automation PLC controllers Motor control Hydraulics Logical actions Unit operations not integrated Much logistics data collection Elementary Ladder Diagrams Processes assembled from purchased machines
Operations	Long process runs, typically 24x7 Significant attention to process safety / reliability Need for certified operators / maintainers	Short to long runs Significant attention to sanitation and product safety May be need for certified supervision / management	Short runs Little concern for process safety May be concern for product traceability

Table 1

Another depiction indicating differences among these three industries is found as Figure 2 of Mr. Telson's report. This multi-level diagram shows for levels 0, 1 and 2, three distinct types of control system, referred to as discrete, continuous and batch.

It is useful to note that there are readily recognizable professional societies, technologies, publications, educational programs and certification programs that separately serve the process or the discrete industry segments. One example is ISA's Instrument Technician Certification program that is clearly aimed at the needs of the continuous process industries. On the other hand, although there

are many manufacturing plants in the hybrid industry space (sometimes referred to as batch industries), there are fewer resources and programs aimed at supporting these skill needs. Putting students from hybrid industries into training programs aimed at discrete or continuous industries is one of the reasons that employers complain of content being too deep or not properly focused. Some of the “new” training needs being talked about in one industry segment may actually be “old” needs in another segment. For example, PID control and networking have been used for years in process industries, but may be new technologies for discrete manufacturing operations.

The breadth of knowledge required to be adequately qualified as a maintenance technician in all of these segments is extreme and beyond the scope of any single educational program. It is important to recognize the differing needs for these industry segments and to identify the segment which is being served. Programs reviewed in York and Dauphin counties are positioned toward the discrete end of this continuum, which is logical given the large number of metal cutting and forming businesses in these areas. Programs in Berks and Lancaster counties contain a bit more continuous emphasis supporting their former textile and current aluminum and specialty steel industries. The LCCTC has some hybrid focus, no doubt as the result of its advisory board which includes several food industry representatives.

Packaging generally is considered part of the hybrid industry segment. There is relative little continuous industry within the region of study. Many discrete industries are suffering decline in the USA while many hybrid industries continue to show some stability. **With hybrid manufacturing representing a sizeable base in the region, educational organizations should consider a deliberate focus on the needs of hybrid industries, many of which would include packaging operations.**

Segmentation by Job Function: Construction vs. Operations

Construction skills and operations skills including maintenance share many things in common. Yet construction jobs and operations jobs differ in the depth of knowledge required in key areas. Each job type includes skills not found in the other. For example, a construction electrician needs to be skilled in bending conduit and pulling wires of all sizes. The larger sizes require more skill and experience than the smaller sizes. A maintenance electrician may only need to be skilled in small runs of conduit and wire in smaller sizes. The construction electrician needs to understand some basic concepts of PLC's whereas the maintenance person must be skilled in these concepts plus be proficient in software analysis. A maintenance electrician (as contrasted to construction or repair) may need significantly more skills and experience in analytic thinking and troubleshooting. Another differentiator may be the importance of understanding systems and applications as opposed to components and unit operations.

Education and training programs should take account of their target focus relative to construction or operations and tailor programs to include the appropriate level of skills in each. It was noted in the study that many of the maintenance oriented programs do not include some of the craft fundamentals such as bending conduit; and likewise, construction oriented programs are frequently lacking in some of the detail required for operations use. Two curricula were reviewed from the National Center for Construction Education and Research entitled *Industrial Maintenance* and *Instrumentation*. In this analyst's opinion, both of these are oriented to the construction industry (as the sponsor's name would suggest) rather than to operations and maintenance.

Construction activities for packaging differ little from construction activities in other industries. Operations activities are also relatively similar across hybrid industries. **A Center of Excellence for Packaging Operations should focus upon operations support skills while including those construction skills required in support of operations.**

The above discussion points out three axes which may be used to help segment target industries and create focus upon the targeted customer needs. It may not make sense for each educational organization in our study to have the same or similar foci relative to the industries that they serve. For example, participant A may choose to focus on job training for construction and discrete industries, whereas participants B & C might choose to cooperatively focus on technology education for manufacturing operations in the hybrid industries. **In order to have a successful Regional Center of Excellence for Packaging Operations, at least one from each level (2+2+2) of the education and training organizations should have a deliberate focus upon multi-disciplinary education and job related training in the hybrid industries with an operational slant.**

Educational Capabilities: Matches & Gaps

There are certainly many matches between the curriculum offered by the various educational consortium partners and the needs for a regional center of excellence for packaging operations. Existing programs may be refined by taking into account the segmentation suggestions made in the previous section. That is not to say that all of the programs should be identical. Different companies have different approaches to solving the same problem. For example, some companies believe in troubleshooting and repair to the component level. The Stevens program emphasizes this approach. Other companies believe in troubleshooting and repair at the module level, and the programs in other organizations in the study reflect this approach.

There is of yet no definitive source of skills, knowledge or curriculum for support of modern packaging operations for a multi-skilled workforce. The OMAC Packaging Workgroup's PackLearn™ team has undertaken to develop such a set of requirements at the request of several major end users including Unilever, Proctor & Gamble and

Pfizer. Although this work is underway through corporate volunteer efforts, full curriculum development is dependent upon financial grants that are not yet all in place. Consortium educational partners may wish to become actively engaged in this activity.

The skills document provided by one of the region's major manufacturers, while very applicable to the needs, is not reflective of a multi-skills environment. This document assumes that there are both maintenance electricians and maintenance mechanics, each having their own responsibilities as defined by past practices and labor agreements. Despite the single-trade focus of this task analysis, survey participants pointed out that a student might have to complete 3 or more of their existing educational programs (not classes) to obtain a majority of the skills listed in this document. This is a reflection of the high expectations of this particular company, the need for proper focus as previously discussed, and the need for 2+2 or 2+2+2 programs to meet the requirements of such jobs.

The author is also aware of various surveys that have been conducted and various recommendations that have been made by groups such as OMAC. He has spoken over a number of years with training managers of various technology providers and end users.

The *Packaging World* survey mentioned in the methodology section of this report asked two questions related to skills:

Indicate the three most important skills for workers entering packaging operations today. The top 4 responses each receiving over 10% of the total responses were, from highest to lowest: Mechanical troubleshooting; Teamwork and communications; Understanding of manufacturing standards; and software troubleshooting.

Indicate the top three emergent machine technologies most important to your packaging operations. The top 5 responses each receiving over 10% of the total responses were, from highest to lowest: Real-time personal computer based machine control, shop floor to top floor integration, standardized operator interface, digital servo motor control, and remote internet based machine monitoring and management.

Mr. Telson's local survey did not identify any future training needs for either incumbent support staff or for students going through the educational systems that are not already contained in the body of knowledge mentioned in the preceding paragraphs. The objective for this report as conveyed by Mr. Sheely was to focus more on an "over the horizon" view of future needs than on present needs as identified by the local participants. Therefore, the matches and gaps identified are based upon the author's analysis of all of the above referenced data sources. Furthermore, the matches and gaps may not exist for all of the study participants and may not be applicable in all programs. Rather, these are generalized lists of matches and gaps that each organization should consider for their particular program.

As a separately identified portion of the contracted study, a detailed analysis of the matches and gaps was completed for a proposed program of study at Reading Area Community College. This analysis is the subject of a separate report.

In the match / gap analysis presented in the present report, the region has been considered as a whole. In other words, the question asked is; “does the region as a whole have the educational capability to satisfy the educational needs of a Center of Excellence for Packaging Operations?” In the list that follows, a match means that the courses of study were offered by multiples of the participants. All of the courses may not have been offered within the particular program that was evaluated. For example, it may be necessary to combine aspects of an electrical, mechanical and electronics program to cover all of the areas; but the organizations had the capability to make the studies available.

Match Areas

Electrical Theory	Sensors
DC circuits	AC & DC Motor Control
AC circuits	Mechanical power systems
Motors and generators	Belts
Basic Electronics	Bearings
Semiconductors	Chains
Analog	Gears
Digital logic	Cams
Component level maintenance	Alignment
Board level maintenance	Fluid Power Systems
Basic Electrical Construction Practices	Pneumatics through intermediate
Conduit	Hydraulics through basic level
Wire	Fluid power systems and control
Circuit protection	Logic & Motor Control Systems
Control Panel fabrication	Relays
National Electrical Code	Timers
Test Equipment	Counters
Electrical	Starters
Electronic	Process Control Systems
Mechanical	Documentation – P&ID, Loop
Other	Flow / density
Safety	Pressure
Lock out Tag out	Temperature
Personal Protective Equipment	Level
High voltage 50 < 600 volts	Speed / position
High voltage > 600 volts	Moisture / humidity
Electrically hazardous areas	Proportional Output Devices
Confined spaces	Control Valves
Installation and repair operations	PID Control
Machine Control	Motion Control

- AC & DC variable speed drives
- Steppers
- Programmable Logic Controllers
 - Programming
 - Hardware
 - Basic communications & networking
 - Human Machine Interface
- Computer Science
 - Desktop applications
 - Operating System Fundamentals
 - Communications devices
 - Repair and configure PC's
- Documentation
 - Interpret
 - Maintain
 - Elementary Ladder Diagrams
 - Single Line Diagrams
 - P&ID's
 - Loop Diagrams
- Electric Power Distribution

- Circuit Protection / fault currents
- Ground fault systems

Systems beyond this point are not directly associated with packaging, but maintenance staff may be expected to have these skills.

- Electric Power Distribution
 - Power factor systems
 - Bus systems
 - Switchgear < 600 volts
 - Emergency Generating Equip.
- Facility Systems
 - Lighting
 - Non-electric utilities (air, boilers, flame)
 - Fire protection and security
 - HVAC systems
 - Building management systems

In a manner similar to that used for the match areas, a gap means that few if any of the participants have the courses of study that are anticipated to be necessary to support the technologies for a Regional Center of Excellence for Packaging Operations.

Gap Areas

- PC's and PC based control
 - PC communications / drivers
 - Real-time considerations using PC's
 - Using PC's for control
- General Motion Control
 - Fundamentals of Mechanics
 - Servo motors
 - Speed and position feedback
 - Types of motion control
 - Camming, gearing, etc.
 - Motion control networks
 - Motion control functions
 - Motion control programming
 - Integrated motion and logic
 - Coordinated multi-axis systems
 - Networking for Manufacturing
- Network fundamentals
 - The seven layer network model

- Network protocols
- Device level networks
- Control level networks
- Motion control networks
- Enterprise level networks
- Networking standards
- Human Machine Interface
 - Basic concepts of HMI
 - Types of HMI
 - One to one, one to many, many to many concepts
 - Use of color, symbols, screen layout
 - Alarm management
 - Performance considerations
- Troubleshooting Practices
 - Use of documentation
 - Troubleshooting methods

Hybrid and Batch Control
Weighing
Batch records
Integration Standards
S88 / S95 standards
Specialized Control Operations
Vision

Bar code scanning
Metal detectors
Checkweighing
Coding
RFID
Robotics

In general, there are significant matches and relatively few gaps within the programs being offered in the region. Some organizations indicated prior intention to move into some of the gap areas. All organizations should evaluate their own programs against both the match and gap lists to determine their particular situation. A major area of concern is the capability of fitting all of the subject matter areas into a 2-year program at the high school, 2 year or 4 year college level. This adds support to the need for 2+2+2 programs and for coordination and matriculation agreements among the parties. **The region has the needed educational capacity from the perspective of courses of study offered, with relatively minor additions, to support the proposed center of excellence.**

Need for Real Industrial Equipment – Practical Hands-on

Two types of hands-on experiences were noted during the study. Generic hands-on uses equipment specially built for training. Although this equipment may use real components and serves a useful purpose in the educational program, it is not installed or applied in the manner that it would be in industry. Practical hands-on uses real equipment applied with real industrial machines and equipment in the same way that it would be encountered in the factory. In order for graduating students to seek better jobs and to hit the ground running, they should have practical hands-on experience. For students already familiar with industrial practice (typically those being sent for training by their company), this is of less concern.

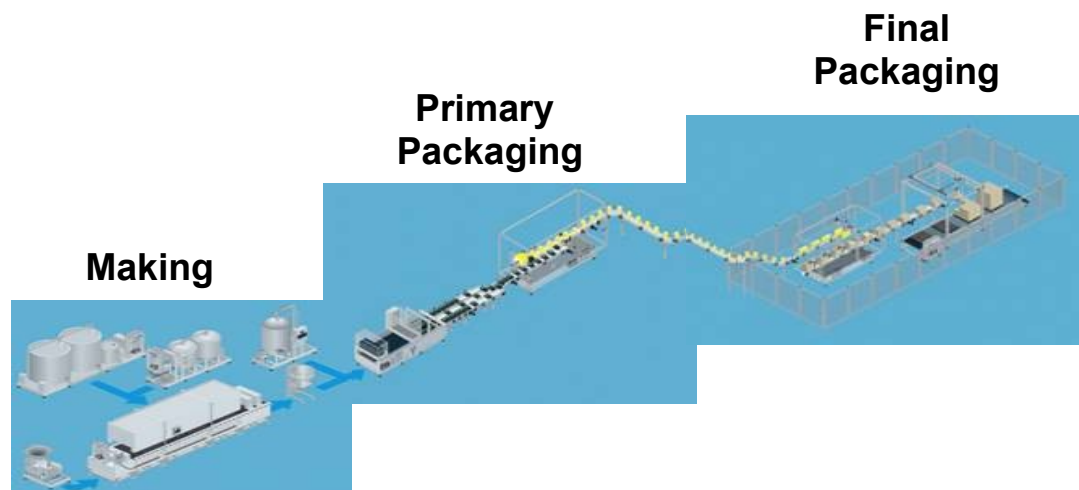
All of the teaching laboratories visited contained real industrial components such as PLC's, sensors, motor starters, etc. and all provided opportunities for generic hands-on experience. Many of these facilities, however, lacked real systems of components and real machinery. One of the organizations visited took older equipment and had students update it as a learning project. Another organization worked with a local employer to build simulators with the real equipment used in the factory. A third participant used maintenance of the facility equipment in his building as an opportunity for students to get practical hands-on experience. It is suggested that all teaching laboratories endeavor to bring in real industrial systems and equipment on which students can work. Such equipment is frequently scrapped by manufacturers or sold at auction for pennies on the dollar. Various technology suppliers have programs for donation or drastic discounting of equipment for school labs.

A coordinated effort to solicit donations of equipment for local schools from both end users and suppliers could result in obtaining useful systems, machinery and documentation. Such an effort could be launched at the consortium level.

Incorporate Systems Level Training

Manufacturing Systems (with a capital S) are comprised of multiple unit operations. Each unit operation may consist of a control system (with a lowercase s) together with pumps, valves, tanks, heat exchangers and sensors or it may consist of a complex machine with its integral control system. Unit operations are combined in a series/parallel fashion to create a manufacturing System or process. The more highly automated the System, the more tightly coupled to one another these unit operations will be and the more highly integrated will be the adjacent control systems.

For example, stopping a case packer may cause a wrapping machine to stop. Stopping two wrapping machines may cause an extruding line to stop. Stopping an extruding line may cause a batch of product to become overcooked and discarded. Turning off the power to a PLC on a network may cause all machines on the network to cease functioning (although not a particularly good design). Using an HMI device to check an internet site may affect the performance of the machine control. Using a spreadsheet to gather data from a PLC could cause a machine jam. The point is, knowledge of the components and the unit operations is not sufficient to work on today's advanced systems. Knowledge is required about how components interact in a system and how unit operations interact in a System. Therefore, troubleshooting and repair of a modern industrial process requires a systems approach at both the big S and the little s levels.



Typical Hybrid Industry Process Flow Requires a “Systems”

Figure 2

There is yet another level at which a proficient maintenance technician will have skills and that is at the process or application level. This will involve an understanding of the interactions between the products being manufactured, the machinery and Systems being used and the automation, control and data integration systems and strategies that are employed. This knowledge, however, will vary widely from company to company, and will generally only be learned on the job.

At the little s level, most of the instructional programs reviewed included learning about combining components into control systems, at either the generic or practical level. However, at the big S level, there was virtually no opportunity for students to gain Systems experience through the educational or training programs unless they took part in some sort of an intern assignment or participated in extra-curricular activities such as competitions.

The study confirmed reluctance on the part of larger companies to hire graduates immediately out of school. This may be related to many factors including maturity, level of independence, lack of tested interpersonal skills, and so on. However, one of the needed skill areas that would be clearly lacking in the new graduate would result from the lack of Systems level experience in the educational process. A typical career path is for a student to start employment with a smaller “feeder” company where the equipment is less Systematized, gain experience working with a smaller number of unit operations and small Systems, and then move on to the larger companies. This career path may pose more of a problem in the future as significant numbers of highly skilled staff begin retirement from the larger companies. At least one major company has indicated a willingness and desire to deviate from its past practices and seek recent graduates to fill its maintenance positions.

A possible solution to the need for Systems level training could be a shared or mobile System comprised of packaging machinery that could be used by schools in the consortium to offer Systems experience to their students. At the same time, such a System would provide direct evidence of the region’s intent to be a Center of Excellence for Packaging Operations. For programs with only generic hands-on, this would fill a gap of a practical hands-on experience. Such a System could also be employed as part of an operator training program or a workforce readiness program. An analogous example might be the career center students running an on site restaurant or beauty shop. This provides experience with the “business Systems” of restaurants and beauty shops and provides real experience for hostesses, servers, cooks, dish washers, stylists, manicurists and others who will eventually fill similar jobs in industry. **The consortium should consider acquiring a packaging System to be shared among the various participating schools and each school should incorporate a Systems module into their curriculum.** With planning, such a system could be used to serve the community or as a revenue generator by packaging things such as

promotional items, educational handouts, customized party favors, or other items that local business might need to have co-packaged.

Prepare for the Global Economy

Many of the companies visited and virtually all of the multi-national packagers are acquiring equipment from around the globe. The days of US end users being able to mandate conformance to US standards are certainly going if not already gone. Maintenance staff need to be able to deal with documentation prepared to foreign standards, marginally acceptable translations to English, equipment built to foreign standards (such as IEC), metric parts and measurements, etc. Furthermore, US companies will not always be able to obtain machines with controls from their preferred controls vendor. Although not confirmed in our study, other analysts have noted that international consensus standards are playing a larger role in equipment specifications than they once did. **Particularly education programs (as contrasted to training) should be presenting a global view and creating an awareness of international standards rather than focusing solely on popular US suppliers and practices.** All of the study participants focus primarily on a single supplier for PLC's and related systems. Several mentioned that they would prefer not to do so, but are strongly encouraged by their advisory boards.

Leverage Industry Leaders

None of the gaps mentioned above go beyond the present state of the art already being applied in local industry and none of the skills go beyond expectations already in place for technician level jobs of leading companies in the ten county area of study. The skill and expectation levels are sure to increase and at the same time, the present skills of technicians will migrate down the workforce to the maintenance and craft employees. Although all of the schools seem to be making effective use of local industrial advisory boards, they are not meeting all of the needs of the most advanced packagers in the area. At least one packager has a corporate-wide initiative underway to provide training on state-of-the-art technologies for its maintenance staffs. This corporation has contracted with out-of-state educational institutions and local consultants to develop curricula in areas very close to the curricula being taught by the study organizations. Comments received during the study made note of the fact that technological leadership typically comes from corporate engineering departments, not local maintenance staffs. **The consortium should undertake to become more closely tied to major corporations who may be leaders in their industries. This may require going outside of the region to corporate offices or other plants.** In addition to helping consortium members to benchmark their educational programs, where proprietary concerns do not exist, such contacts would allow the consortium to bring benchmark data into the region for use by smaller or less advanced companies.

Balance Today's Needs and Future Needs

Educational programs need a proper balance between now and the future and between meeting the needs of the typical company and the exceptional company in the region. Training programs can and should be more reactive, while

educational programs need to be more proactive. Several participants indicated a desire to increase the level of their proactive educational programs. One participant suggested a 75 / 25 split between reactive and proactive programs. Another suggested moving to a 50 / 50 split between educational programs and training programs. It was pointed out that new technology leadership generally comes from engineering, not from operations and maintenance. In some plants, new equipment is purchased to the perceived capabilities of the operations and maintenance staffs. In others, new equipment is purchased utilizing the latest practical technology and the skills of the staff are expected to rise to the level of the technology. Programs such as the one at Millersville, that aim to train the next generation of supervisors and managers, can do much to build confidence in new technology on the part of operations and aid in communications between engineering and plant personnel. **Consortium members that wish to increase the proactive, future looking components of their program should use care to balance their advisors between engineering and operations and between progressive and less progressive manufacturers.**

Continue to Leverage Industry Expertise

All of the programs offered by consortium members benefited from the fact that instructors were available with industrial backgrounds. Some institutions rightly made note of the fact that this was one of their strengths. In most cases it was observed that the industry expertise came out of the discrete segment, sometimes as the result of this segment going through restructuring. **All programs should continue to rely upon instructors with industry experience, and those programs focused upon hybrid or packaging industries should seek to augment their staff with experience from these areas.**

The Opportunity for Education

Need meets Desire

Four of the seven organizations that participated in the study saw significant opportunity in preparing students for support of advanced packaging operations. Of the remaining three, two could be characterized as having their focus primarily on construction and discrete industries. Of the three sensing limited opportunity, each saw only a small percentage of their students working in packaging related areas, whereas three of those who saw significant opportunity have 20% or more of their students in packaging related jobs. Three of the interested organizations have strategic interest in exploring new areas as their schools are slated for expansion and growth. An apparent desire exists to explore the packaging center of excellence concept as a means of growth and service to the region.

Returning to the *Packaging World* survey, the following results were found:

In response to the question: “Is today’s work force adequately prepared to operate and maintain the latest packaging equipment?”, 58% said No and 42% said Yes.

In response to the question: “If a Packaging Automation Center of Excellence existed and was capable of certifying people in the subject area of “mechatronics”.....” 73% expressed a moderate or extreme interest in the concept.

Asked if survey responders would be willing to participate in a steering committee charged with assessing the gap between industry needs and educational programs for automation technicians and technologists, 15% said yes while 79% said no, but think it is a good idea. This is a greater positive response than this analyst has seen to similar questions posed to manufacturers and may be consistent with local reluctance to participate in such activities.

Asked if their company would be interested in funding such an effort, only 7% replied positively. This seems consistent with companies’ general unwillingness to fund training as seen in Mr. Telson’s study.

An unexplored opportunity is with technology providers and packaging machine manufacturers who may have more interest in participating in and providing funding for such an effort.

One final question from the *Packaging World* survey: Which of the following statements best characterized the university, community, or technical college upon whom you rely for packaging automation technicians and technologists?

- 26% The faculty are knowledgeable about packaging science and materials but have little or no focus on packaging machinery.
- 20% The faculty are very engaged in the industry and understand current packaging machine technology.
- 16% The faculty are knowledgeable but lack adequate laboratory facilities to conduct relevant courses.
- 16% Faculty have not kept up with rapid changes in packaging machine technology.
- 13% Faculty have little interest in the science of packaging machines.
- 9% Faculty stress theoretic research rather than applied research.
- 100% Total

These results would indicate that only 20% of users believe that their local educational resources are providing adequate support for packaging machinery technicians.

In summary, a national survey shows that a majority of packagers believe that the workforce is inadequately prepared for the jobs available and that only 20% believe that their educational resources are adequately engaged in meeting their needs. Nearly three quarters of packagers have high or moderate interest in the concept of a center of excellence. Regional results suggest that the more sophisticated packagers are finding it necessary to hire maintenance staff away from other companies that have provided them with on the job training, and that most have no significant plans for incumbent worker training. Demographics would suggest that many skilled workers will be retiring over the next decade. Regionally, we have seen that many more students could already be placed in good jobs than are going through our existing programs. It would seem that there is a need, both regionally and nationally for the concept of a packaging center of excellence, although interest in providing leadership and funding to support better educational programs is small within the industry. Four of the study participants have indicated interest in the Packaging Center of Excellence opportunity, their current focus is consistent with multi-skilled hybrid industry education for job preparation and three of the four see expansion and growth in their organization's future. **There is both a need for packaging machinery education and a desire to expand multi-disciplinary programs by regional organizations with which this area of focus would be a good fit. With appropriate leadership and funding, it would seem that a significant opportunity exists to establish the region as an educational center of excellence for packaging operations.**

Increase Graduation from CTC and Community College Programs

Whether or not a decision is made to proceed with establishment of a center of excellence, there is reason to improve student participation in career and technology center and 2 year college technical programs. Given the need for skilled technicians, the good pay and the relative security of the employment, there are a very small number of students pursuing these jobs from high school through the career centers and community colleges. Most of the students at the community college level and some at the career center level are displaced employees seeking retraining rather than younger students seeking to complete their education before entering the workforce.

It was reported that there are a number of impediments to attracting high school students to the career centers. These include political/financial issues with the home school, social/behavioral issues with students, concern on the part of parents, under-informed parents and guidance counselors, lack of adequate marketing, lack of matriculation agreements, etc.

In this analysts' opinion, this places the region and the US in general at a great disadvantage over our global competitors who make deliberate efforts to develop a well educated technical workforce to support industry. The National Association of Manufacturers in their report entitled *Keeping America*

Competitive made the following observations, referred to as the High Wage Paradox:

- High-wage nations are increasingly outperforming low-wage economies in attracting U.S. manufacturing foreign direct investment.
- Yet, the greater challenge to America is not low-cost goods from low-wage producers in developing countries, but rather it concerns high-skilled workers in advanced and emerging economies.
- The potential exists that manufacturers will increasingly move production operations overseas to seek the technological talent that is being strategically and purposefully prepared.... If they cannot find talent here.

A corollary to this paradox based upon the author's experience is:

- No matter where leading global or US companies invest in manufacturing infrastructure, the machinery employed (including packaging machinery) is increasingly imported from high-wage, high-skilled countries whose machines provide competitive advantage due to appropriate use of advanced technology.

One can presume from this discussion that manufacturing survivability in any economy is dependent upon (among other factors) the appropriate use of advanced technology and the availability of a high productivity, low cost labor force. Plotting these two factors along two perpendicular axes and characterizing each factor as more favorable or less favorable results in the typical 4 quadrant matrix which is frequently seen to analyze vulnerabilities of a business. This particular matrix developed by the author is called the manufacturing survivability matrix.

Manufacturing Survivability

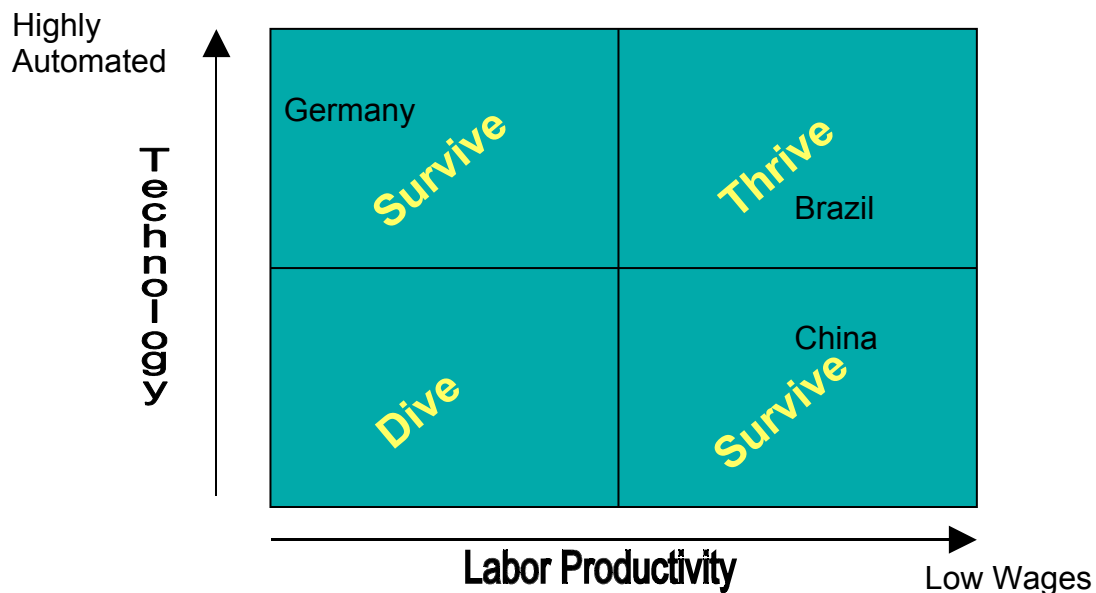


Figure 3 © Campbell Management Services

High levels of automation based upon application of technology together with low wages make for a thriving manufacturing economy. Brazil may be an example of such a region. High automation with high wages or low automation with low wages may allow manufacturing to survive. Germany is an example of the former situation and China may be an example of the latter. Low levels of automation technology together with high wages will result in manufacturing taking a nose dive. Some would argue that the US falls into this quadrant. Since it is unlikely that the US can move to the right toward lower wages, it is necessary that we either outsource or move toward the upper left by becoming better at applying technology. This requires that our labor force be educated in the application, operation and support of the necessary technologies.

Despite the fact that manufacturing jobs are being lost around the world, the manufacturing jobs that remain are better jobs requiring broader skills and are still significant in number. According to Alliance Capital Management, between 1995 and 2002, the US lost 11% of its manufacturing jobs while low wage manufacturing powerhouses like China lost 15%, and Brazil 20%. More goods are being produced with fewer workers due to increased productivity enabled by technology. Manufacturing is following the same path as agriculture. In less than a century, farm jobs in the US fell from 33% of adult workers to less than 3% due to mechanization of farming, but making us the most productive agricultural producer in the world. Could we also become the most productive manufacturing country in the world?

The US must do more to deliberately prepare a highly trained and educated workforce to support manufacturing. This will require deliberate efforts to attract students into career and technical center programs and for them to continue on for 2 year associate degrees, and potentially for 4 year technical or management degrees. Suitable matriculation agreements must be in place. **The consortium should take deliberate steps to increase the participation in electro-mechanical technology programs in the career centers and 2 year colleges.**

Methods that appear to have had some success include high school recruiting by career center staff, 8th grade career center visits, and industrial tours. Pointing out to parents the potential for college after the career center, marketing the 2+2+2 concept and marketing manufacturing jobs will also be beneficial. A program similar to Project Lead the Way for future technicians and technologists should also be considered. Project Lead the Way is implemented in this area by Penn State Berks. This is a program that allows middle school, high school and career center students to explore technology and engineering in a standards-based hands-on curriculum. The program includes a 9 week segment on automation and robotics.

Helping students obtain scholarship money would also aid in their continuing to and graduating from 2 or 4 year college programs. The Central Keystone Section of ISA which serves our region offers a scholarship for students studying in areas related to this study. This scholarship has recently gone unclaimed due to lack of applicants.

Drive Innovation by Valuing Education

To this point, the region has had a strong focus on meeting the workforce needs of the typical employer and in retraining displaced workers for new or better jobs. These are important needs to be filled, but do not necessarily address the need for growth through innovation. Trained workers can do today's jobs using the tools and methods for which they have been trained. When tomorrow's tools and methods become available, the need for retraining is likely. A colleague of mine always reminded me that when the only tool you have is a hammer, then everything looks like a nail. When everything looks like a nail, innovation is unlikely.

The best mechanic that I found for my wife's classic Mercedes was *educated* as an auto mechanic in Austria. I asked him one day why he was so adept and creative in his profession. He told me that his educational program started out in the secondary school system with casting an engine block. From that point, and continuing at that level of detail, he was taught to be an automotive technician. When I crinkled some metal on my high tech aluminum-bodied Audi and took it to the body shop, the body shop manager confided in me that I should expect my car to come back like brand new. He had assigned my car to a technician that was educated in Germany and is working here in the US as part of a technical

exchange program. Both of these examples point to the value of an educated technician as contrasted to a trained one.

Even the smallest of companies can be more innovative when their technicians have a broader educational base that allows them to suggest innovative improvements and to make innovative repairs. The fastest way to convince company management of the value of an educated technical operations work force is to make one available to them.

Learning multi-disciplinary skills will require more time in school than learning skills in a single discipline. Being broadly educated will require more time (initially) than being trained. **To provide the opportunity for a multi-disciplinary technical education that will make our region more innovative, high schools, career centers and 2 and 4 year colleges must work more closely together in defining curricula and developing appropriate matriculation agreements. Funding and other incentives should be put in place to encourage students to complete 2+2 or 2+2+2 programs.**

Develop Multiple Training Foci

If a center of excellence for packaging operations is to exist, an opportunity is presented to provide education and training for more than the maintenance technicians. Mr. Telson's study pointed out interest in operator training. Multiple training foci should exist aimed, for example, at the following positions.

Operators

These folks can benefit from basic employability skills training, learning their place in the bigger system, how companies make money, how to recognize and describe basic industrial components, how to keep a clean workspace, how to climb a ladder, how to use a human-machine interface, basic keyboard skills, the difference between Emergency Stop and Cycle Stop and many similar skills that would be common from company to company. In some companies, machine operators have essentially become control room operators with broad span of control. In some companies, operators are responsible for basic maintenance functions.

Helpers

Whether helpers are moving material for operators or helpers are assisting the crafts with "heavy lifting", helpers need many of the same skills as operators and sometimes many of the basic trade skills that a tradesperson might have.

Crafts

Skills for the crafts people such as millwrights, pipe fitters, and electricians are obvious.

Maintenance

Maintenance Crafts such as maintenance electricians and maintenance mechanics need a broader based set of skills.

Technicians

Technicians will have generally completed at least a two year college program.

Technologists

Technologists will have completed at least a two year college program and perhaps hold a Bachelor of Technology degree.

Engineers

Engineers in manufacturing will generally have a Bachelors degree in engineering science or technology.

Supervisors

Supervisors both in operations and maintenance are more likely to have college and technical backgrounds than in the past.

Managers / Executives

Managers and executives can benefit from programs that could be sponsored by the center on topics such as “new technology”, “justifying capital improvements”, “developing operator training”, etc.

Several comments were heard on the need to coach or educate company managers to the value of training. Training is often sought to close a wound, as a band-aid, rather to improve productivity and prevent wounds from opening. When employees are trained, they may not understand why they are being trained due to lack of communication from management.

Corporations in which the managers are technology aware are more likely to see the need for training operatives and to act on that need, either through formal training or OJT and coaching. Some training programs have been disappointments to managers because they did not understand enough about the technology to choose the proper training for their employees. Programs that help managers to feel more comfortable with technology should result in better targeted training initiatives.

A corporate business plan should include a manufacturing technology plan. The technology plan should impact the structure of the organization, the expected roles of people, and help to identify the skills and training required of the workforce.

Large corporations have rigorous procedures in place for evaluating capital improvements and use these procedures to drive, and in fact require, productivity improvements through technology investments that result in improved cash flow. Given the frequency with which we hear that “there is no plan or money for improvements”, perhaps businesses would benefit from training or coaching on manufacturing investment analysis.

The region has the educational capacity to provide focus on a wide range of jobs in support of packaging operations, from shop floor to top floor, and should do so.

Leadership Required

Mr. Telson’s survey showed a wide range of intentions with respect to future plans for growth, modernization, use of technology and development of workforce. Many of the smaller companies in the study indicated no intent in these areas. This should be of concern to those interested in maintaining a thriving manufacturing sector in the economy. In addition, both regional and national studies show little interest on the part of industry to lead efforts to improve the workforce. Without leadership, improvement will be disjointed at best. **For many companies, public leadership will be required to bring about an environment of support for growth, modernization, application of technology and development of a competitive workforce.**

Summary of Recommendations

This section repeats in one list the various recommendations that are indicated in **bold face** in the section entitled Findings and Recommendations.

- 1) A Center of Excellence for Packaging Operations needs to focus upon education and training for jobs with *multidisciplinary technologies*.
- 2) With hybrid manufacturing representing a sizeable base in the region, educational organizations should consider a *deliberate focus on the needs of hybrid industries*, many of which would include packaging operations.
- 3) A Center of Excellence for Packaging Operations should *focus upon operations support skills* while including those construction skills required in support of operations.
- 4) In order to have a successful Regional Center of Excellence for Packaging Operations, *at least one from each level (2+2+2) of the education and training organizations must have a deliberate focus* upon multi-disciplinary education and job related training in the hybrid industries with an operational slant.
- 5) The region has *the needed educational capacity* from the perspective of courses of study offered, *with relatively minor additions*, to support the proposed center of excellence.
- 6) A coordinated effort to *solicit donations of equipment* for local schools from both end users and suppliers could result in obtaining useful systems, machinery and documentation.
- 7) The consortium should consider *acquiring a packaging System* to be shared among the various participating schools and each school should *incorporate a Systems module* into their curriculum.
- 8) Particularly education programs (as contrasted to training) should be *presenting a global view and creating an awareness of international standards* rather than focusing solely on popular US suppliers and practices.
- 9) The consortium should undertake to *become more closely tied to major corporations* who may be leaders in their industries. This may require going outside of the region to corporate offices or other plants.
- 10) Consortium members that wish to increase the proactive, future looking components of their program should use care to *balance their advisors* between engineering and operations and between progressive and less progressive manufacturers.

- 11) All programs should continue to rely upon *instructors with industry experience*, and those programs focused upon hybrid or packaging industries should seek to augment their staff with experience from these areas.
- 12) There is both a need for packaging machinery education and a desire to expand multi-disciplinary programs by regional organizations with which this area of focus would be a good fit. With appropriate leadership and funding, it would seem that *a significant opportunity exists to establish the region as an educational center of excellence for packaging operations*.
- 13) The consortium should take deliberate steps to *increase the participation in electro-mechanical technology programs* in the career centers and 2 year colleges.
- 14) To provide the opportunity for a multi-disciplinary technical education that will make our region more innovative, high schools, career centers and 2 and 4 year colleges must *work more closely together in defining curricula and developing appropriate matriculation agreements*. Funding and other incentives should be put in place to encourage students to complete 2+2 or 2+2+2 programs.
- 15) The region has the educational capacity to provide *focus on a wide range of jobs in support of packaging operations*, from shop floor to top floor, and should do so.
- 16) For many companies, *public leadership will be required* to bring about an environment of support for growth, modernization, application of technology and development of a competitive workforce.

Best Practices

In the course of this study, many innovative and successful approaches were observed. Some of these should be highlighted for others to see. The following are identified as best practices observed during the study. At least one practice has been identified with each participant. This is not to say that similar practices may not in place by other participants or that other practices are not also worthy of note.

Troubleshooting Methods

Bruce Shreiner at Stevens teaches a 1 credit course on troubleshooting methods. This course includes theory and hands-on practice using electronic modules that contain hidden faults. The program is aimed at teaching students to think, analyze and break problems down into manageable units.

Computerized Maintenance Management of Building

Greg Burkholder uses the career center facility as a practical hands-on learning center. Using a computerized maintenance management system, students receive work orders for systems that need repaired. These may be for commercial kitchen equipment, HVAC systems, boilers, compressors, machine tools or any of the equipment found in the school. Students have an opportunity to practice their troubleshooting and repair skills on real equipment.

Multi-disciplinary Programs

The staff at Penn State Berks has put together a multi-disciplinary electro-mechanical engineering program that is one of only four in the nation. Accreditation is in process, potentially as a Mechatronics program.

Student Recruiting

John Mestishen, instructor at the Berks Career and Technology Center personally seeks out students for his program among the participating school districts. He takes robots to the schools, invites 8th graders to tour his labs, and arranges for plant visits to let students see the excitement of manufacturing. His students keep up their excitement by competing in national robot competitions. Over half of his career center students go on for higher education.

Looking over the horizon

John Devere and the staff at Reading Area Community College are taking steps to truly look over the horizon and plan for the future. With a new building and labs on the way, they are looking for programs that can meet today's needs and grow to meet tomorrow's as well. They are considering a 2 year Mechatronics program.

Homemade training systems

Bill Thompson and his staff at HACC's Community Center for Technology & Arts have worked with representatives from a local manufacturer to build process

simulators that are similar to the skills test stands that this particular employer uses to test candidates for maintenance jobs. These simulators use only real components, installed as they would be in industry with industrial documentation. Working on them is just like working on the real thing. In addition, these simulators are certainly less costly than would be their commercial counterparts.

Partnering with local associations

Dan Bernardy at the William F. Goodling Advanced Skills Center partners with the local Manufacturers' Association in a mutually beneficial relationship that provides customers for the center and skills for the customers. The center brokers training from multiple sources for its industrial customers. Another partner is local high schools for which the center provides internships for students through the High School Internship Training program (HIT).

Using National Competitions

John Wright of Millersville University involves students, on an extra-curricular basis, in national competitions that require the design and construction of operating systems such as a challenge robot, a one person submarine or a battery operated motorcycle. These projects provide students with a full range of systems experience from R&D through design, construction, implementation, troubleshooting and operations. Such programs also provide project management experience, develop team skills and give students an opportunity to see how to apply education to the job.

Questions from Participants

Study participants had questions about the study and about the Center of Excellence for Packaging Operations.

What will be done with the study and who will receive it?

What does a center of excellence look like? Where will it be located? How will it be funded? What will be its organizational structure? Will there be certification programs for students?

The response given to these questions was that these answers are either undecided at this time or unknown to the study contractors and should be referred to the study sponsors.

Options for Further Study

The following are potential areas relating to this study that could developed further:

Identify actions that would encourage additional participation in and graduation from career center and junior college programs.

Determine means of taking existing single discipline curricula and creating multi-discipline curricula that would fit within an appropriate period of study.

Identify sources of instructional equipment that would provide additional focus on packaging machinery.

Develop a program of identifying and obtaining real industrial control equipment and packaging machinery for use by consortium partners.

Develop and obtain a packaging System for use by consortium partners.

Develop program of managerial seminars on capital investment, technology, justification and similar topics.

Identify sources of curriculum for gap areas.

Develop needs and plan for operator related training.

Develop program for exchange of best practices and benchmarking among packagers or among educational organizations.

Identify interested organizations, and begin implementation of recommendations for establishment of the center of excellence.

Further develop matriculation agreements among the schools in the region.

Summary of Interviews

The following tables 2 through 9 summarize major portions of the interview findings conducted as part of this study.

Study Organizations and Primary Contacts

Organization	Short Name	Contact(s)	Position
Berks Career & Technology Center	BCTC	Judith A. Diffendal John Mestishen	Director of Continuing Education Robotics & Automation Technology Instructor
Lancaster County Career & Technology Center	LCCTC	Greg Burkholder	
Manufacturers' Association of South Central PA William F. Goodling Regional Advanced Skills Center	MASCPA WFGASC	Dana Dehoff Bond Daniel L. Bernardy	Director of Education & Training Program Manager
Harrisburg Area Community College Community Center for Technology & Arts	HACC	William R. Thompson Bob Gill Bob Koenig	Assoc. Professor/Coordinator Regional Skills Specialist Area Skills Specialist
Reading Area Community College	RACC	John M. DeVere	Associate Dean of Academic Affairs
Thaddeus Stevens College of Technology	TSCT	Bruce Shreiner	Electronics Technology
Penn State Berks-Lehigh Valley College	PSB	Walter F. Fullam Terry Speicher Gregory D. Stanton Michael Zigner	Director of Continuing Education Assistant Professor of Engineering Lecturer, EET Continuing Education
Millersville University	MU	Perry R. Gemmill John R. Wright Joe McCade	Prof & Chmn Dept of Industry & Technology Assist Professor, Dept of Indus & Tech Assist Professor, Dept of Indus & Tech

Table 2

The above organizations were identified by the Workforce Investment Board as consortium educational partners.

Description of Study Organizations

Short Name	Website	Type of Organization	Objectives of Organization
BCTC	www.berkscareer.com	An Area Vocational Technical school sponsored by a group of public school districts in Berks County, PA.	In partnership with its sponsoring districts and business and industry, and utilizing a system of continuous improvement, to prepare secondary and adult students with the knowledge, skills and attitudes necessary for gainful employment and further education.
LCCTC	www.lcctc.org/	An Area Vocational Technical school sponsored by a group of public school districts in Lancaster County, PA.	Based on identified occupational needs, prepare high school students and adults to be academically competent, to be occupationally proficient for employment, and to have a sound foundation for continued learning.
<p>MASCPA</p> <p>WFGRASC</p>	<p>www.mascpa.org/contact.html</p> <p>www.advskills.org/</p>	<p>A regional employers' organization that provides training services for members</p> <p>A non-profit grant-funded training "factory"</p>	<p>To assess needs, form consortia, seek funding and provide soft-skills training for the membership. Work with the Advanced Skills Center for hard skills training.</p> <p>To provide certificate or training programs that support the manufacturing companies in the area and to contribute to the development of a local workforce that meets the current needs of industry. Help students achieve meaningful, long-term employment at family-sustaining wages; provide productive, positive-thinking men and women who are prepared for today and tomorrow's manufacturing jobs; and develop a capable workforce that permits confident business planning for the future.</p>
HACC	www.hacc.edu/COLLEGE/ccta/index.html	Publicly supported 2-year community college	To provide educational and job training opportunities to the community. Upgrade skills and processes to make companies more productive.
RACC	www.racc.edu	Publicly supported comprehensive community college	<p>In general- To provide: the first two years of a Bachelor's degree; career education for immediate employment; courses to assist in the transition from high school to college; community education and public service activities; and training for area business and industry.</p> <p>Specific to study programs- To provide educated and skilled</p>

Short Name	Website	Type of Organization	Objectives of Organization
			technicians for manufacturers located with the region served; and to provide training for incumbent workers so that they have specialized skills.
TSCT	www.stevenstech.org	A two year state owned residential technical college	To offer a two-year technical education to academically qualified students of Pennsylvania. Prepare students to get a job, teach them how to learn, stay in touch with industry, be more flexible.
PSB	www.bk.psu.edu	A branch campus of Pennsylvania's primary "state-related" university, Penn State	The Penn State Berks-Lehigh Valley College serves the educational and employment needs of Berks County, the Lehigh Valley, and its extended service area. The mission of Penn State Berks-Lehigh Valley focuses on the following three areas of activity: teaching and learning; research, scholarship, and creative activity; and community service and outreach. In the specific field of interest, goals are to provide high quality accredited degree programs, provide a broad education including the technical and analytical skills to allow continuing education and assistance in a career, and to provide hands on applications of learning to benefit local industry.
MU	www.millersville.edu	A member of Pa's State System of Higher Education	The mission of MU is to promote intellectual development through an exemplary liberal arts-based education. The Department of Industry & Technology provides broad-based liberal arts and technical preparation for technical careers and management preparation for leadership careers in business and industry.

Table 3

From an educational perspective, these organizations cover the range from high school vocational/technical education through community and technical colleges to full 4 year university programs. Each of the partners is in some way publicly funded.

Programs Available Relevant to Study

Short Name	Degrees /Programs Available	Relevant Courses of Study	Students Participating	Comments
BCTC	High school certificate programs; adult certificate programs; adult training classes; contract training for industry.	Robotics and Automation Technology in Technology Cluster.	Students from less affluent school districts, displaced workers, students sent from RACC.	More than 50% going on for further education. Credits may be earned for HACC or Penn College. Manufacturing Cluster programs are all related to metal forming.
LCCTC	High school certificate programs; adult certificate programs; adult training classes; contract training for industry.	Industrial Electricity/Machine Repair Technology- federally approved apprenticeship program.	Started with night students, opened adult day program, now have high school and adults both in the same day classes.	Could place 5X the students that they have with best A & B students going to major food packagers at \$15/hr.; C students going to stepping stone companies at \$12 - \$13 per hour.
MASCPA	Soft skills training for industry; certificates			
WFGRASC	Adult industrial training courses; High School Internship Training (HIT)	Repair Technology	80% sent by industry for upgrading. HIT 100 students, 4 hrs per day, 2 semesters.	Customers develop curricula; Center finds someone to teach it.
HACC	Non-credit customized and non-customized training, certificate programs, AAS	Industrial Maintenance Technology, HVAC Technology, Industrial Automation, Electrical Technology, Electronics Technology	Avg. student 35-40 yrs. Old. Many of the electrical technology students don't make it to their second yr., rather get jobs. Don't get many students directly from high school.	Provide both traditional and new technology training (25%) to respond to European model. Work with advisory board, employers are waiting for graduates.
RACC	Associate degrees, certificate programs, credit and non-credit training in house or on customer site	Industrial Maintenance Technology Process Control/Mechatronics Technology (future)	Displaced workers for education programs; company supported for training	Currently 90% training, 10% education with goal to move to 50/50
TSCT	Associate degree. Don't do industrial training.	Electronics Technology	More than 60% underprivileged on full scholarship. Graduate about 12 per year.	Have purchased facility to add space. Plan to change to a more college-like program with core courses and specialized

Short Name	Degrees /Programs Available	Relevant Courses of Study	Students Participating	Comments
				electives
PSB	Baccalaureate & Associate Degrees, Certificate Programs that build on strengths of degree programs	Mechanical Engineering Technology Electrical Engineering Technology Electro-Mechanical Engineering Technology PLC Certificate AutoCAD Certificate	Graduate 15/yr MET, Graduate 15/yr EET, ½ of MET & EET go on for 4 yr programs. Grad 15/yr BS. 100 students/yr in various continuing educ courses	One of only 4 schools in nation that offer BSEMET
MU	Bachelor of Science, Associate of Technology plus a variety of associate, baccalaureate and masters degrees in other areas. No relevant training programs	Industrial Technology with options for: Electronics/Control Systems; Manufacturing Technology; Mechanical Technology	Industrial Technology- 200 students split among 7 areas. Electronics/control systems-graduate 4 to 5 per year, growing.	Weak connections to local industry

Table 4

Displaced workers dominate the community college programs and are present in the career and technology center programs.

Customer Goals for Study Programs

Short Name	Student Goals	Parent Goals	Industry Goals	Specific Skills Requested
BCTC	Adult students are displaced workers seeking retraining.	Prepare for post secondary education	Specific Training	Motor controls, PLC's, Industrial electricity, mechanical. Seeing more basic skill requests such as math, welding, print reading. HVAC/ building maintenance potential bridge to industrial maintenance.
LCCTC	Obtain entry level skills; Not aware of opportunities that exist in industry.	Prepare for jobs with decent pay and security.	Set by 16 companies on occupational advisory board. Upgrade curriculum every year. Companies want practical specific training.	Electrical systems; mechanical systems; fluid power systems; control systems; PLC's; HVAC; Variable speed drives;
MASCPA WFGRASC	Students are sent by industry	NA	Upgrade skills in specific areas	PLC's, welding
HACC	Retraining for new job	NA	Competitiveness; cross-craft training	HVAC, hydraulics, pneumatics, PLC's, print reading, CAD/CAM, team building, lean mfg. Safety
RACC	Educ students: to prepare for a job with above avg wages and with transferable skills. Training students: to obtain skills to advance on the job	NA	Hard skills with specific equipment that are immediately transferable to the workplace	PLC's, fluid power, industrial electricity, industrial electronics
TSCT	Get a good job	Teach how to learn	Specific equipment skills	AB PLC's, PLC networking, Data Acquisition, component level repair, troubleshooting
PSB			Very supportive advisory board	PLC, CAD, Design of Experiments, Design for manufacturability, management soft skills
MU	Get a well rounded education		Technical & management skills for employment	Skills focus is across 7 industrial areas including graphic communication, CADD, Occupational Safety & Hygiene and those related to study. Communications, teamwork, work attitude

Table 5

Industry goals were reported universally as being aimed at specific pieces of equipment and specific skills. Some educators expressed dismay over this, viewing this approach as applying a band-aid to a problem.

Primary Industries Served

Short Name	Jobs that Students are Prepared For	Industries Served	Companies Served	% of Students Working in Packaging Related Jobs	Opportunity for Preparing Students for Advanced Packaging Support
BCTC	Electro-mechanical Technician; Commercial & Industrial Equipment Repairer; General Maintenance & Repair Worker; Installation, Maintenance & Repair Worker Helper	Metals; Automotive; Woodworking, Food	Cabbot; East Penn Mfg.; Tymet; Hershey Reading	Very Low	Not a big potential, however being part of a consortium would have benefit. Food park idea has evaporated.
LCCTC	Industrial Technician; Electrician; Millwright; Operators	Food, Flooring, Metals	Have trained from 72 companies. Y&S Candies, M&M Mars, Pepperidge Farm	Almost all	Absolutely a good opportunity. Have been involved with PMMI since 1985. Mechatronics and packaging would really enhance an already good program.
MASCPA	Management, professional	Hired Penntap for food consortium	Graham Packaging	15%	Repair technologies are transferable to packagers. Companies want "Points of Authority" on the plant floor
WFGRASC	Construction, plant level	Metal bangers		Only as students' companies are contracted by packagers to perform repairs	
HACC		Focus on Heavy industry. Printing, Heavy Mfg., Light Mfg., Packaging. Varies by credit or non-credit.		Small number unless you include printing	It may not make sense to have multiple foci. Should have somewhere to steer people.
RACC	Maintenance mechanic, Maintenance electrician, Industrial Maintenance technician, Operator	Manufacturing, surgical equipment, food, metals rolling, specialty manufacturers. Not		25%	Like the concept. Currently in needs analysis stage.

Short Name	Jobs that Students are Prepared For	Industries Served	Companies Served	% of Students Working in Packaging Related Jobs	Opportunity for Preparing Students for Advanced Packaging Support
		construction.			
TSCT	Technician, industrial electrician, industrial maintenance person, research technician	Entertainment; Packaging Machinery; Primary Metals	Longwood Garden, Heat & Control, Sight & Sound, Alcoa, Lukens Steel	20 – 30% including printing	Definitely an opportunity. See benefit to concept of integrating machines, each with a PLC. Starting stepper motor instruction and pneumatics.
PSB	General Titles: Quality Tech/Eng, Electronics Tech, Project Eng, Process Development Tech/Eng,	Specialty steel	Carpenter Dana	None	Think so / Great opportunity. Could help in retaining students that might otherwise go elsewhere. Positive development that WIBs are taking lead and making it data-driven. See the need to migrate degree programs eg elect toward computer science. Trying to figure out how to design interdisciplinary programs. Berks is a young college, still forming, needing to grow and talking about interdisciplinary programs.
MU	Project Engineer, Sales Engineer, Owner, Manufacturing Engineer, Designer, Coordinator, Analyst, Specialist	Controls, Manufacturing, Food, various	Optima Controls, GES, Bemis, Hershey, Svedala, Mannesmann, many companies with no particular major employers	10-15%	See potential for control systems option. Would be open to teaching packaging applications.

Table 6

Availability of Special Programs of Study

Short Name	Mechatronics	Courses of Study Supporting Mechatronics	Packaging Related Courses	Workforce Readiness
BCTC	Not familiar	Yes	No	Some
LCCTC	Multi-skilled people with mechanical, electronics and control systems. Somewhat sales jargon.	Yes If DACUM was the definition, would be 3 programs- Industrial Electronics, computer networking, computer software and a bit of metalworking and machining.	No	Some
MASCPA WFGRASC	None None	No Not specifically	No	Some Some
HACC	Use of integrated computers to control industrial processes	Yes	No	Some
RACC	Technology that marries mechanics, electronics, computers and sensors for control.	Yes	No	Yes
TSCT	Probably fits with electronics and mechanics.	No	No	No
PSB	Mixed understanding among staff. Blending of electrical and mechanical engineering.	Yes	Have discussed for future. Would like to have some sort of flexible line for PLC training.	Some in CE area
MU	Self-rated: 8 out of 10. Aware of definition and multi-disciplinary nature. Some experience from Central Connecticut University that had a program but had difficulty selling name to industry. Changed to electro-mechanical.	Yes	No	Yes – Occupational Safety & environmental health has programs such as confined space. Courses for professional readiness.

Table 7

Workforce Readiness Courses Cited: Lock-out / Tag-out; Ladder Safety; Serve-safe; industrial safety; OSHA; hazmat; communication skills, team building, lean mfg, shop math, PR, team building, computers in the workplace, orientation to manufacturing

International Standards Taught

Short Name	Vendor or Stds	61131	61512	62264	61491	61158	62026	21CFR	802.3
BCTC	Vendor	No	No	No	No	No	Yes	No	No
LCCTC	Vendor	No	No	No	No	No	No	No	Yes
MASCPA WFGRASC	Vendor	No	No	No	No	No	No	No	Yes
HACC	Vendor	No	No	No	No	No	No	No	No
RACC	Vendor	No	No	No	No	No	Yes	No	No
TSCT	Mostly vendor	Yes	No	No	No	No	Yes	No	Yes
PSB	Vendor	Yes	No	No	No	Yes	Yes	No	No
MU	Vendor	No	No	No	No	No	No	No	No

Table 8

All of the organizations focus upon vendor-specific products and North American practices as opposed to systems based upon international standards. All report that this is at the insistence of their industry partners, even though some would like to offer broader training. . Stevens and Penn State Berks are notable exceptions in the extent to which standards were mentioned in covering 3 of 8 in their programs.

Methods / Strengths

Short Name	Teaching Methods	Strengths (self reported)
BCTC	40% Theory; 40% Generic Hands-on; 20% Attitude Coops available, but reduces breadth of study	Equipment and labs are available. Community College students in same classes.
LCCTC	6 textbooks; Theory; Generic Hands-on; Practical Hands-on (use school building systems with computerized maintenance management system; Coops	Can change curriculum over night if needed. Listen to local industry and set curriculum based upon their needs. Great instructors with industrial experience.
MASCPA WFGRASC	Classroom, generic hands-on, video conferencing, distance learning	We are not supposed to compete. Repair technology, welding, machining, geospatial technology hub.
HACC	Theory; practical hands-on	Instructors are industry experienced. Flexibility because of faculty, can customize and take training equipment to the customer, strong network of industrial contacts
RACC	Theory, Generic Hands-on. Use BCTC labs and instructor. Practical hands-on for training held at customer site.	Building new training and technology center with mindset to create new programs of study to support regional companies. Ability to customize training to employer needs and be flexible on content, delivery time and location.
TSCT	Theory, heavy hands-on, both generic and practical. Heavy on component level. Focus on troubleshooting methods.	Troubleshooting program. Students learn to think. Heavy in old school work ethic and discipline. Work on real equipment, lots of time in lab.
PSB	Theory, Generic hands-on	No competition in the region. RACC may be in the future.
MU	2 hrs lecture with 3 hrs lab. Labs use generic hands-on trainers, multi-discipline approaches. Problems presented for design, implementation & assessment. Build real product, prepare technical reports, use simulation, models (eg Lego).	Well rounded, technical management preparation, communications, total quality, design, safety, . Technical strengths include electronics, electro-mech, robotics, computer literacy.

Table 9

All of the organizations use a mix of theory and hands-on. One distinction in hands-on education is the mix of generic vs. practical hands-on. Generic hands-on is done by way of machine simulators or specialized educational fixtures. Practical hands-on is working on actual industrial equipment. There is often a fairly significant reorientation needed to make this jump. Although generic hands-on is useful for learning the basic concepts, practical hands-on makes students ready to hit the ground running in industry.

Each of the programs introduces students to components (such as relays or PLC's) and to the combination of components into to a working pneumatic, hydraulic or electrical / electronic system. In some cases, such a system may be applied to an industrial unit operation, either via a simulator or an actual industrial application. However, none of the programs exposed students to industrial systems comprised of multiple unit operations and multiple integrated controllers.

On multiple occasions, it was pointed out that having high school and adult students in the same class is an advantage.

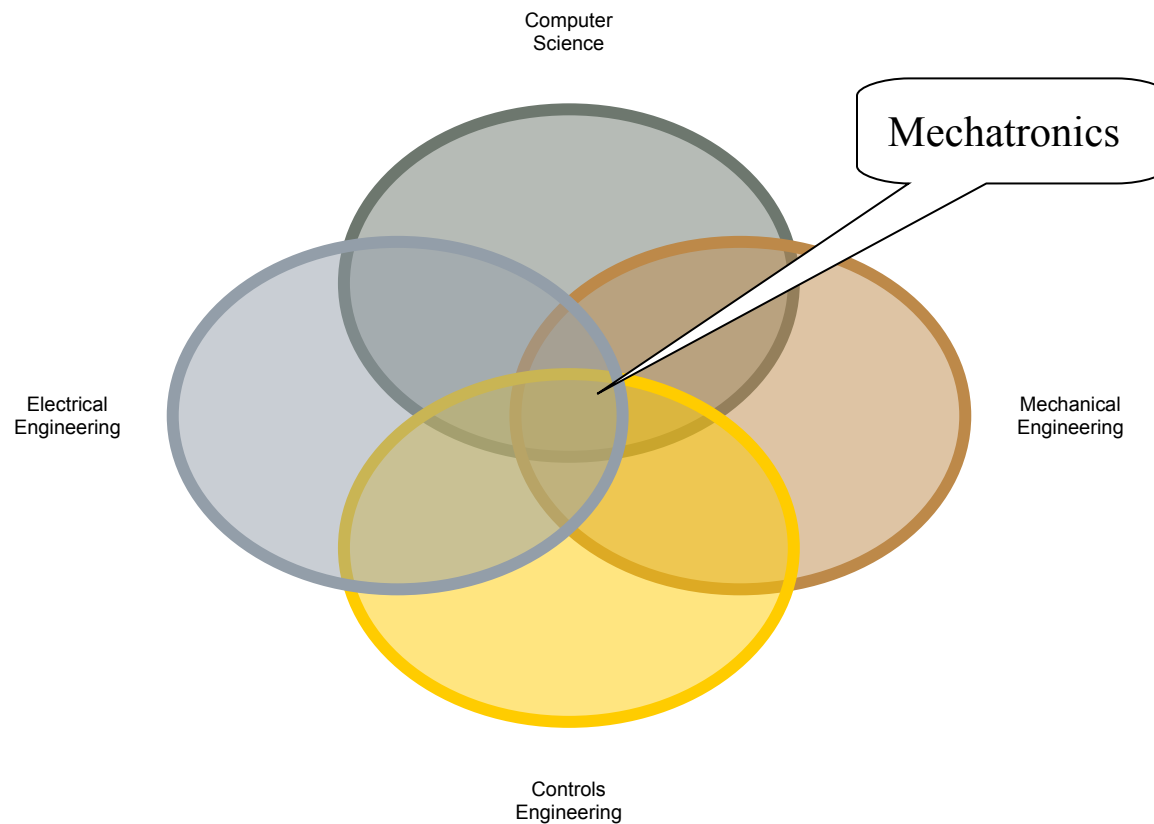
Appendices

Appendix 1	Mechatronics Defined
Appendix 2	Mind Maps As used at interviews Final
Appendix 3	Blank Questionnaire Used at Interviews
Appendix 4	Task Analysis for Local Packager

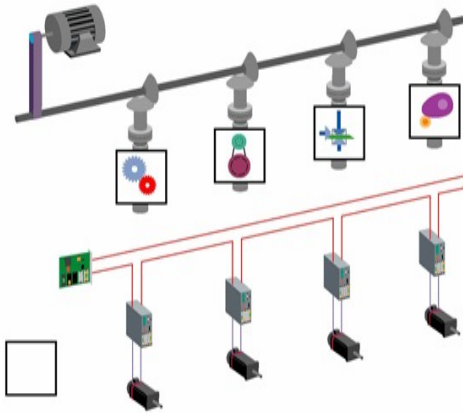
Appendix 1 **Mechatronics Defined**

Mechatronics is the application of the latest techniques in mechanical engineering, electrical engineering, computer science and control theory to design and create more functional and adaptable products.

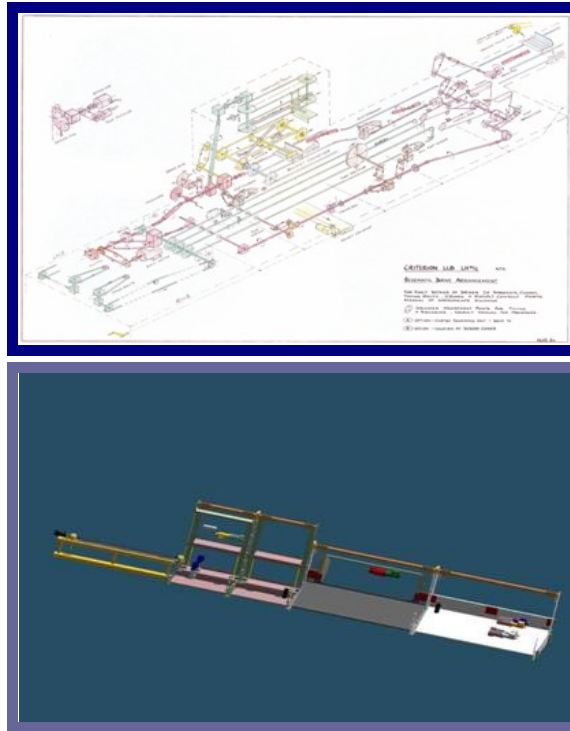
These products may include precision machinery such as disk drives heavy machinery such as locomotives, or specialized machinery such as machine tools, printing presses or packaging equipment.



Motion Concept



Design Concept



Actual Machines



Part count reduction

- Pulleys - 45 to 0
- Belts - 15 to 0
- Drive sprockets - 15 to 0
- Spline shafts - 2 to 0
- Gearboxes - 16 to 10
- Motors - 1 to 10
- Bearings - 18 to 3

Case Study in Mechatronic Design

Generation 1 to generation 3 machine design, courtesy of R.A. Jones Packaging.

Appendix 2

Mind map as presented during interviews.

Mind map with conclusions.

These documents are separate Adobe pdf files.

Print the following file:

Appendix 2a_1.pdf

Print the following file

Appendix 2b_1.pdf

Appendix 3
Questionnaire for Interviews

Programs

Please consider the following questions with respect to programs that prepare students to support industrial manufacturing operations.

- 1) How would you define your institutions goals for education programs? for training programs?
- 2) What is the breakdown between education and training programs?
 - Curricula
 - Demand
 - Number of classes taught
 - Revenue
 - Need
- 3) With respect to support of industrial manufacturing operations, what are the specific jobs for which your programs are preparing students?
- 4) How would you describe the goals of your customers for education and training programs? Students / parents? Industry employers?
- 5) In what industries are your students being employed? Give specific examples if possible.
- 6) From what industries are students being sent to you for training? Give specific examples if possible.
- 7) What skills are being requested to be taught by your industrial partners?
- 8) What percentage of your students work for companies that do packaging, converting or printing?
- 9) How do you assess the opportunity in preparing students for support of advanced packaging and related systems?

Mechatronics

- 11) What is your understanding of the discipline called “Mechatronics”?
- 12) Do you have courses of study that address the needs of mechatronics technicians? If so, please describe them.
- 13) Are these courses structured to support packaging operations?
- 14) Do your students obtain familiarity with any of the following standards that support advanced manufacturing operations? IEC61131-3 (PLCOpen)
IEC61512 (ISA/ANSI S88 Batch)
IEC62264 (ISA/ANSI S95 Integration)
IEC61491 (SERCOS network)
IEC61158 (ProfiBus),
IEC62026 (DeviceNet)
21CFR part 11 (Electronic Signature and Records)
- 15) Do your programs emphasize vendor-specific solutions such as Rockwell (Allen-Bradley) or international standards and open system solutions?

Curricula Specifics

Please consider the following questions with respect to courses of study aimed at preparing students to be electrical technicians, process control technicians, electro-mechanical technicians, mechatronics technicians and closely related jobs in manufacturing industries such as food, beverages, pharmaceuticals, packaging or converting.

- 14) Please outline the typical or required courses of study for a student completing a program aimed at the above referenced careers.
- 15) Please provide course syllabi for the courses in the program(s) described above.
- 16) Please give indications of the instructional methods used in the above courses with particular reference to the hands on experiences of the students.

- 17) Your institution was provided with a task analysis that was recently developed by a major local food processor / packager. How do the skill requirements reflected in this analysis match those that you are seeing from your industrial constituents?
- 18) Given the task analysis provided by a major local packager, can you describe a program of study leading to a degree from your institution that would meet the majority of these requirements? What are the gaps or excesses as you see them?
- 19) Given the task analysis provided by a major local packager, can you describe credit or non-credit training programs that would fulfill some or all of these requirements?
- 20) What are the strengths of your institutions programs in the related area over those of your local competitors?

Appendix 4

Task Analysis from Local Packager

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Appendix 4_1.xls

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